ornl

ORNL/Sub/91-SL794

OAK RIDGE NATIONAL LABORATORY

MARTIN MARIETTA

LITERATURE SURVEY OF HEAT TRANSFER ENHANCEMENT TECHNIQUES IN REFRIGERATION APPLICATIONS

M. K. Jensen

B. Shome

MANAGED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

ORNL/Sub/91-SL794

LITERATURE SURVEY OF HEAT TRANSFER ENHANCEMENT TECHNIQUES IN REFRIGERATION APPLICATIONS

M. K. Jensen

B. Shome

May 1994

Prepared by
Department of Mechanical Engineering
Aeronautical Engineering and Mechanics
Rensselaer Polytechnic Institute
Troy, NY 12180-3590
under
Subcontract No. 85X-SL794V
Prepared for
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831-6285
managed by
Martin Marietta Energy Systems, Inc.
for the U.S. Department of Energy
under
Contract DE-AC05-84OR21400

CONTENTS

Page

LIST OF FIGURES v

ABSTRACT ix

EXECUTIVE SUMMARY xi

1. INTRODUCTION 1

2. DESCRIPTION OF HEAT TRANSFER ENHANCEMENT TECHNIQUES 4

3. TECHNICAL LITERATURE AND PATENT SOURCES 6

   Technical Literature and Bibliographic Data Base, 6 ■ Patent Literature and Coding, 14

4. ENHANCED CONDENSATION HEAT TRANSFER 18

   Shellside Condensation, 18 ■ Tubeside Condensation, 29

5. ENHANCED POOL BOILING HEAT TRANSFER 41

6. ENHANCED FLOW BOILING HEAT TRANSFER 68

   Shellside Flow Boiling, 68 ■ Tubeside Flow Boiling, 69

7. ENHANCED HEAT TRANSFER IN REFRIGERANT MIXTURES 86

   Pool Boiling, 86 ■ Flow Boiling, 88 ■ Condensation, 91

8. EFFECT OF LUBRICANTS ON ENHANCED HEAT TRANSFER 98

   Pool Boiling, 98 ■ Flow Boiling, 104 ■ Condensation, 106

9. SUMMARY REVIEW OF THE PATENT LITERATURE 111

   Pool Boiling, 111 ■ Flow Boiling, 121 ■ Condensation, 129

10. CONCLUSIONS AND RECOMMENDATIONS 137

    Pool Boiling, 137 ■ Flow Boiling, 139 ■ Condensation, 142 ■ Concluding Remarks, 145

Page

REFERENCES 146

APPENDIX 1. TECHNICAL CITATIONS ON ENHANCED HEAT TRANSFER 169

Pool Boiling, 171 ■ Flow Boiling, 231 ■ Condensation, 285

APPENDIX 2. PATENTS ON ENHANCED HEAT TRANSFER 353

Pool Boiling, 355 ■ Flow Boiling, 361 ■ Condensation, 365

FIGURES

4.1 Experimental data for single integral-fin tubes with (a) R-11 and (b) R-114 24
4.2 Row effect for condensing R-11 on various enhanced tube bundles 24
4.3 Performance of enhanced tubes compared to smooth tube for condensation of R-11 26
4.4 Condensation heat transfer coefficient for spirally fluted and smooth tube for condensing R-114 and ammonia 26
4.5 Electrohydrodynamic enhancement of R-12 condensing on a smooth tube 31
4.6 Tubeside condensation coefficients of R-22 in multi-grooved tube 31
4.7 (a) Fin profiles, (b) condensation coefficient, and (c) condensation pressure drop results for R-113 condensing in a micro-fin tube 35
4.8 Pumping power per unit heat transfer rate for condensation of R-113 inside a tube with in-line static mixer inserts 37
4.9 Experimental results of (a) overall heat transfer coefficient and (b) overall pressure drop for condensing R-113 inside externally finned tubes and tubes with twisted-tape inserts 39
4.10 Electrohydrodynamic enhancement of average heat transfer coefficient for intube condensation of R-113 39
5.1 Enhanced boiling surfaces 43
5.2 Boiling curve for Thermoexcel-E surface 43
5.3 Composite plot of data from different gap width Gewa-T and smooth tube for R-113 45
5.4 Heat transfer coefficient versus gap width 45
5.5 Boiling heat transfer in R-113 on a Turbo-B tube 48
5.6 Thin Film NH_3 evaporation performance with porous surface 48
5.7 Boiling heat transfer in R-113 on porous surface 49
5.8 The boiling of Freon-113 for samples 2, 3, and 6 49
5.9 Comparison of the boiling performance of an integral fin, the Gewa-SE, and the Turbo-B tubes 53
5.10 Effect of pit density on the nucleate boiling curve 53
5.11 Comparison of the heat transfer measurements with R-115 for four of the investigated plates at two different saturation pressures 57
5.12 (a) Finned tubes tested. (b) Comparison of boiling performance of R-11 at 35°C 58
5.13 Heat transfer coefficient for simultaneously heated middle tubes 63
5.14 EHD heat transfer enhancement of R-123 at 0% oil 63
5.15 Effect of an applied voltage on the boiling heat transfer of the porous surface 65
5.16 Relation between CHF and jet velocity obtained for R-12 65

5.17 Augmentation of critical heat flux and mean bubble detachment period in a liquid jet when EHD enhancement is used 67
6.1 Effect of the heated tube surface on the heat transfer coefficient 71
6.2 Heat transfer coefficient for intube boiling of R-22 in microporous tube 71
6.3 Measured pressure drop and heat transfer coefficient for flow boiling of R-12 in a cross-ribbed flat channel 74
6.4 Average heat transfer coefficients for flow boiling in internally finned tubes 74
6.5 (a) Fin profiles, (b) evaporative heat transfer coefficient, and (c) evaporative pressure drop for flow boiling of R-113 in micro-fin tube 78
6.6 Evaporative heat transfer coefficients for flow boiling of R-22 inside micro-fin and smooth tube 80
6.7 Effectiveness of in-line static mixers in augmenting the rate of forced flow boiling heat transfer of R-113 80
6.8 Effect of tape-twist ratio on heat transfer coefficient for flow boiling of R-113 83
6.9 Effect of tube-to-coil diameter ratio on CHF for flow boiling of R-113 83
7.1 Saturated pool boiling curve for the Turbo-B tube in mixtures of R-11 and R-113 at P = 103 kPa 87
7.2 Saturated pool boiling curve for the High Flux tube in mixtures of R-11 and R-113 at P = 103 kPa 87
7.3 Comparison of two-phase flow boiling heat-transfer coefficients on enhanced surface tubing and on plain tube 90
7.4 Effect of mixture concentration and heat flux on the High Flux heat transfer coefficients 90
7.5 A comparison between (a) the difference between the liquid and vapor concentrations of R-11 and (b) experimental trends in heat transfer coefficients at $q'' = 60$ kW/m^2 and P = 200 kPa 92
7.6 Free convective condensation on Surface 2 93
7.7 Free convective condensation on Surface 1 95
7.8 Measured R-114/R-12 mixture condensing performance on tube B 95
7.9 Condensation on finned tube 97
7.10 Average condensing coefficient for R-143a/R-124 mixtures computed from linear regression of data 97
8.1 Ratio of heat transfer coefficients with and without oil present as a function of mass concentration of oil in the mixture 101
8.2 26 fpi Gewa-K data for 0, 3, and 10% oil concentration 101
8.3 Thermoexcel-E data for 0, 3, and 10% oil concentration 102
8.4 High Flux data for 0, 3, and 10% oil concentration 102
8.5 Turbo-B data for 0, 3, and 10% oil concentration 105
8.6 EHD heat transfer enhancement of R-123 at 5% oil 105

8.7 Evaporation enhancement factors due only to the effects of oil for the micro-fin tube in addition to the smooth tube and the low-fin tube 107
8.8 Experimental results with low oil concentrations 107
8.9 Experimental results with high oil concentrations 109
8.10 Condensation enhancement factors due only to the effects of oil for the micro-fin tube in addition to the smooth tube and the low-fin tube 109
9.1 (a) Cross section of flame sprayed treated surface and (b) heat exchange surface with porous coating and subsurface cavities 113
9.2 Cross section of two laminated foils showing a nucleate boiling cavity 114
9.3 Enhanced surface geometry and boiling heat transfer characteristic on the outer tube surface 114
9.4 Schematic of the enhanced heat transfer surface 115
9.5 (a) Tool gang arrangement, (b) sectional view of the enhanced heat transfer surface, and (c) comparison of the boiling performance with commercial TURBOCHILL tube 117
9.6 (a) Front view of the gas jet impingement system and (b) graph showing the cooling enhancement 119
9.7 Schematic axial section of the rotary evaporator 120
9.8 Schematic of the vacuum plated groove and boiling performance with R-11 120
9.9 Perspective view of the enhanced surface and performance data obtained 123
9.10 Tooling arrangement and cross sectional view of the enhanced tube geometry 123
9.11 Boiling heat transfer performance obtained with internally enhanced tube 124
9.12 Cross sectional view of the internally ribbed heat pipe 126
9.13 Perspective view of a cut away section of the heat transfer tube 126
9.14 Perspective view of the enhanced plate for the evaporative heat exchangers 128
9.15 Front view of the enhanced plate-type refrigerant evaporator 128
9.16 Comparison of the condensation performance of the enhanced geometry with that of a standard grooved tube 131
9.17 Groove geometry and representative performance data 131
9.18 Cutaway view of the internally enhanced tube representative performance data obtained with R-22 134
9.19 (a) Schematic sectional view of the condenser tube in the process of production and (b) enlarged sectional view of the tube with fin and rib enhancement 134
9.20 Partial elevation view of the spirally fluted tube 136
9.21 (a) Axial section of the EHD enhanced shell-and-tube heat exchanger and (b) elevation of the electrode used 136

ABSTRACT

A survey has been performed of the technical and patent literature on enhanced heat transfer of refrigerants in pool boiling, forced convection evaporation, and condensation. Extensive bibliographies of the technical literature and patents are given. Many passive and active techniques were examined for pure refrigerants, refrigerant–oil mixtures, and refrigerant mixtures. The citations were categorized according to enhancement technique, heat transfer mode, and tube or shell side focus. The effects of the enhancement techniques relative to smooth and/or pure refrigerants were illustrated through the discussion of selected papers. Patented enhancement techniques also are discussed.

Enhanced heat transfer has demonstrated significant improvements in performance in many refrigerant applications. However, refrigerant mixtures and refrigerant–oil mixtures have not been studied extensively; no research has been performed with enhanced refrigerant mixtures with oil. Most studies have been of the parametric type; there has been inadequate examination of the fundamental processes governing enhanced refrigerant heat transfer, but some modeling is being done and correlations developed. It is clear that an enhancement technique must be optimized for the refrigerant and operating condition. Fundamental processes governing the heat transfer must be examined if models for enhancement techniques are to be developed; these models could provide the method to optimize a surface. Refrigerant mixtures, with and without oil present, must be studied with enhancement devices; there is too little known to be able to estimate the effects of mixtures (particularly NARMs) with enhanced heat transfer. Other conclusions and recommendations are offered.

EXECUTIVE SUMMARY

An extensive survey of technical literature and patents on enhanced heat transfer techniques as applied to boiling and condensing refrigerants was undertaken. Enhanced pool boiling, flow boiling, and condensation of pure refrigerants, refrigerant–oil mixtures, and refrigerant mixtures were examined. Two sources of the literature, namely an existing database at Rensselaer and appropriate heat transfer journals (up to March 1993) were reviewed for technical citations. The U.S. patent literature on enhanced heat transfer was reviewed from 1928 to March, 1993.

Enhanced pool boiling has the largest number of technical citations of the three heat transfer modes reviewed. Significant enhancement of heat transfer coefficient over that of a smooth surface has been obtained for many of the enhancement techniques. For some enhancement techniques, phenomenological models (physically–based mathematical descriptions of the heat transfer and fluid flow mechanisms involved with the process) have been developed to describe the heat transfer characteristics; however, the majority of the experimental studies were of a parametric nature (i.e., a systematic testing of fluid operating conditions and surface geometries over a range of values). While the latter type of research is valuable, it is insufficient to generalize and model the heat transfer.

Structured and porous surfaces have received the most attention of the various enhanced pool boiling techniques. Generally speaking, an enhancement in the heat transfer coefficient of 5 to 20 times that of a smooth surface has been obtained. The majority of the studies have been conducted in pools of saturated liquid; minimal effort has been expended in studying thin film evaporation. Electrohydrodynamic (EHD) enhancement and jet impingement were the most widely used active techniques. For the former, the critical heat flux and the heat transfer coefficients were enhanced up to a maximum of 400%. For the latter, the focus of the studies has been on its application to electronic cooling.

The effect of refrigerant mixtures on enhanced pool boiling has not been studied extensively. The mixture heat transfer behavior is similar to that on a smooth surface. However, it is not clear that explanations for mixture boiling on smooth surface are completely transferable to enhanced surfaces. There has been a reasonable number of studies on the effect of refrigerant–oil mixtures on enhanced pool boiling. Small amounts of oil tend to enhance the heat transfer, while with increasing oil concentration the heat transfer is diminished. Enhanced surfaces tend to be degraded more than the smooth surfaces; however, the actual amount of degradation depends on the nature of the oil and the structure of the surface used.

Structured and porous surfaces appear to be the most widely used passive enhancement technique, while EHD enhancement has the largest potential for active enhancement. Phenomenological models are required. This generalization is required so that optimization of surfaces can be accomplished for various refrigerants and operating conditions. This is true for pure and refrigerant mixtures.

Impressive improvements in enhanced flow boiling heat transfer coefficients have been obtained relative to smooth tube results; however, this benefit is offset in most cases by large increases in pressure drop. Correlations based on parametric experimental studies have been developed to describe the heat transfer process, while minimal effort has been spent in examining the fundamental processes governing the heat transfer. Shellside flow boiling has received the least attention. Results have been obtained for structured, porous, and low–fin surfaces. For most structured and porous surfaces, the heat transfer was governed by the subsurface heat transfer mechanisms. Pressure drop for these surfaces were similar to the smooth tube results.

Tubeside flow boiling has been studied extensively. A variety of rough and extended surfaces have been employed to enhance the heat transfer. Similarly, swirl flow devices, such as twisted tape inserts, have been used to enhance the heat transfer. Even though the heat transfer enhancement obtained by these devices is significant, the

associated pressure drop is substantially higher (up to 30 times that of a smooth tube). To offset this disadvantage, micro–finned tubes are being increasingly used. The pressure drop associated with these tubes is modest, being in the range of 10 to 40% greater than that of a smooth tube, while the heat transfer coefficient is increased up to 200%. The majority of the experimental data on micro–finned tubes were obtained with R–22 and R–113 only. Correlations for predicting the heat transfer and pressure drop behavior are not available yet.

Limited studies have looked at the flow boiling of refrigerant mixtures on enhanced surfaces. Insufficient and inadequate information exists about the governing mechanisms with refrigerant mixtures to model the process. Enhanced flow boiling with refrigerant–oil mixtures has been studied with finned and micro–finned tubes. Some visual observation of flow patterns governing the heat transfer in refrigerant–oil mixtures also are available.

There are similar research needs for both shell and tubeside flow boiling. Little effort has been spent to develop phenomenological models for enhanced surfaces. For micro–finned tubes, more investigations are required for different refrigerants, as well as different fin/tube geometries. There is also a lack of experimental data on CHF and post–CHF heat transfer for micro–finned tubes.

Enhanced condensation, unlike pool and flow boiling, has been addressed both experimentally and theoretically. Data have been obtained for many enhancement techniques (both shellside and tubeside), modeling of shellside condensation has been performed, and correlations of forced convective condensation have been developed. However, for dropwise condensation surfaces that can be wetted by refrigerants have not been found yet. For shellside condensation, many models have been developed that takes into account variables such as fin geometry, surface tension, condensate retention, etc. and the models agree reasonably with experimental data. However, these models have been largely limited to single tubes only. In contrast, little is known about shellside condensation in tube bundles. Both two– and three–dimensional extended surfaces have

been tested; however, generalized models of these surfaces are not available. EHD enhancement of shellside condensation has been used with a good degree of success. In particular, pseudo–dropwise EHD enhanced condensation seems to be quite promising. The literature indicates that in the near future EHD enhancement has the potential to become competitive with more conventional techniques such as extended or treated surfaces.

The majority of the shellside enhancement techniques also are applicable to tubeside condensation. Various rough and extended surfaces have demonstrated around 100% to 300% increases in the heat transfer coefficient with the pressure drop increase ranging from small to around 200%. Micro–finned tubes tend to increase the heat transfer coefficient up to a factor of three with a modest increase (typically in the range of 20 to 40%) in the pressure drop. However, as stated earlier, micro–fin tube data are limited to R–22 and R–113 only and no correlations are available. Other enhancement techniques (such as injection/suction, fluid or surface vibration) have been pursued for academic interest only. Due to inherent difficulties, these techniques are not commercially viable.

Limited studies have been performed on enhanced condensation of refrigerant mixtures and refrigerant–oil mixtures. A small amount of a second refrigerant can cause a large decrease in the condensing coefficients for both vapor space and intube condensation. Vapor space condensation with refrigerant–oil mixtures have exhibited a negligible decrease in the heat transfer coefficient. Similar results have been obtained for condensation in micro–finned tubes. Compound enhancement techniques (such as a porous extended surface) have been used with a high degree of success particularly for shellside condensation.

To assist modeling efforts, local (as opposed to length–averaged) measurements of heat transfer coefficient should be obtained for a variety of refrigerants and enhancement techniques. As with pool and flow boiling, additional study of condensation of refrigerant mixtures and refrigerant–oil mixtures is required.

A large number of patents for enhanced shellside pool boiling have been developed for treated surfaces. These surfaces include chemically etched or flame–sprayed porous surfaces, laminated foil surfaces, etc. Rough surfaces (such as grooved, knurled, or corrugated surfaces) also have been described in many patents. However, limited information has been provided about the performance data. In addition, the majority of the surfaces described in the patents have been tested in R–11 only. A significant number of patents have been devoted to intube surface tension devices such as porous wicks, etc. However, the focus of these patents is on heat pipe applications.

The majority of the recent patents in enhanced tubeside flow boiling has been focused on internally grooved and micro–finned tubes. Performance data limited to R–11 and R–114 have been presented. A few of these patents have described the manufacturing techniques and the tooling geometry required to produce such tubes. Enhanced flow boiling in plate–type heat exchangers with ribbed or recessed plates have been described by a few recent patents. One such patent described a flow passage whose cross sectional area was continually varied from the inlet to the outlet section by having ribs of varying sizes.

For tubeside condensation, grooved surfaces have been extensively patented. The general trend is towards a large number of small grooves. The performance data (obtained mostly with R–11) indicate around 80% enhancement in the condensation coefficients. In addition, tubes have three–dimensional extended surfaces with cavities on both inner and outer surfaces have been patented. The advantage of such devices is that they can be used for both boiling and condensation applications. A few of these patents have also described the manufacturing techniques and the tooling in detail. For shellside condensation, a large number of patents dealt with finned and fluted tubes. Many of such tubes also had doubly enhanced surfaces. In contrast to the number of technical citations dealing with EHD enhancement, only one patent on an EHD enhanced condenser was found. Performance data obtained with R–12 and R–114 showed an enhancement of around 150% in the shellside heat transfer coefficient.

A variety of enhancement techniques have been developed and commercialized for boiling and condensing refrigerants that demonstrate superior heat transfer performance. In order to optimize these enhancement techniques for a specific fluid and operating conditions, sufficient data should be obtained so that a complete performance evaluation can be conducted. A quantitative assessment of the heat transfer enhancement should be conducted against the pressure drop/pumping power penalty subject to the constraints present in a particular application. Furthermore, there is a need for development of generalized models which accurately describe the heat transfer phenomena. To do this, more fundamental research, as opposed to parametric experimental studies, is required.

1. INTRODUCTION

The field of study focused on increasing the heat transfer coefficient between a solid surface and a fluid is called heat transfer enhancement, augmentation, or intensification. Enhanced heat transfer techniques have been applied to many different applications in many different industries. The usual goals of adoption of one of the variety of techniques available are to increase the heat duty of a fixed size heat exchanger, to reduce the size for a heat exchanger of fixed heat duty, to lower the required inlet temperature difference between the two fluids, or to reduce the pumping power. Heat transfer enhancement techniques also are used in non–heat–exchanger applications typically to reduce surface temperature for a given heat flux.

Both single–phase and two–phase (boiling and condensation) heat transfer have been augmented through the use of surface geometry modifications, modifications to the channel configuration, insertion of devices to change the fluid flow path past a surface, application of force fields to change the body forces acting on a fluid, and addition of a second material to the fluid flow to improve the heat transfer. However, different enhancement techniques perform differently depending on the use. What may be a superb enhancement device for single–phase flow may not do anything for boiling heat transfer and vice versa. Likewise, what is beneficial at one flow rate may become much less beneficial at another, and what works well with one fluid may not work well with another fluid which has significantly different fluid properties. Hence, choice of the enhancement technique must depend on the mode of heat transfer, the fluid used, the operating conditions, the application, and other considerations.

Enhanced heat transfer techniques have gained wide acceptance in the refrigeration and air conditioning industries. In particular, enhancement techniques are widely used in evaporators and condensers, and manufacturers have optimized their enhancement techniques to perform best with any one of a variety of refrigerants. There have been

several bibliographies compiled of the technical literature (Bergles et al. 1982; Bergles et al. 1983; Bergles et al. 1991) and the patent literature (Webb et al. 1983) that list numerous citations on different techniques to enhance heat transfer. Many of these citations are specifically for refrigerant applications; others are for water, hydrocarbons, liquid metals, air, etc. The body of literature on enhanced heat transfer continues to grow so that continued effort must be made to maintain a reasonably up–to–date compilation.

Because the fluid properties of refrigerants are significantly different from those of water, hydrocarbons, liquid metals, etc., the heat transfer characteristics of a refrigerant with a particular enhancement technique may be different from those with another fluid. Likewise, the presence of oil in a refrigerant or the use of a mixture of refrigerants may result in the heat transfer behavior being different from those of other fluids. While studies with other liquids would shed some light on the physical processes governing the heat transfer for a particular enhancement technique, it is the intent of this survey to examine the literature of only those citations specifically dealing with boiling and condensing refrigerants and related fluids. Thus, the objectives of this survey are: to compile papers and patents on applicable enhancement techniques for pure refrigerants, refrigerant mixtures, and refrigerant–lubricant mixtures; to categorize the literature according to enhancement technique, heat transfer mode, fluid and fluid mixture, and shell or tube side heat transfer; to discuss information found in these citations relative to the applicability of enhanced heat transfer technology; and to present opinions on gaps in the knowledge base relative to enhancement techniques applied to refrigerants and recommendations of needed research.

To accomplish these objectives, the technical literature contained in the principle journals, conference proceedings, and workshop reports which cover the field of enhanced heat transfer was searched, the citations found were classified according to the taxonomy of the field, and these papers and reports were entered into an existing database. This existing Rensselaer Enhanced Heat Transfer Database was then used to compile the

literature applicable to refrigerant boiling and condensing heat transfer. The next two chapters (**2. DESCRIPTION OF HEAT TRANSFER ENHANCEMENT TECHNIQUES** and **3. TECHNICAL LITERATURE AND PATENT SOURCES**) are based extensively on similar chapters from Bergles et al. (1991) and Webb et al. (1983) because the same approach is taken in this survey as was taken in those reviews. The next five chapters address various aspect of the technical literature on enhanced refrigerant heat transfer. The patent literature is then briefly discussed. Finally, conclusions are drawn and recommendations made. The listing of the technical and patent literature according to various categories is given in the appendices.

2. DESCRIPTION OF HEAT TRANSFER ENHANCEMENT TECHNIQUES

Bergles (1985) has presented a classification taxonomy and has identified 15 different heat transfer enhancement techniques. Some of these techniques are strictly applicable to only one mode of heat transfer; other techniques have been found to enhance heat transfer for several modes of heat transfer. Given below is a listing and short discussion (adapted from Bergles, 1988) of these 15 techniques. The techniques which perform the heat transfer enhancement without the application of additional external power (that is, power over and above that required to pump the fluid through the channel) are called passive techniques. Those techniques which do require additional external power to operate are called active techniques. (Because of reliability concerns, most emphasis has been place on developing passive techniques.) Note that two or more techniques may be utilized simultaneously to produce an enhancement larger than that produced by either technique individually. The simultaneous use of two or more enhancement techniques is called *Compound Enhancement*.

Passive Techniques

Treated Surfaces involve fine–scale alteration of the surface or coating (continuous or discontinuous). They are used for boiling and condensing; the roughness height is below that which affects single–phase heat transfer. The fine–scale structures used to enhance nucleate pool boiling are generally included in this category.

Rough Surfaces are produced in many configurations ranging from random sand–grain type roughness to discrete protuberances. The configuration is generally chosen to promote turbulence rather than to increase heat transfer surface area.

Extended Surfaces add heat transfer area. Of particular interest is the improvement of the heat transfer coefficient on extended surfaces by shaping or interrupting the surface.

Displaced Enhancement Devices are inserted into the flow channel so as to improve energy transport at the heated surface by improving mixing between the fluid at the wall and in the core and by increasing fluid velocities at the wall.

Swirl-Flow Devices include a number of geometric arrangements or tube inserts for forced flow that create rotating and/or secondary flow: inlet vortex generators, twisted–tape inserts, and axial–core inserts with screw –type windings. The swirl improves mixing between the fluid at the wall and in the core.

Surface Tension Devices consist of wicking or grooved surfaces to direct the flow of liquid in boiling and condensing.

Additives for Liquids include solid particles and gas bubbles in single–phase flows and liquid trace additives for boiling systems.

Additives for Gases are liquid droplets or solid particles, either dilute phase (gas–solid suspensions) or dense phase (fluidized beds). Liquids droplets increase the heat transfer process through the very efficient evaporation process, and solid particles tend to agitate/disrupt the boundary layer.

Active Techniques

Mechanical Aids stir the fluid by mechanical means or by rotating the surface. Surface "scraping," widely used for viscous liquids in the chemical process industry, can also be applied to duct flow of gases.

Surface Vibration at either low or high frequency has been used primarily to improve single–phase heat transfer. This is somewhat impractical given the mass of most heat exchangers and mechanical reliability considerations.

Fluid Vibration is the most practical type of vibration enhancement. The vibrations range from pulsations of about 1 Hz to ultrasound. Pulsed combustion is a common technque applied to smaller installations.

Electrostatic Fields (d–c or a–c) are applied in many different ways to dielectric fluids and can be directed to cause greater bulk mixing of fluid in the vicinity of the heat transfer surface.

Injection involves supplying gas to a flowing liquid through a porous heat transfer surface or injecting similar fluid upstream of the heat transfer section. Only single–phase flow is of interest.

Suction involves either vapor removal through a porous heated surface in nucleate or film boiling or fluid withdrawal through a porous heated surface in single–phase flow.

Jet Impingement involves the near–normal impingement of a jet of fluid on a solid surface. High velocities at the surface result in high heat transfer coefficients.

3. TECHNICAL LITERATURE AND PATENT SOURCES

Technical Literature and Bibliographic Data Base

Two primary source locations were searched for the technical literature on enhanced heat transfer. The first was the Rensselaer Heat Transfer Enhancement Database previously used in conjuction with earlier bibliographic reports by Bergles et al. (1983,1991); this covered much of the world–wide literature on all modes and techniques of enhanced heat transfer (including fouling considerations as applied to enhancement devices) up to 1990. The second source was the Rensselaer library which was used to extend the existing bibliographic database by searching publications generally up to December 1992 through an intensive search of the primary journals, conference proceedings, etc. covering heat transfer. Some sources earlier than 1990 also were examined as they came to our attention; some of the more prominent journals were reviewed up through March 1993 because of their prompt appearance in the library.

The computerized bibliographic database has been set up on the mainframe computer (IBM 9021–580) at Rensselaer Polytechnic Institute. A general purpose database management system program called SPIRES (Stanford Public Information REtrieval System) is used because it has extensive and fast search–and–report capabilities which include the following "search by" indices:

(1) Author name(s)

(2) Title of the article/paper/report

(3) Year of publication

(4) Name of the journal/publication source

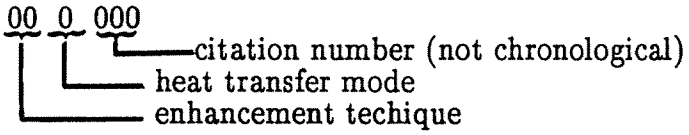
(5) Keywords which relate to the type of heat transfer enhancement technique, mode of heat transfer, year of publication, journal/conference/source, and mass transfer/fouling

(6) Keycodes or reference numbers

The working literature citations are stored on the mainframe computer with a backup on a standby magnetic tape. Retrieval is accomplished by invoking the SPIRES program and specifying one or more of the search–and–report indices either individually or in combination.

For this literature survey only those citations dealing with pool and forced convective boiling and condensation of refrigerants or refrigerant mixtures were of interest. Hence, once all the citations were entered into the database, the database was searched for those three modes of heat transfer; the resulting citations were examined manually to determine the working fluid and if the heat transfer emphasis was on the shell or tube side.

The literature has been organized according to the enhancement technique and the mode of heat transfer, with a unique reference number assigned to each citation. The reference number (or Keycode) for each citation is a 6–digit number which is formed according to the enhancement technique (first two digits), heat transfer mode (third digit), and the serial number in that technique–mode category, as follows:



The different enhancement techniques with their codes and associated keywords are listed below. In addition to the 15 enhancement techniques (Fluid injection and suction, earlier discussed separately, have been combined into a single category with code no. 13.), literature surveys on heat transfer enhancement, performance evaluation of enhancement devices, and compound usage of two or more techniques are also included in the list.

Code	Technique	Keyword
00	Surveys	LITSURVEY
01	Treated Surfaces	TREATSURF
02	Rough Surfaces	ROUGHSURF

03	Extended Surfaces	EXTENDEDSURF
04	Displaced Enhancement Devices	DISPENHDEVICE
05	Swirl–Flow Devices	SWIRLFLO
16	Coiled Tubes	COILEDTUBE
06	Surface Tension Devices (includes heat pipes)	SURFTENSION
07	Additives for Liquids	ADDFORLIQUIDS
08	Additives for Gases (includes fluidized beds)	ADDFORGASES
09	Mechanical Aids	MECHAID
10	Surface Vibration	SURFVIB
11	Fluid Vibration	FLUIDVIB
12	Electric or Magnetic Fields	ELECTROFIELD
13	Injection or Suction	INJECTORSUCT
17	Jet Impingement	JETIMPINGE
14	Compound Enhancement	COMPOUNDTECH
15	Performance Evaluation	PERFORMANCE

There are some difficulties in classifying some devices according to the above categories. For example, should corrugated tubes and fluted tubes be classified as rough surfaces or extended surfaces? In the present compilation, the somewhat arbitrary decision has been made to classify them as rough surfaces for internal flows and extended surfaces for external flows. Also, distorted (or twisted) tubes have been classified as extended surfaces.

The bibliography presented in this report contains world literature on heat transfer enhancement of boiling and condensing refrigerants. The heat transfer mode is coded as follows:

Code	Heat Transfer Mode	Keyword
3	Pool Boiling	POOLBOIL
4	Forced–Convection Boiling	FLOBOIL
5	Condensation	CONDENSATION

A listing of the major sources covered in the search is included in this section. These sources were searched manually because past experience (Bergles et al., 1983) has shown that computerized searches of library databases are not effective. For the majority of the sources, the searches were carried out for the publication years January 1990 to December 1992. Previous extensive searches (Bergles et al. 1983, 1991) covered much of the earlier years of these publications. However, some new reference sources were found and searched as far back as we could find available Tables of Contents For references available in the Rensselaer library, this was easily accomplished; for those references needing to be borrowed from other libraries, at times there were difficulties experienced due to non–cooperation of the other libraries. Likewise, because of delays in the library's acquiring publications, delays in publications of journals, etc., not all of the 1992 publications have been logged–in. Note that this is not a complete list of all the sources for the citations included in the bibliography; it is only representative of the extensive literature search carried out. However, it does include those references from which the vast majority of the citations were obtained; sources that contained relatively few relevant citations have been omitted from the list.

Journals

1. AICHE Journal
2. Applied Energy
3. Applied Scientific Research
4. ASHRAE Transactions
5. ASME Journal of Heat Transfer
6. Canadian Journal of Chemical Engineering
7. Chemical Engineering Communications
8. Chemical Engineering Journal
9. Chemical Engineering Science

10. Chemical and Process Engineering
11. Energy
12. Experimental Heat Transfer
13. Experimental Thermal and Fluid Science
14. Heat Recovery Systems and CHP.
15. Heat Transfer Engineering
16. Heat Transfer – Japanese Research
17. Heat Transfer – Soviet Research
18. High Temperature (Teplofizika Vysokikh Temperatur)
19. Indian Journal of Technology (partial)
20. Industrial and Engineering Chemistry
21. International Chemical Engineering
22. International Communications in Heat and Mass Transfer
23. International Journal of Heat and Fluid Flow
24. International Journal of Heat and Mass Transfer
25. International Journal of Heat and Technology (limited collection)
26. International Journal of Refrigeration
27. Journal of Chemical Engineering of Japan
28. Journal of Engineering for Gas Turbines and Power
29. Journal of Engineering Physics
30. Journal of Fluid Mechanics
31. Journal of Thermophysics and Heat Transfer
32. Journal of Turbomachinery
33. JSME International Journal (formerly Bulletin of JSME)
34. Latin American Applied Research (limited collection)
35. Numerical Heat Transfer

36. Thermal Engineering (Teploenergetika)

37. Warme– und Stoffubertragung

Conference Proceedings

1. AIChE Symposium Series
2. All–Soviet Union Conference on Heat and Mass Transfer
3. ASME National Heat Transfer Conference
4. ASME Winter Annual Meeting
5. ASME–JSME Thermal Engineering Joint Conference
6. International Congress of Refrigeration
7. International Heat Transfer Conference
8. International Symposium on Heat Transfer (China)
9. National Heat and Mass Transfer Conference, India (limited collection)
10. Proceedings of Indian Academy of Sciences – Engineering (limited collection)
11. Proceedings of The Institution of Mechanical Engineers (U.K.)
12. U.K. National Heat Transfer Conference
13. USNC/IIR – Purdue Refrigeration Conference
14. World Conference on Experimental Heat Transfer, Fluid Mechanics, and Thermodynamics

Edited/Special Topic Books and Reports

1. Ceramics in Heat Exchangers, Advances in Ceramics – Vol. 14, The American Ceramic Society, Columbus, OH, 1985.
2. Compact Heat Exchangers, R.K. Shah, A.D. Krause, and D. Metzger (eds.), Hemisphere Publishing, New York, 1990.
3. Design and Operation of Heat Exchangers, W. Rietza, P.J. Heggs, and D. Butterworth (eds.), Springer–Verlag, New York, 1991.
4. Handbook of Single–Phase Convective Heat Transfer, S. Kakac, R.K. Shah, and W. Aung (eds.), John Wiley, New York, 1987.

5. Heat and Mass Transfer in Refrigeration Systems and in Air Conditioning, International Institute of Refrigeration, Paris, 1972.

6. Heat Transfer Enhancement and Energy Conservation, S.–J. Deng, T.N. Veriroglu, Y.–K. Tan, and L.–Q. Chen (eds.), Hemisphere Publishing, New York, 1990.

7. Heat Transfer Equipment Design, R.K. Shah, E.C. Subbarao, and R.A. Mashelkar (eds.), Hemisphere Publishing, New York, 1988.

8. Heat Transfer in High Technology and Power Engineering, W.–J. Yang and Y. Mori (eds.), Hemisphere Publishing, Washington, D.C., 1987.

9. High Temperature Heat Exchangers, Y. Mori, A.E. Sheindlin, and N.H. Afgan (eds.), Hemisphere Publishing, Washington, D.C., 1986.

10. Multi–Phase Flow and Heat Transfer, X.–E. Chen, T.N. Veziroğlu, and C.L. Tien (eds.), Hemisphere Publishing, New York, 1989.

11. Several monographs and handbooks

12. Numerous available technical reports

Bibliographic Sources

1. Applied Mechanics Reviews

2. HTFS Digest

3. Previews of Heat and Mass Transfer (partial)

The results of the literature search on heat transfer enhancement in applications using condensing and boiling refrigerants are listed in Appendix 1. The listings include citations, coded according to the keywords discussed previously. The citations are arranged according to the mode of heat transfer and further subdivided according to the enhancement technique. It should be emphasized that these are technical citations only and only reflects the boiling and condensing refrigerants literature only. The breakdown of the number of citations in each enhancement category for the three modes of heat transfer is shown in Table 1.

Table 1. Citation count by technique–mode for papers dealing with refrigerants

	Heat transfer mode		
Technique	Pool boiling	Flow boiling	Condensation
Literature surveys	12	11	28
Treated surfaces	133	26	14
Rough surfaces	29	31	34
Extended surfaces	70	63	178
Displaced enhancement devices	4	8	7
Swirl flow devices	0	21	8
Surface tension devices	0	21	8
Coiled tubes	0	12	5
Additives for liquids	12	9	2
Additives for gases	0	0	0
Mechanical aids	4	0	7
Surface vibrations	0	0	3
Fluid vibrations	3	0	0
Electric fields	20	8	27
Injection or suction	0	2	2
Jet impingement	10	9	0
Compound enhancement	4	2	7
Performance evaluation	3	5	7
Total	309	207	333
Grand total	849 citations		

Patent Literature and Coding

The U.S. patent literature on enhancement techniques from 1928 to March, 1993 was reviewed to identify devices that might be applicable to boiling and condensation heat transfer in refrigerant applications. Three sources of patent citations were used, namely the patent bibliography by Webb et al. (1983) and the patent listing provided in each issue of the journals: Heat Recovery and CHP and Air Conditioning, Heating, and Refrigeration News. The bibliography was used for patents issued up to June 30, 1983, and the journals were employed to locate patents issued subsequent to that date.

In many cases patents issued before 1984 were available in the files of the Heat Transfer Laboratory at Rensselaer Polytechnic Institute; later ones were obtained from the New York State Library located at Albany, NY. Note that most of the patents do not specifically refer to a particular fluid. Hence, all patents addressing boiling or condensing were included in the listing.

All the relevant patents are listed in Appendix 2. These have been classified by the method used by Webb et al. (1983), with the patents in each class arranged in order of patent number. Their coding scheme uses the same keywords as for the technical literature citations, but use different keycode numbers. To maintain consistency, the coding scheme of Webb et al. (1983) is adopted here and is outlined below:

Code	Technique
01	Treated surfaces
02	Rough surfaces
03	Attached promoters
04	Extended surfaces
05	Displaced enhancement devices
06	Formed channels
07	Swirl flow devices

08	Surface tension devices
09	Additive for liquids
10	Additive for gases
11	Mechanical aids
12	Surface vibration
13	Fluid vibration
14	Electrostatic fields
15	Injection or suction
16	Compound enhancement

Code	Heat Transfer Mode
3	Pool Boiling
4	Flow Boiling
5	Condensation

Code	Geometry Classification
A	Inside tubes
B	Outside tubes – gases
C	Outside tubes – liquids
D	Plate–type heat exchangers
E	Fin–type heat exchangers
F	Other geometries

For example, a code of 044C indicates a extended surface for flow boiling of liquid, with the surface extension on the outer surface of the tube.

The patent bibliography of Webb et al. (1983) and the patents cited in Heat Recovery Systems and CHP and Air Conditioning, Heating and Refrigeration News cover both refrigerant and non–refrigerant applications, as well as the full range of enhancement

techniques indicated in the previous section. It was necessary to select those techniques which were likely to be of greatest commercial value with refrigerants; however, most patents were not specific or did not mention the fluid tested. Thus, to make the scope of the review as wide as possible within the limits of the most promising commercial techniques, those patents (particularly those issued before 1983) which, in the authors view, could be used for refrigerant application but were not specific about the fluid used, were also included in this review. The classes of enhancement technique considered in this survey are summarized in Table 2 according to: (a) the type of enhancement; and (c) the location of enhancement and (b) the mode of heat transfer. The number of patents reviewed in each class are also indicated in the table.

In most cases the patent only describes the enhancement technique; only a few patents do mention the manufacturing technique and present representative performance data. Each one of the patents selected for the review was analyzed according to the following criteria:

i. proposed application as stated by the patentee

ii. type and location of enhancement

iii. performance data

iv. applicability to refrigerant applications

Table 2. Patent count by technique–mode

Technique	Heat transfer mode		
	Pool boiling	Flow boiling	Condensation
Treated surface	18	2	23
Rough surfaces	20	7	11
Attached promoters	3	1	3
Extended surfaces	30	14	25
Displaced enhancement devices	0	3	0
Formed channels	1	0	10
Swirl flow devices	2	3	2
Surface tension devices	10	3	14
Additive for liquids	0	1	0
Additive for gases	0	0	2
Mechanical aids	1	0	1
Surface vibration	0	0	0
Fluid vibration	1	0	0
Electric fields	0	0	2
Injection or suction	3	1	0
Compound enhancement	1	1	2
Total	90	36	95
Grand total	221 patents		

4. ENHANCED CONDENSATION HEAT TRANSFER

Extensive review articles (e.g., Renz, 1986; Bergles, 1988; and Webb, 1988) dealing with enhanced condensation heat transfer for both refrigerant and non–refrigerant applications have been published in recent years. These reviews have discussed in detail the merits and penalties associated with several active and passive enhancement techniques for both shellside and tubeside condensation.

In this section, a synopsis is given of enhancement techniques for condensing refrigerants; representative papers are cited. This chapter is subdivided into shellside and tubeside condensation with subheadings for the different enhancement techniques.

Shellside Condensation

This section discusses shellside or vapor space condensation on vertical or horizontal tubes and plates. A brief summary describing the heat transfer characteristics for each enhancement technique is discussed; typical results are noted.

Treated surfaces

Surface treatment has been investigated in detail in order to promote dropwise condensation of steam (see review by Webb, 1981). This is desirable since the dropwise heat transfer coefficient is usually an order of magnitude larger than that of film condensation. However, this technique has not been successful for refrigerants due to extreme wettability of refrigerants. Iltscheff (1971) condensed R–22 on several promoters and reported heat transfer coefficient approximately the same or lower than the predictions by film condensation theory.

Rough surfaces

Rough surfaces promote condensation primarily by turbulizing the condensate film. Part of the enhancement is due to increased surface area, but the surface area increase obtained by rough surfaces is typically small. A variety of rough surfaces have been used for enhancing condensation. These include knurled, scratched, ridged, and ribbed surfaces. Medwell and Nicol (1965) analyzed film condensation of a pure vapor on a vertically rough surface. The analysis showed that the enhancement produced by a given roughness height depends on the condensate film thickness. For sufficiently thick films, the roughness characteristic approaches the hydraulically smooth condition, where no mixing occurs, thereby producing little or no enhancement. Their theory shows a maximum possible enhancement of around 100%, but no data for refrigerants were provided.

Carnavos (1980) measured condensation coefficients for R–11 condensing on the outside of eleven different enhanced tubes and a smooth tube. Several of these tubes were doubly enhanced, i.e. they contained both external and internal enhancements. The internal enhancement was provided to reduce the tubeside thermal resistance and thus improve the overall performance. In general, the heat transfer enhancement (based on outside envelope area) was around four to six times the smooth tube value. The maximum enhancements were obtained with the doubly enhanced tubes. However, the tubeside pressure drops associated with these tubes were high (around 155% as compared to smooth tube on a nominal area basis). Chang and Spencer (1971) investigated the effect of surface ridges on condensation of R–12 in the presence of non–condensible gases. The surface ridges were provided by O–rings on the condensing surface. Marginal heat transfer enhancement (5–10%) for pure R–12 vapor was found to occur for film Reynolds number above a certain critical value. The critical Reynolds number was shown to depend strongly on the nature of the non–condensibles. They concluded that O–rings have only a slight effect on the condensation heat transfer for pure vapor, whereas the effect is greatly magnified in the presence of non–condensible gases. For instance, at low Reynolds

numbers, O–rings enhance heat transfer, while at high Reynolds numbers, resistance to heat transfer is increased.

Kabov and Padyukov (1991) obtained heat transfer data for condensing R–11 and R–12 vapor on single horizontal tubes with transverse annular ribs/fins of constant curvature. The heat transfer on the profiled surface was 1.2 to 2.1 times larger than that on a smooth surface for R–11 and around 1.6–3.5 times larger for R–12. The smaller enhancement obtained with R–11 was attributed to greater retention of the condensate film on the ribbed tube surface since the surface tension of R–11 is about twice as large as that of R–12.

It is clear that significant heat transfer enhancement could be obtained with pure refrigerants by using various rough surfaces. However, the actual enhancement obtained depends on the presence of non–condensible gases, properties of the refrigerant, presence of oil, etc. The latter will be discussed in more detail in a subsequent section.

Extended surfaces

Extended surfaces are widely used for enhancing condensation. Apart from providing additional surface area, extended surfaces promote effective drainage of the condensate. Thus, a thin condensate film is formed leading to substantially higher condensation coefficients.

Integral low–finned tubes are commonly used in the refrigerant industry as condensed refrigerants drain off easily due to low surface tension. These low–finned tubes are characterized by fin densities of 600 to 1400 fins/m. Heat transfer enhancement obtained with these tubes could be several fold by optimizing fin spacing and fin shape to provide adequate condensate drainage. Beatty and Katz (1948) measured condensing heat transfer coefficients for several refrigerants including R–22 on commercially available horizontal finned tubes having around 630 fins/m and proposed a semi–empirical correlation based on gravity driven, Nusselt type condensation on both the fin flanks and

the tube surface between the fins. The correlation predicted all of their data to within $\pm$10%. The correlation, however, did not account for surface tension effects and did not distinguish the between the fin tips and the fin flanks; thus, it was not directly applicable to rectangular or trapezoidal shaped fins. Pearson and Withers (1969) obtained data for R–22 condensing on a bundle comprising of sixty similar integral–finned tubes. They showed that by increasing the fin density from 748 fins/m to 1024 fins/m, the heat duty could be increased by 25% for the same log–mean temperature difference. Karkhu and Borovkov (1971) investigated the effect of surface tension forces on film flow and heat transfer. Analysis and experiments were performed for condensing R–113 on four different finned tubes having 782 or 1238 trapezoidal shaped fins/m. A 50–100% increase in the heat transfer coefficient was obtained.

Marto et al. (1988) investigated R–113 condensation on several families of horizontal integral–finned tubes having rectangular shaped fins. The maximum heat transfer was obtained with an optimum fin spacing of 0.25–0.5 mm. The heat transfer coefficient based on the same temperature difference was enhanced by a factor of four to seven over that of a smooth tube. The existing theoretical models of Beatty and Katz (1948), Webb et al. (1985), and Honda et al. (1987) were found to be, in general, conservative and accurate to around $\pm$20%. Honda et al. (1983) investigated condensation augmentation on single horizontal integral–finned tubes by attaching a porous drainage plate at the tube bottom. Three low–finned tubes and a saw–toothed fin tube were tested for R–113. The enhancement ratio based on comparison of tubes with and without the drainage plates ranged from 1.13 to 1.36. The increased enhancement could be attributed to the reduction in condensate retention and to the three–dimensional surface configuration. The maximum enhancement was obtained with the saw–toothed fin tube which has the lowest pitch. It was suggested that further enhancement could be obtained by reducing the fin pitch.

Webb et al. (1985) proposed an analytical model for prediction of the condensation coefficient for horizontal integral–finned tubes. Unlike the Beatty–Katz model, the analysis accounts for the effect of condensate bridging between the fins as well as for the surface tension driven condensate drainage on the fin flanks. The model could predict condensation coefficients to within $\pm$20% for condensing R–11 on tubes having 748 to 1378 fins/m. The success of the model clearly shows that condensate bridging and drainage are both surface tension driven phenomena. Some of the drawbacks of the model were that it does not account for gravity forces or the curvature of the condensate film. The former assumption might lead to over–prediction of the heat transfer coefficient. Furthermore, the correlation provided is valid for single tubes only. A more comprehensive model for integral–finned tube has been proposed by Honda et al. (1987). The model divides the tube into flooded and unflooded regions, and included both the surface tension and gravity forces in the analysis. In addition, both axial and circumferential variations in tube wall temperature were taken into account in the model. The model predicted most of the experimental data to within $\pm$20%.

Murata and Hashizume (1992) proposed an analytical model for predicting the condensation heat transfer coefficient in horizontal integral–finned tube bundles. The model is based on the assumption of negligible vapor shear and took surface tension and gravity forces into account. Condensate flooding is taken into account, where the condensation heat transfer coefficient decreases due to decrease in effective fin area as the condensate inundates the interfin region. The predicted heat transfer coefficients agreed reasonably well with experimental data obtained with R–11, R–113, R–123, and R–114 for single integral fin–tubes. Some representative results are shown in Fig. 4.1. Additional experiments were carried out in an eight–row integral–finned tube bundle for R–11 and R–114. The predicted heat transfer coefficients agreed with the experimental data with sufficient accuracy. In general, the enhancement obtained was in the range of 5.5 to 9 times that of a smooth tube, depending on the fin density. Even though visual

observations of the stability of the falling condensate stream were made, no attempt was made to systematically investigate the row effect in tube bundles with different enhanced tubes. Webb and Murawski (1990) investigated row effects for condensation of R–11 on a five–row tube bundle comprised of 1024 fin/m integral–finned, Wolverine Turbo–C, GEWA–SC, and Tred–D tubes. The Turbo–C tube showed the highest single tube performance but poor row effect (as seen in Fig. 4.2) degrades the bundle performance. In contrast, the standard integral–finned tube showed virtually no row effect. This was attributed to the continuous fins acting as dams and preventing axial spreading of the condensate which drips from the tube row above.

In recent years, three–dimensional extended surfaces have been used extensively for augmentation of horizontal tube shellside condensation. One such commercially available surface is the "THERMOEXCEL–C." The "THERMOEXCEL–C" surface has around 1380 saw–toothed fins/m. The results of Nakayama et al. (1975) have shown that significant enhancement in the condensation coefficient, around seven fold as compared to the smooth tube value, could be obtained for condensing R–113 (Fig. 4.3). It was argued that similar enhancements could be carried over to tube bundles and could lead to about a 30% reduction in a heat exchanger's volume as compared to using conventional low–finned tubes. The substantial increase in enhancement as compared to integral–finned tubes is due to multi–dimensional drainage provided at the fin tips. Arai et al. (1977) investigated the performance of the "THERMOEXCEL–C" surface for condensing R–11 and R–12 in tube bundles. The most crucial factor for the "THERMOEXCEL–C" surface was reported to be the groove pitch. The optimum groove pitch was found to be 0.7 mm. Significant reduction in the condenser length (around 30% for both R–11 and R–12) was reported based on the same log–mean temperature difference.

Vertical fluted tubes have been commonly used for enhancing condensation of refrigerants. The fin profile is altered according to a mathematical analysis to take full advantage of the "Gregorig effect." Mori et al. (1981) investigated the optimum surface

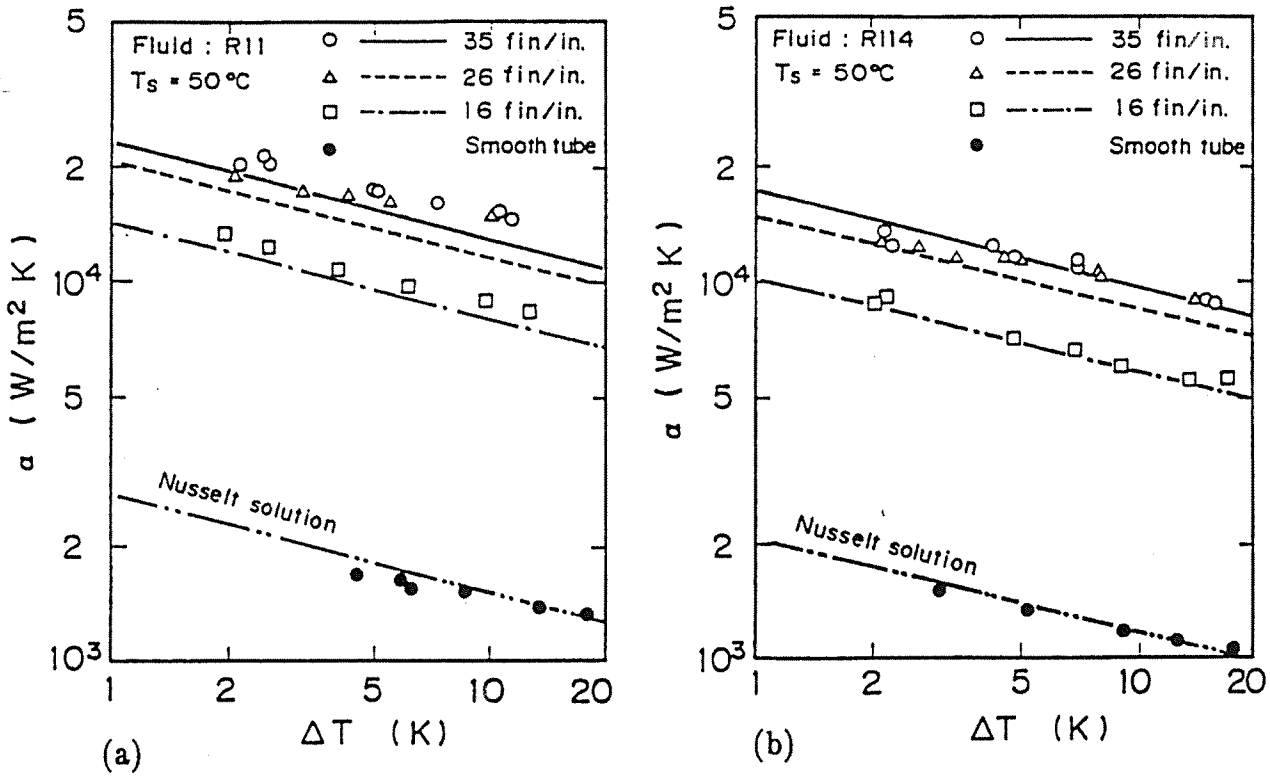


Figure 4.1. Experimental data for single integral–fin tubes with (a) R–11 and (b) R–114 (Murata and Hashizume, 1992).

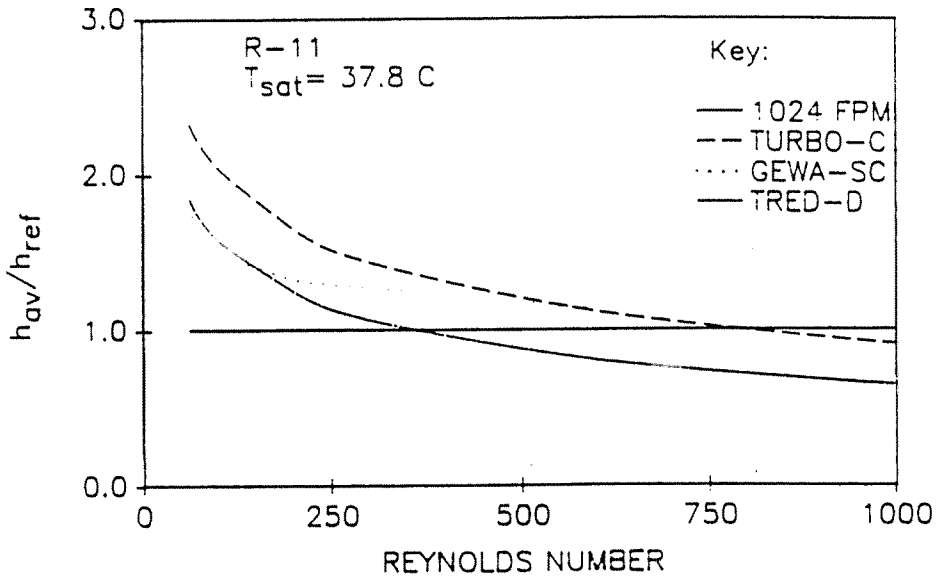


Figure 4.2. Row effect for condensing R–11 on various enhanced tube bundles (Webb and Murawski, 1990).

geometry of a vertically fluted condenser. The objective of the optimization was to make the condensate film as thin as possible. Based on numerical analysis, the optimum fin shape, fin pitch, and stripper spacing were presented for R–113. Using optimized fin dimensions and shape, their experimental data for R–113 demonstrated approximately a ten–fold larger average heat transfer coefficient as compared to the smooth tube.

Some recent developments on designing optimum fin shapes for R–11 have been reported by Kedzierski and Webb (1990). Optimum high–performance fin shapes for surface–tension drained condensation were presented. In contrast to previous analyses, their work presented the optimum fin profile in terms of fin tip radius, fin height, and fin base thickness, which are more suitable for commercial manufacture. The analysis was based on the assumption of surface tension driven flow, negligible vapor shear, and constant fin temperature. The analysis showed that the performance of these finned tubes are insensitive to moderate deviations in the fin tip radius and, thus, the effect of manufacturing tolerances on the performance would be minimal. In addition, general guidelines for practical design of the geometrical parameters were provided.

Performance of these fluted surfaces could be further improved by a factor of five to ten by spiraling the flutes. The spiral flutes remove the condensate film by action of centrifugal forces and thereby enhance condensation. Some examples are the studies by Comb et al. (1978) for R–11, R–21, R–22, R–113, R–114, R–115 and ammonia and by Panchal et al. (1992) for R–114 and ammonia (see Fig. 4.4). Michel and Murphy (1980) recommended the use of drain–off skirts for effective reduction in condenser tube length for the same heat duty. However, they pointed out that heat flux and the condensing fluid strongly influences the length dependency. Furthermore, in contrast to the vertical tube bundles, the performance of horizontal fluted tube bundles was found to be lower than the single tube (typically around 30%) depending on pattern of condensate drainage and number of rows.

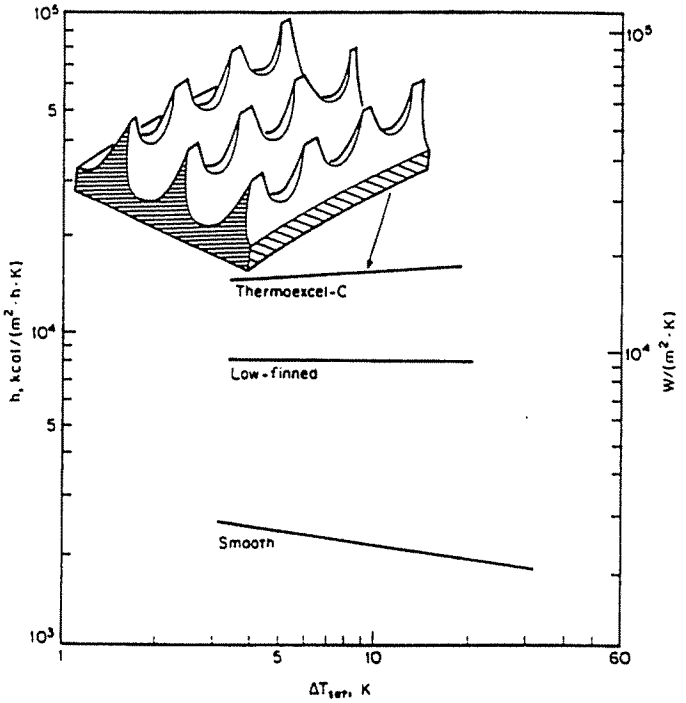


Figure 4.3. Performance of enhanced tubes compared to smooth tube for condensation of R–11 (Nakayama et al., 1975).

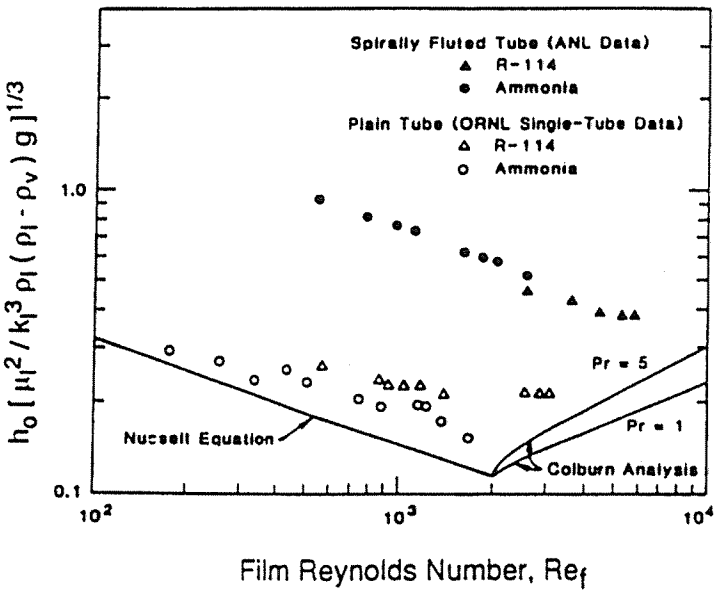


Figure 4.4. Condensation heat transfer coefficient for spirally fluted and smooth tube for condensing R–114 and ammonia (Panchal et al., 1992).

Some other extended surfaces used for shellside condensation enhancement are the helical wire–wrap used by Thomas et al. (1980) for ammonia, vertical wires on smooth tubes used by Rifert et al. (1976) for R–12 and ammonia, and three–dimensional spine–fin array proposed by Webb and Gee (1979) for R–11 and R–12. Generally speaking, these methods allow a two to five fold increase in heat transfer coefficient as compared to smooth tubes. In particular, the analytical predictions based on a Nusselt film model for R–11 and R–12 showed that the spine–fin array will provide the same condensing performance as integral–fin tube (based on equal fin spacing, height, and thickness) but will offer a 60% savings in fin material.

Surface tension devices

Surface tension devices enhances condensation by providing effective condensate removal through the wicking action. This results in a smaller condensate film thickness, leading to a higher heat transfer coefficient. In recent years, these devices have been typically used in heat pipe and aircraft/space cooling applications. Some recent studies dealt with condensation enhancement using packed beds. Plumb et al. (1990) and Sozen and Vafai (1990) reported experimental data and analysis for condensing R–11 and R–12 vapor, respectively, on packed glass beads. Moderate enhancement (typically around 20%) in heat transfer coefficient over that of smooth surface was reported. It was shown that the degree of enhancement depended on the relative size of the beads as compared to the film thickness. For large diameter beads, when the film is actually thinner than the bead diameter, surface tension driven condensate holdup could actually thicken the film and degrade the performance.

Mechanical aids

Mechanical aids (typically rotating surfaces and scrapers) have been widely used in refrigerant applications. These devices augment condensation by destabilizing and

breaking off the condensate film by mechanical means. Nandapurkar and Beatty (1960) reported a 0.45 power dependence of heat transfer coefficient on the rotational speed for R–113 condensing on smooth rotating surface. It is thus apparent that to provide a practical degree of enhancement, the rotational speed has to be quite high. In order to circumvent this difficulty, Maeda et al. (1985) used surface scrapers for R–11 condensing on both vertical and horizontal rotating tubes. With this arrangement, an enhancement in the heat transfer coefficient of around 100–150% over that of stationery tubes without surface scrapers was achieved at low rotational speeds (80–200 rpm) for both vertical and horizontal configurations.

Surface vibrations

Several studies have utilized surface vibration for condensation enhancement. Surface vibration destabilizes the condensate film and removes it, thereby enhancing condensation heat transfer. Nishiyama et al. (1986) imposed a pendulum motion with a frequency of 0.3 Hz and an amplitude of 5 degrees and found a maximum increase in heat duty of around 15% for R–11 condensing on horizontal cylinders. Because of this small degree of enhancement, it is clear that surface vibration enhancement of condensation is not a practical technique.

Electrostatic and magnetic fields

Refrigerants are good dielectrics and this permits the possibility of electrostatic enhancement of condensation. In contrast, application of magnetic fields with or without electric fields has been limited to liquid metal applications so far. Electrostatic body forces result in a thinner and a more agitated film; this is responsible for condensation enhancement. Yabe et al. (1986) investigated electrohydrodynamic (EHD) pseudo–dropwise condensation of R–113 on vertical tubes. Helical wire electrodes were used for destabilizing and removing the droplets. A 350% increase in the heat transfer

coefficient over those without electric field was reported. Similar data and analysis were presented by Trommelmans and Berghmans (1986) for R–11, R–113, and R–114 condensing on a horizontal tube. Some typical results (Poulter and Allen, 1986) showing EHD enhancement are shown in Fig. 4.5.

Injection and suction

Theoretical studies (Lienhard and Dhir, 1972 and Faghri and Chow, 1987) indicate that heat transfer coefficients could be increased several hundred fold by reducing the condensate layer by suction. However, no experimental data for refrigerants attesting to this theory were found.

Compound enhancement techniques

Shekarriz and Plumb (1989) reported that the heat transfer coefficient can be enhanced by a factor of two when 95% porous fins are used instead of plain–finned tubes for condensing R–11 vapor. The porous fin thins the condensate film by surface tension driven flow, thereby enhancing condensation. Optimum fin spacing and fin dimensions were presented. Some other applications of compound enhancement includes attaching a drainage suction pipe, which was used by Hijikata et al. (1987) for enhancing condensation coefficients by two to three fold for R–113.

Tubeside Condensation

This section discusses tubeside or forced convective condensation inside vertical or horizontal tubes. Augmentation techniques applicable for condensation outside vertical tubes are also applicable to condensation inside vertical tubes. However, the enhancement requirements for horizontal intube condensation are different from those of vapor space condensation because gravity forces often drain the condensate transverse to the flow

direction. A review article by Lazarek (1980) describes passive enhancement techniques for intube condensation of refrigerants. In this section, a brief summary describing the heat transfer and pressure drop characteristics for each enhancement technique is discussed and representative results shown.

Rough surfaces

Luu and Bergles (1981) investigated the effect of helical repeated rib roughness on condensation of R–113. The average heat transfer coefficient was increased by about 80% above the smooth tube value. In contrast, the deep spirally fluted tubes (which can be considered as the extreme case of surface roughness) provided an increase of about 50% in heat transfer coefficient over that of smooth tube, based on the same inside diameter. Tojo et al. (1984) investigated the performance of Multi–Grooved Tubes (MGT) for condensing R–22. These MGT's had 48–60 grooves with a groove depth in the range 0.15–0.20 mm. The average inside heat transfer coefficient was about 1.6 times the smooth tube value. The enhancement obtained was attributed to enlarged inner surface area as well as due to turbulence generated by the grooves. The pressure drop associated with these MGT's was reported as slightly larger than that in smooth tubes. Representative results are shown in Fig. 4.6. Other rough surfaces include, "sand–grain" type roughness which was used by Fenner and Ragi (1979) for condensing R–12. The condensation coefficient was increased by 300% for high exit quality by using metallic grains with 50% area density. The accompanying pressure drop was increased by about 105% over the smooth tube value. It appears that sand–grain roughness could provide significant heat transfer enhancement without considerable pressure drop penalty and with the additional promise of significant material savings.

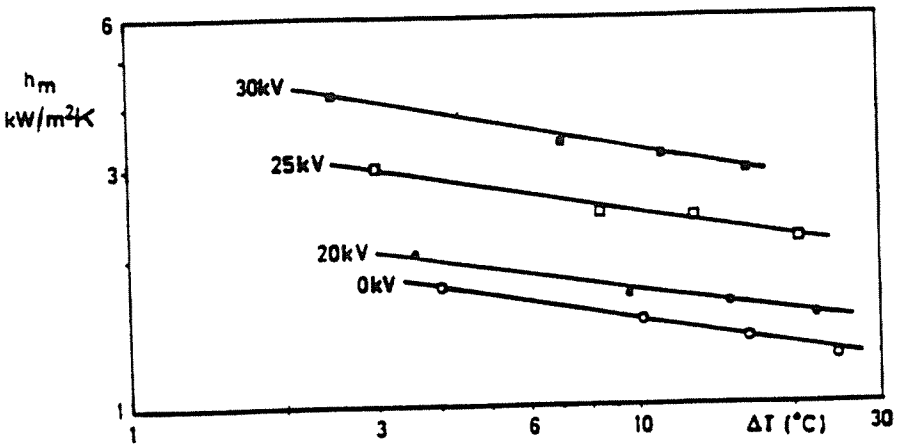


Figure 4.5. Electrohydrodynamic enhancement of R–12 condensing on a smooth tube (Poulter and Allen, 1986).

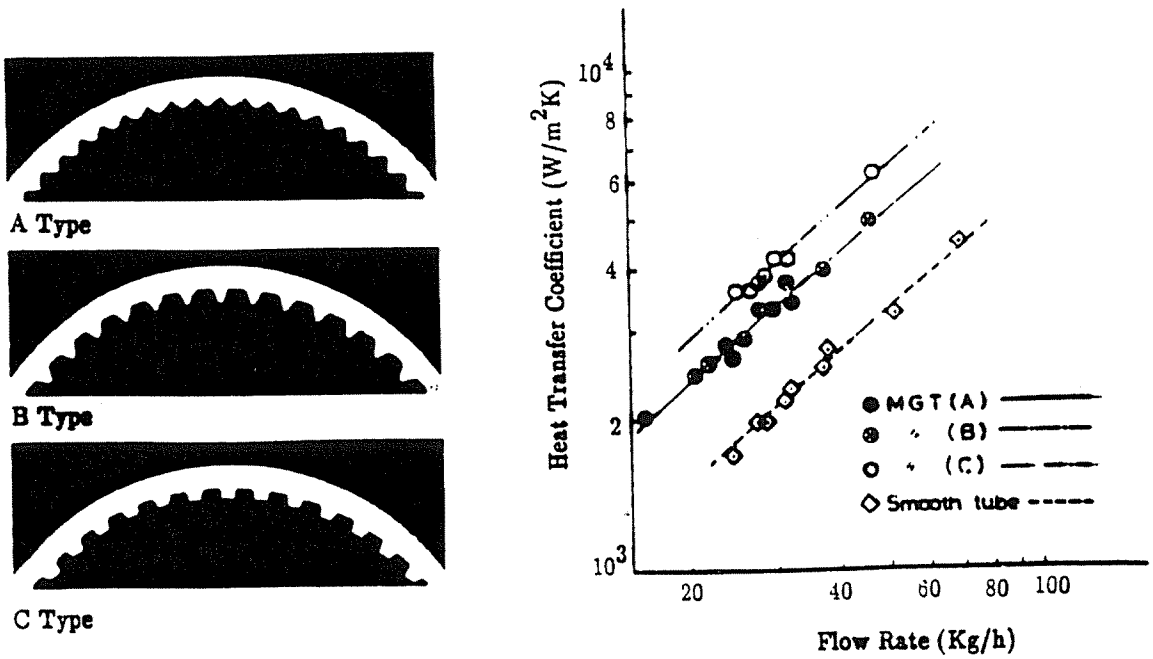


Figure 4.6. Tubeside condensation coefficients of R–22 in multi–grooved tube (Tojo et al., 1984).

Extended surfaces

Extended surfaces, which are typically used for tubeside condensation enhancement, includes conventional internally–finned tubes and micro–finned tubes. The former have fins which are relatively long and few in number (around 6 to 32), and may be straight or spiraled, whereas the latter typically have sixty to seventy fins of small height (0.15–0.3 mm).

Luu and Bergles (1979) investigated condensation of R–113 in three different internally–finned tubes. The best performing finned tube was reported to enhance the heat transfer coefficient by as much as 120% over the smooth tube based on the nominal area, with a marginal increase in pressure drop. A correlation for the heat transfer and the pressure drop that predicted their results to within $\pm$ 30% was formulated by modifying the smooth tube correlation by a geometrical factor. Larger enhancements in heat transfer coefficient (up to 300%, based on the nominal area) and design correlations based on hydraulic diameter for R–12 condensing in internally–finned tubes were reported by Vrable et al. (1974) and Reisbig (1974). Kröger (1976) reported that the heat transfer rate for condensing R–12 is further enhanced by about 200% for internally–finned tubes inclined at 10 degrees to the horizontal. The increased enhancement was attributed to the increased condensate removal due to droplet migration as the tube is inclined.

Said and Azer (1983) studied condensation of R–113 inside horizontal internally–finned tubes with both straight and spiral fins. Over the mass flux range tested, a maximum enhancement in the heat transfer coefficient of 51% over the smooth tube results was reported. Design correlations and performance criteria based on the ratio of the pumping power to the heat transfer rate and subject to the constraints of fixed geometry, same mass flow rate, and same inlet pressure were presented. The results showed that the pressure drop per unit heat transfer rate of the finned tube is around three to four times higher than the smooth tube value.

Kaushik and Azer (1988) used both singly augmented (internally finned or knurled on outside) and doubly augmented tubes (internally finned and knurled on outside) to enhance intube condensation of R–113. Generally speaking, the internally–finned tubes enhanced the inside heat transfer coefficient by 17–51%, whereas the pressure drop increased by about 200% over the smooth tube value. The results suggested that the enhancement ratio increased as the mass flux was raised. Performance criteria for predicting the increase in overall heat transfer conductance by using doubly enhanced tubes were presented. Kaushik and Azer (1988) proposed a generalized correlation to predict the heat transfer coefficient for condensation inside an internally–finned tube. The correlation was generated from a database which is broader than the database of previous correlations (Luu and Bergles 1979, Said and Azer 1983). The correlation predicted the authors' data and the results of other investigators to within $\pm$30%. However, the correlation was tested against the condensation data of R–11 and R–113 only and thus is of unknown applicability for use with other refrigerants.

One of the main disadvantages of the internally–finned tubes is the high pressure drop penalty associated with the heat transfer enhancement. Even though an enhancement in the heat transfer coefficient of 200–300% over the smooth tube value is not uncommon, the pressure drop per unit heat transfer rate of the finned tube is significantly higher than the smooth tube value. To circumvent this difficulty, micro–finned tubes are increasingly being used for enhancing intube condensation.

Khanpara et al. (1986a) tested eight micro–finned tubes with different fin geometries and a smooth tube for condensing R–113. A maximum enhancement in the heat transfer coefficient of up to 283% was reported for tubes having 65 spiraled fins with a flat peak and a flat valley. Although their results were inconclusive, intermediate fin spiral angles of about 20 degrees appeared to be more effective than the smaller or larger spiral angles. The pressure drop increase generally was less than 100%. The heat transfer enhancement was attributed to the increase in surface area, condensate thinning due to

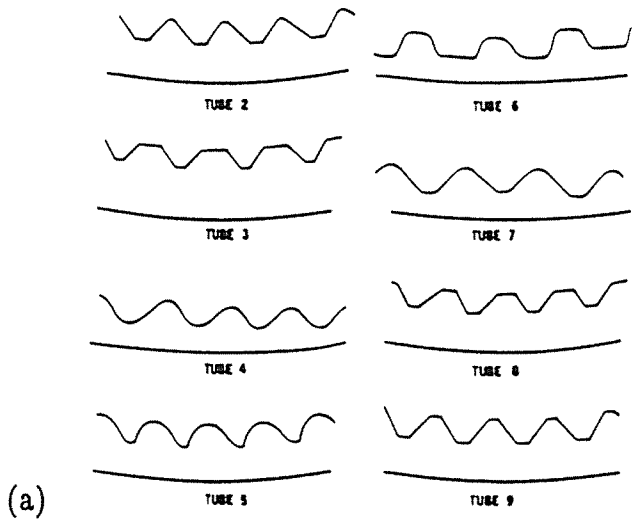
surface tension effects, and film disturbances caused by the protruding fins. Some typical fin profiles and experimental results obtained with micro–finned tubes are shown in Fig. 4.7. Schlager et al. (1989a) reported a results for condensing R–22 inside three different micro–finned tubes and a smooth tube. The enhancement factor (ratio of condensation coefficient with micro–fins to that without) ranged from 1.5 to 2.0 depending upon the mass flux. The pressure drop was found to increase on the order of 20 to 40% over the smooth tube values. Their results showed no significant difference in the performance between 9.52mm and a 12.7 mm micro–finned tube. This indicates that results for a particular micro–finned tube could be reasonably applied to another tube with slightly different geometry.

Eckels and Pate (1991) measured condensation coefficients for smooth and micro–finned tubes with R–134a and R–12. The performance of the micro–fin tube was compared to the smooth tube performance for both the refrigerants. The heat transfer enhancement factor varied from 1.75 to 2.5 for R–134a and from 1.7 to 2.3 for R–12. The pressure drop penalty factor was around 1.3–1.4 for R–12 and about 1.8 for R–134a. Generally speaking, the heat transfer and the pressure drop penalty factor were about the same for both R–12 and R–134a, based on similar mass flux and equivalent cooling capacity.

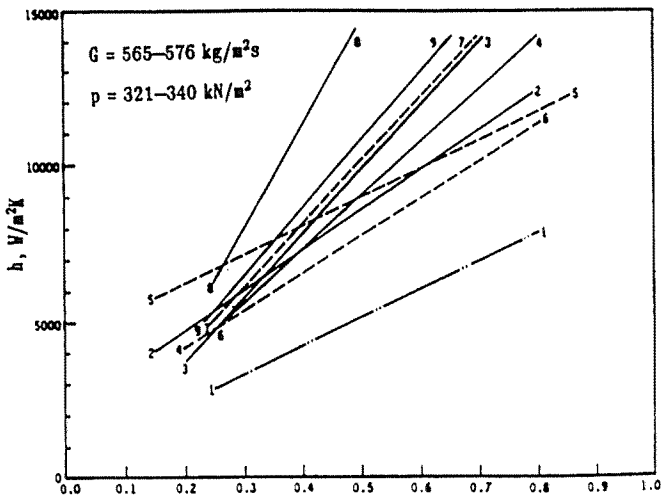
It is clear that significant heat transfer enhancement could be obtained at the expense of modest pressure drop penalty by using micro–fin tubes for intube condensation of refrigerants. Some guidelines are available for selection of optimum geometry; however, these are limited to specific refrigerants (mostly R–113 and R–22) only. In addition, no design correlation for micro–finned tubes is available yet.

Displaced enhancement device

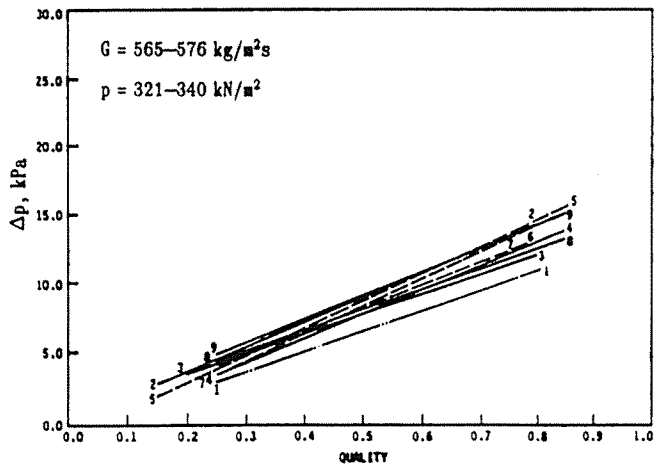
Displaced enhancement devices enhances condensation by promoting bulk mixing of the flow. These devices typically includes static mixer inserts and as well as coiled wire inserts. Azer et al. (1976) reported data for condensing R–113 inside a smooth tube fitted



(a)



(b)



(c)

Figure 4.7. (a) Fin profiles, (b) condensation coefficient, and (c) condensation pressure drop results for R–113 condensing in a micro–fin tube (Khanpara et al., 1986a).

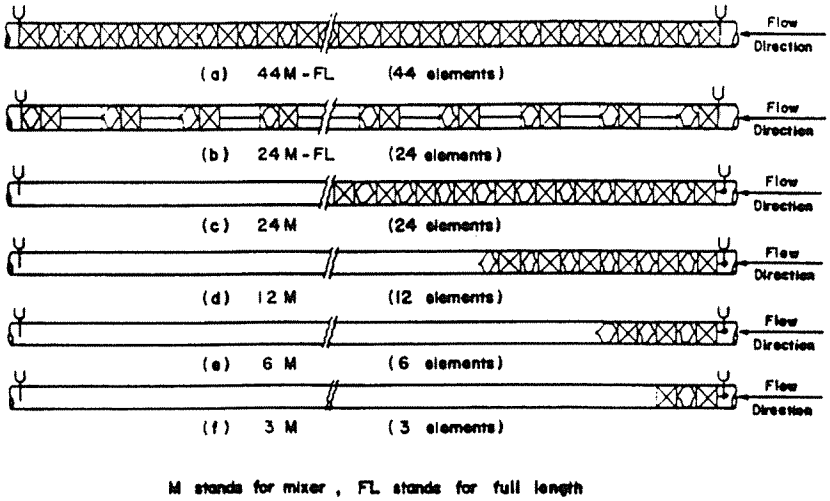
with a in–line static mixer insert. The average heat transfer coefficients were increased; however, the corresponding increase in pressure drop was very large (see Fig. 4.8). Faynzilberg et al. (1979) reported an increase in the maximum heat flux by 5 to 7 times through the use of inserts for condensate recycling. The inserts contained internal channels that recycled the condensate from the heat removal to the heat supply zone thereby enhancing condensation. Design correlations were presented for R–11 and other organic fluids.

Liu et al. (1988) presented flow regimes, pressure drops, and heat transfer data for R–113 condensing inside horizontal tubes fitted with inserts. A 35% to 70% increase in condensing heat duty was reported for tubes with inserts over those of smooth tube values.

Due to modest heat transfer enhancement at the cost of significantly larger pressure drop, it is clear that the use of mixers or any novel inserts to enhance tubeside condensation is rather impractical.

Swirlflow devices

Swirlflow devices, such as twisted tape inserts, have been used with limited success for enhancing intube condensation of refrigerants. These devices provide the necessary turbulence, as well as an extended surface, to enhance heat transfer. The results of Luu and Bergles (1979) and Said and Azer (1983) have shown that a modest increase of around 23–30% in the overall heat transfer coefficients over those of a smooth tube is obtained for condensing R–113. However, the associated pressure drop for the same mass flux and inlet pressure is increased by nearly as much as 250% over the smooth tube value. Correlations for both heat transfer and pressure drop were proposed in these studies. As seen in Fig. 4.9, the internally–finned tubes are much more favorable than the twisted–tapes for intube condensation enhancement.



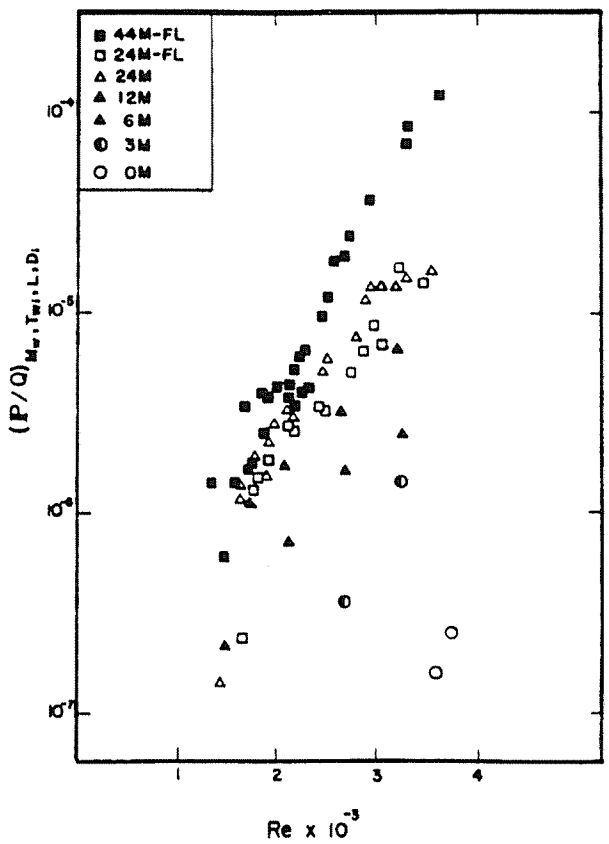


Figure 4.8. Pumping power per unit heat transfer rate for condensation of R–113 inside a tube with in–line static mixer inserts (Azer et al., 1976).

Mechanical aid

Daniels and Williams (1979) investigated the performance of a rotating heat pipe condensing R–113. The rotating heat pipe enhances condensation by providing effective condensate removal through centrifugal action. Their results indicated that the enhancement in the local heat transfer rate of the condenser based on the same wall–to–saturation temperature difference is marginal (around 20–25% by increasing the rotational speed from 600 to 1000 rpm). Due to this low degree of enhancement by pure rotational only, Futagami et al. (1989) proposed the use of a scraper in conjunction with a rotating horizontal condenser. Experimental results and an analytical model based on laminar condensate film were presented for R–113 condensing inside the rotating cylinder. However, no results pertaining to the actual enhancement obtained were presented.

Electrostatic and magnetic fields

Choi (1968) reported significant enhancement in the heat transfer coefficient for condensing R–113 inside a vertical tube by applying a radial dc field. By applying an electric field of 30 kV, a maximum enhancement of around 100% was obtained. Representative results showing the heat transfer enhancement for various field strengths and vapor mass flux is shown in Fig. 4.10. The enhancement was attributed to the appearance of electrohydrodynamic waves on the liquid–vapor interface which reduced the condensate film thickness. In addition, an empirical correlation for predicting the condensation Nusselt number was presented.

The reviews by Poulter and Allen (1986), Yamashita et al. (1991), and Yabe (1991) indicate that no recent studies dealing with EHD enhancement of intube condensation for refrigerant or non–refrigerant applications has been conducted. One of the main reasons is that it difficult to place electrodes suitably inside the tube, whereas for shellside applications, the electrode can be conveniently wrapped around the tubes.

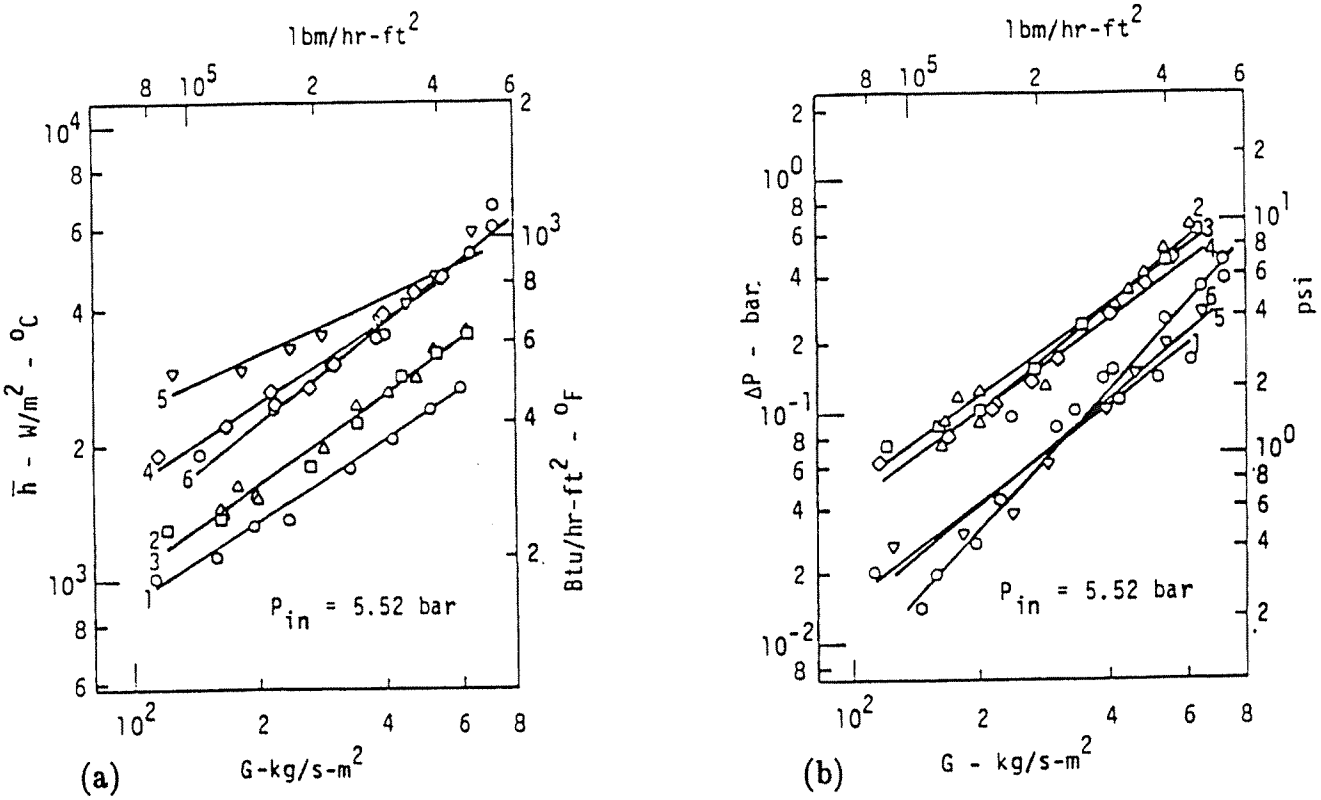


Figure 4.9. Experimental results of (a) overall heat transfer coefficient and (b) overall pressure drop for condensing R–113 inside internally–finned tubes and tubes with twisted–tape inserts (Luu and Bergles, 1979).

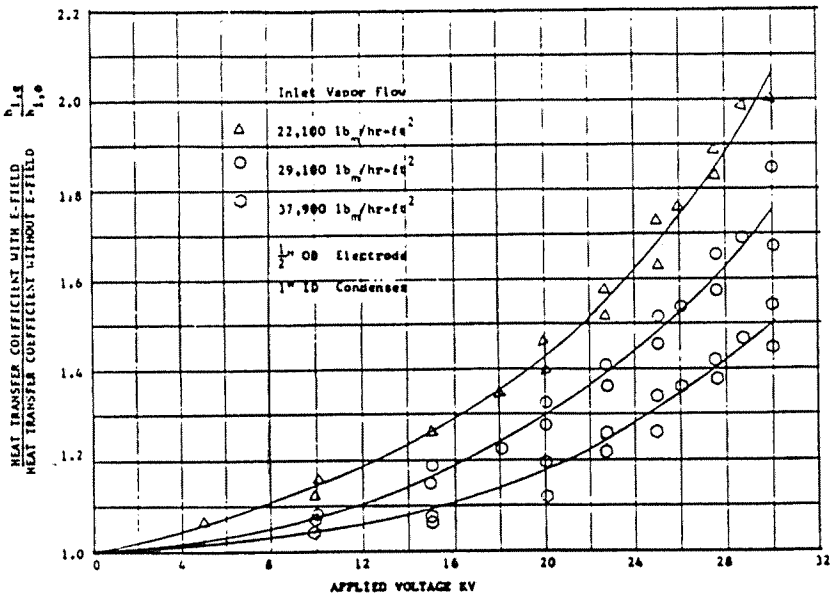


Figure 4.10. Electrohydrodynamic enhancement of average heat transfer coefficient for intube condensation of R–113 (Choi, 1968).

Compound enhancement technique

Vasil'ev et al. (1984) reported that by providing grooves on the inner surface of a rotating condenser, the heat flux for condensing R–113, could be increased by four to six times over that of a smooth condenser, based on the same temperature difference. Some other applications of compound enhancement includes a coiled fluted tube used by Anand et al. (1988) for condensing ammonia.

5. ENHANCED POOL BOILING HEAT TRANSFER

The largest number of papers on enhanced heat transfer in refrigerants are those dealing with enhanced pool boiling. A wide variety of enhancement techniques – both active and passive – have been studied with many different pure refrigerants. Several literature reviews have been presented, although not all address refrigerants exclusively. Westwater (1973) discusses the use of extended surfaces with boiling liquids. Webb (1984) discusses porous surfaces, and Vasil'ev et al. (1978) and Pais and Webb (1991) review structured and porous surfaces. Webb (1981), Nishikawa (1983), and Thome (1992) review boiling surfaces in general. For some of the enhancement technques very few citations were found; for others (e.g., extended surfaces and treated surfaces) numerous references are available. Below are given representative examples of the research performed with the different techniques.

Treated Surfaces

The largest number of investigations on enhanced pool boiling have focused on modifications to the surface by cold working the surface to create subsurface channels with small cavities or pores connecting these channels to the surface, by sintering a thin porous layer of metal to the surface, or by other treatments which enhance the nucleate pool boiling mechanism by creating more cavities or reentrant cavities on the surface. Pais and Webb (1991) list 61 references on finned, structured, and porous coated tubes used in pool boiling.

The three most commonly discussed structured surfaces in the literature are the Hitachi Thermoexcel surfaces, the Wieland Gewa surfaces, and the Wolverine Turbo–B surface. As shown in Fig. 5.1, the Thermoexcel surface has numerous small pores connected by subsurface tunnels. Numerous studies (e.g., Fujii et al., 1975; Torii et al., 1978; Nakayama et al., 1975,1978,1979,1980, 1982) found that at the same wall

superheat the heat transfer coefficient could be enhanced by a factor of about ten compared to a smooth surface (Fig. 5.2). The diameter and population density of the pores were determined to be the most important geometric parameters; an optimum value of the pore diameter exists that depends on pressure level and wall superheat or heat flux. A visualization of the boiling process (Nakayama et al., 1980) suggested that the governing heat transfer mechanism was a cyclic process consisting of liquid being sucked into the tunnels, thin film evaporation of the liquid on the channel walls, and the evaporation driving the formation of bubbles at the pores. The CHF also is enhanced relative to a smooth surface but CHF occurs at a lower wall superheat; the authors speculated that because the vapor bubbles were ejected from the pores, it may be difficult for a stable vapor blanket to cover the surface, thus enhancing the CHF. Kuwahara et al. (1990) tested R–11 in a falling film over a pore and tunnel tube. They found that at low wall superheats the thin film evaporation had higher heat transfer coefficients than pool boiling but that at higher heat fluxes the enhancement was less. Hysteresis was completely eliminated with the film flow evaporation, and the CHF was higher than that of a smooth surface.

Attempts have been made to analytically model the heat transfer process in this surface (Nakayama et al., 1979, 1980; Webb and Haider, 1992). Nakayama et al. (1980) developed a mechanistically–based model which incorporates a bubble waiting period and a bubble growth period; both latent heat flux and convective heat flux are taken into account. Eight empirical constants are needed in the model. Reasonable agreement was obtained between the experimental and predicted heat flux. Webb and Haider (1992) suggest there are several weaknesses in the Nakayama model. Hence, they developed an alternative model which eliminates these weaknesses and which uses no empirical constants other than for bubble departure diameter. The slope of the predicted boiling curve was greater than that of the experimental data, but the predictions were reasonable at lower

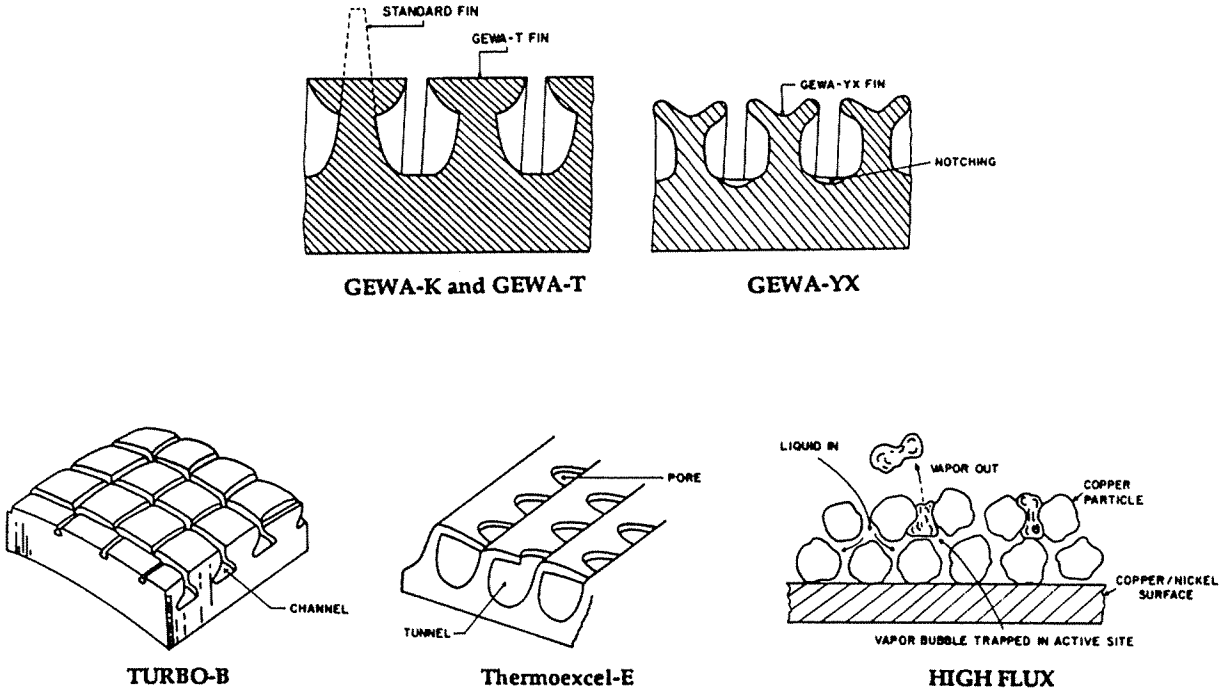


Figure 5.1. Enhanced boiling surfaces (Memory and Marto, 1992)

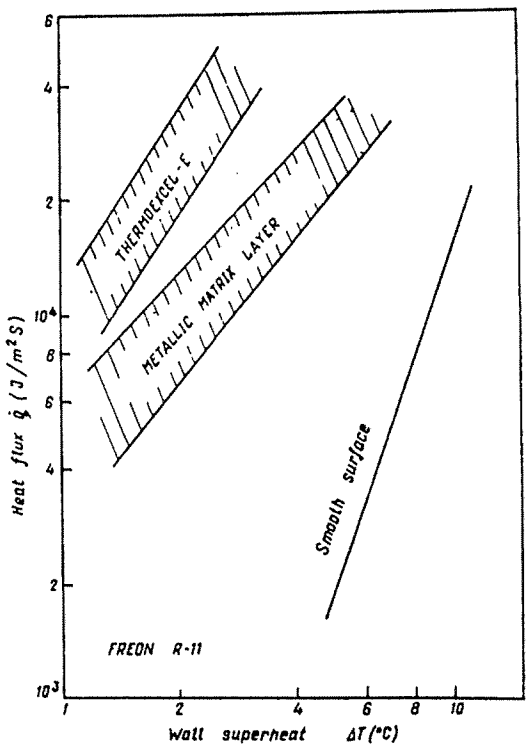


Figure 5.2. Boiling curve for Thermoexcel–E surface (Nakayama et al., 1975).

heat fluxes; higher heat flux data were overpredicted, which indicates that perhaps another mechanism (such as partial dryout) influences the process at higher heat fluxes.

The Gewa–T surface differs from the Thermoexcel surface in that the Gewa–T tube has a continuous opening around the circumference of the tube with a larger subsurface channel. Marto and Lepere (1982), Stephan and Mitrovic (1981), and Marto and Hernandez (1983) obtained heat transfer coefficients which ranged from about 1.7 to 2.8 times those of a smooth surface. The liquid–vapor flow in the subsurface channels is credited with the improved heat transfer performance. Marto et al. (1985) demonstrated that the fin–tip gap affected the heat transfer. Ratios of the Gewa–T heat transfer coefficient to that of a smooth tube ranged as high as nine at low wall superheats and, for all six tubes tested, the enhancement ratios approached about 3.5 at higher heat fluxes. The performance could be further increased if small wires were wrapped around the tube in the inter–fin channels; a 140% increase in the heat transfer coefficient was obtained at 10 kW/m^2 when three wires were used. Ayub and Bergles (1985, 1987, 1990) obtained results which indicated that the enhancement of the Gewa–T surface was a well behaved function of the gap width. (See Figs. 5.3 and 5.4.) However, the optimum value of the gap was different for R–113 and water, and the R–113 enhancement was greater than that of water. They also noted that boiling curve hysteresis, which can be quite large for refrigerants, was small compared to a smooth surface and smaller than that obtained with other enhanced surfaces.

The Turbo–B tube is similar to the Gewa–T except that the Turbo–B tube has longitudinal gaps in addition to the circumferential gaps. Memory et al. (1992) tested a bundle of Turbo–B tubes in R–113 and found that compared to a smooth tube bundle, the Turbo–B bundle had an average heat transfer coefficient about 4.6 times larger at low heat fluxes and about 3.6 times larger at high heat fluxes. These values were, respectively, 60% and 22% greater than that of a single Turbo–B tube in pool boiling; the enhancement was

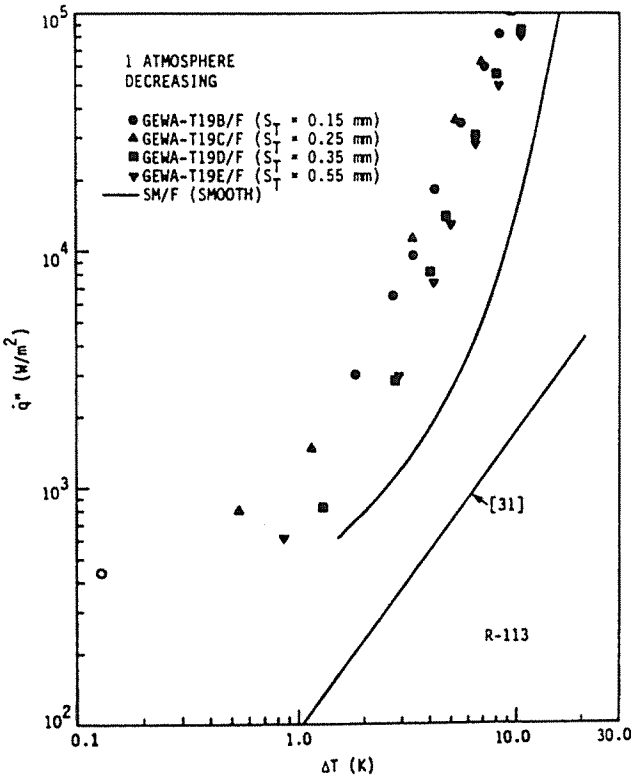


Figure 5.3. Composite plot of data from different gap width GEWA–T and smooth tube for R–113. (Ayub and Bergles, 1985)

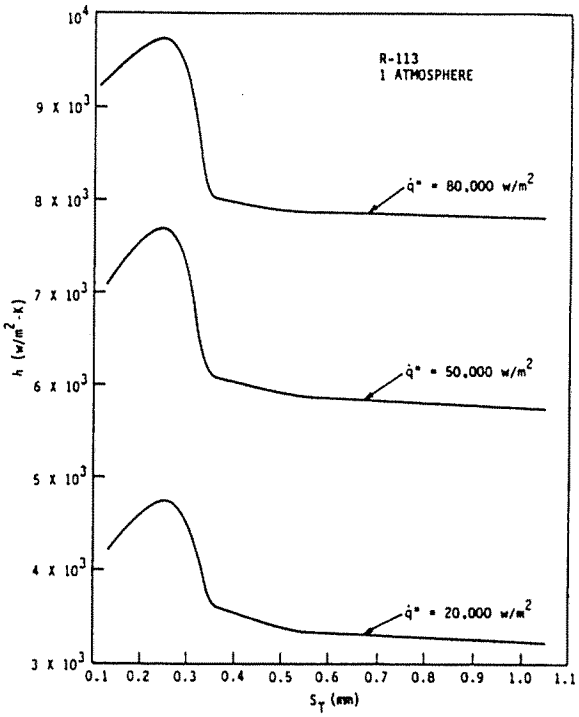


Figure 5.4. Heat transfer coefficient versus gap width. (Ayub and Bergles, 1985)

attributed to the "bundle effect" caused by convection in the bundle. Single tube results are shown on Fig. 5.5.

Porous surfaces are typically made by sintering a metallic powder to the surface of the base material. The powder will have a distribution of sizes and when the binder holding together the powder layer is removed during the sintering process, numerous cavities and inter–connected channels and pores are left on the surface. The Linde High Flux surface is the most common example of this technique. O'Neill et al. (1972), Czikk and O'Neill (1979), and Czikk et al. (1981) describe the results of tests with a thin layer (0.010 to 0.020 in. thick) with a void fraction in the range of 50 to 65%. At a given heat flux the High Flux surface had a heat transfer coefficient in the range of 10 to 20 times that of a smooth surface. Because of the geometry, numerous stably reentrant cavities are present on the surface and these cavities reduce the superheat required to form bubbles; vaporization within the porous layer is a major contributor to the heat transfer process. Capillary forces ensure a flow of liquid through the porous layer. A correlation was developed that used the characteristic pore diameter, a geometric factor related to the type of packing, and fluid properties. Danilova and co–workers (Danilova et al., 1976, 1990, 1991; Dyundin et al., 1981; Bukin et al., 1982; Danilova and Tikhonov, 1984) obtained results similar to O'Neill and co–workers. They noted that results from single tubes or from tube bundles were the same, thus implying that flow velocity or vapor flow past the surface had no effect on the tube's performance.

Kajikawa et al. (1980, 1983) boiled a variety of refrigerants on porous surfaces composed of sintered metal fibers and obtained a tenfold increase in the boiling performance relative to a smooth surface. Using R–11 on 26 surfaces, they developed a correlation that related the boiling heat transfer performance to the number of layers of the fibers and the cavity geometry; working fluid properties were not used in this correlation. Nishikawa et al. (1985) also tested sintered powders and metal fibers with similar results.

Fricke and Czikk (1979) used a porous surface in a sprayed bundle evaporator. The heat transfer performance was five times that of a sprayed smooth tube evaporator and the porous surface was unaffected by liquid loading or vapor crossflow (Fig. 5.6). Jung and Venart (1986), Venart et al. (1986), and Jung et al. (1987) studied the effect of porous surface orientation (horizontally facing up (0^O), down (180^O), or in between) and found that up to 165^O, wall superheats decreased slightly at lower heat fluxes; at higher heat fluxes the superheat remained constant. Coefficients were enhanced two to three times that of a smooth surface. Between 165^O and 180^O film boiling occurred easily and the heat transfer from the porous surface may be better than that of the smooth surface.

Both hysteresis and the CHF condition also may be favorably affected by the porous surface. Czikk et al. (1981) state that the CHF may be increased between 0 and 70% compared to a smooth tube. Zhang and Zhao (1992) measured CHF values on porous tubes that were 1.5 to 2 times that on a smooth surface. Thickness of the porous layer had little effect. A correlation is presented. Afgan et al. (1985) found CHF to occur at values two to three times that of a smooth surface. At high heat fluxes they noted that a vapor film formed at the base of the porous layer and the mechanism governing the boiling changed. While ONeill and co–workers obtained acceptable hystereses effects, Bergles and Chyu (1981, 1982) obtained poorer incipient boiling and temperature overshoot characteristics. For R–113, they had a reduction in wall superheat from 8 C to 0.5 C when explosive formation of vapor occurred upon initiation of boiling. The overshoot did not depend on liquid subcooling. The authors speculate on the mechanism governing this hysteresis problem. The fully developed boiling curves agreed with those of Nishikawa et al. (1982, 1985). Afgan et al. (1985) observed hystereses in thick porous layers. Tekhver (1990) examined the hysteresis phenomenon on porous coatings and also speculated on the mechanism.

A number of models have been proposed for the prediction of the boiling process on porous surfaces. The first was that of O'Neill et al. (1972) who assumed a static model of

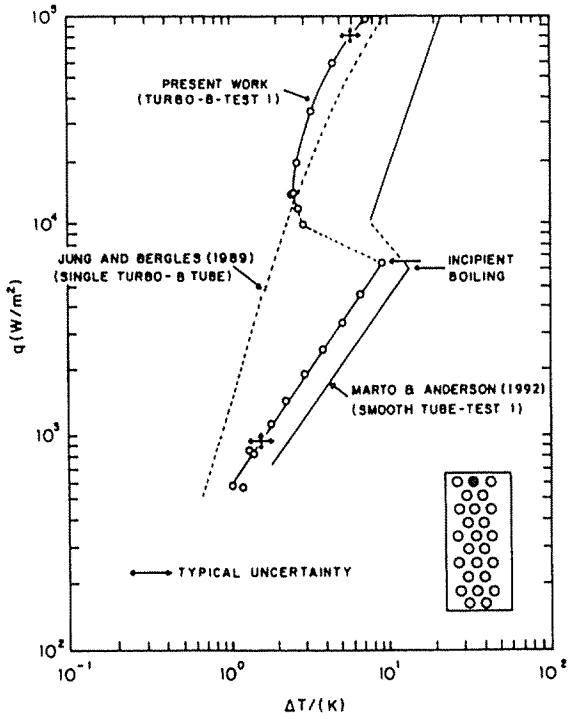


Figure 5.5. Boiling heat transfer in R–113 on a Turbo–B tube (Memory et al., 1992).

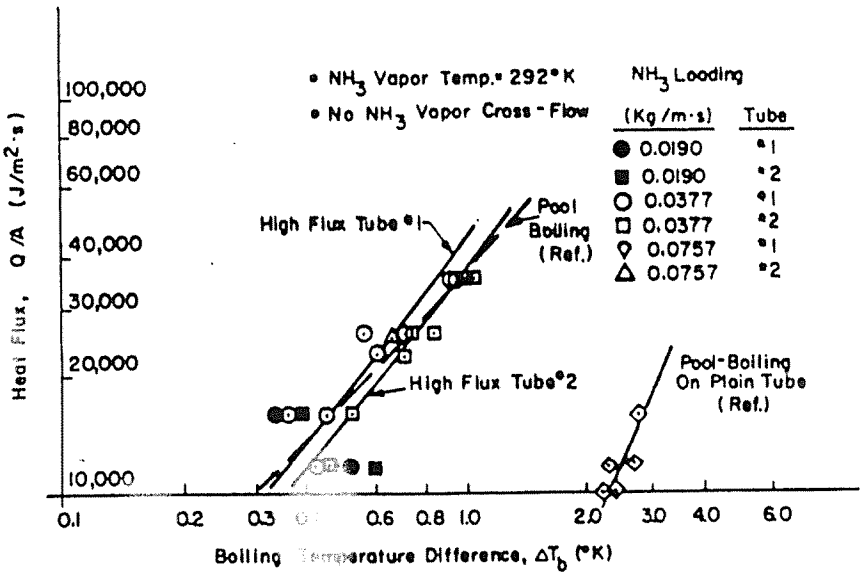


Figure 5.6. Thin Film NH_3 evaporation performance with porous surface (Fricke and Czikk, 1979).

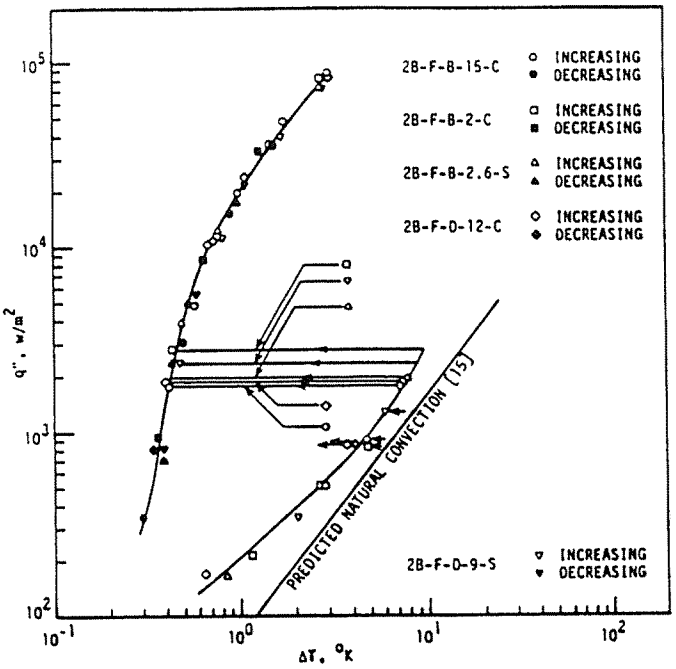


Figure 5.7. Boiling heat transfer in R–113 on porous surface (Bergles and Chyu, 1982).

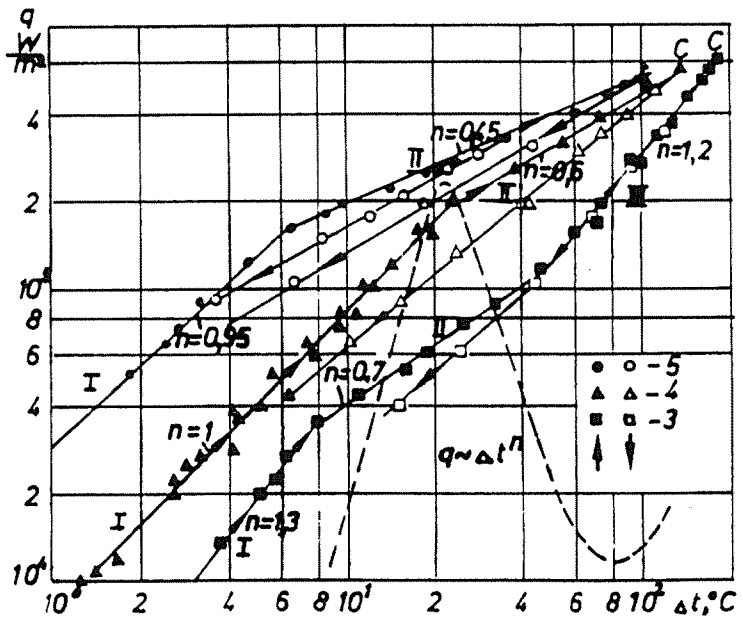


Figure 5.8. The boiling of Freon–113 for samples 2, 3 and 6. The dashed curve is for a smooth surface; solid symbols are values for an increase in q; open symbols are values for a decrease in q; C is the boiling crisis point. (Afgan et al., 1985).

vapor surrounded by a thin liquid film, and vaporization takes place in a regular array of stacked metal spheres. Webb (1983) discusses this model in detail and presents arguments which question its physical basis; in particular, Webb states that any analytic model of boiling on a porous surface must be a dynamic model and not a static model. Ito et al. (1990) propose a static model that requires several empirical constants also. Agreement was reasonable between the model and a variety of data sets covering several fluids and surface porosities. Rosenfeld (1989) presents an analytic model for thick porous surfaces and a numerical model for thin porous layers. He demonstrated that both conduction in the porous layer and simultaneous nucleate boiling should be taken into account in any model. If plain tube data are available, the closed form analytic model can be used to quickly estimate porous boiling performance.

Polezhaev and Kovalev (1990) numerically analyzed the heat transfer and fluid flow in a porous surface. They assumed that vaporization occurred inside the porous layer on the surfaces of stationary menisci and the vapor left through mouths of large pores. Liquid is introduced into the porous surface by capillary forces and flows countercurrent to the vapor. The primary information needed is the porous surface geometric parameters (e.g., porosity, pore size distribution, a constant in the Darcy equation, etc.) and a procedure for calculating the hydrodynamics of countercurrent vapor–liquid flow in a porous surface; a reference is given for this latter procedure. Agreement between the model and experimental data is fair. Another paper uses dimensionless analysis to model nucleate boiling on porous surfaces (Navruzov, 1986). Malyshenko (1991) presents a discussion of all modes of boiling heat transfer on porous surfaces and suggests that the performance of a porous surface can be optimized through the use of only three characteristic parameters of the porous surface and experimental data on the hydraulic resistance of the surface. Bubble departure frequency from a porous surface is discussed by Qi et al. (1990); this type of information would be useful in the development of a dynamic model of boiling.

Several comparisons of the performance of different structured and porous surfaces have been made. Marto and Lepere (1982) tested the High Flux, Thermoexcel–E, and Gewa–T surfaces in R–113 and FC–72. Enhancement ratios of two to ten were obtained with the R–113 but ratios of only two to five with the FC–72. The High Flux surface performed best over the range of heat fluxes; however, the authors noted that the relative performance of each surface might change if the surfaces were optimized for the particular fluid. In FC–72, the CHF for the High Flux and Thermoexcel–E tubes was about that of the smooth surface, but the CHF could not be obtained with the Gewa–T surface. McManus et al. (1986) compared the High Flux and Turbo–B surfaces and obtained enhancements as high as 14.6 and 6.4, respectively. Wanniarachchi et al. (1987) also measured better performance for the High Flux tube relative to the Thermoexcel–E and HE tubes and the Gewa–T tube at higher heat fluxes. The Thermoexcel tubes performed better at low heat fluxes, while the Gewa–T showed the smallest degradation in performance in the presence of oil. The Turbo–B tube performed better than the Gewa–T tube in tests run by Jung and Bergles (1989) in R–113. The authors cautioned that the relative performance could be different if the surfaces were optimized for the liquid. Webb and Pais (1991) boiled R–123, R–134a, R–11, R–12, and R–22 on a standard integral fin, the Turbo–B, and the Gewa–SE tubes and concluded that no one tube geometry works best with all refrigerents. (See Fig. 5.9.) Both structured surfaces performed much better than the integral finned surface.

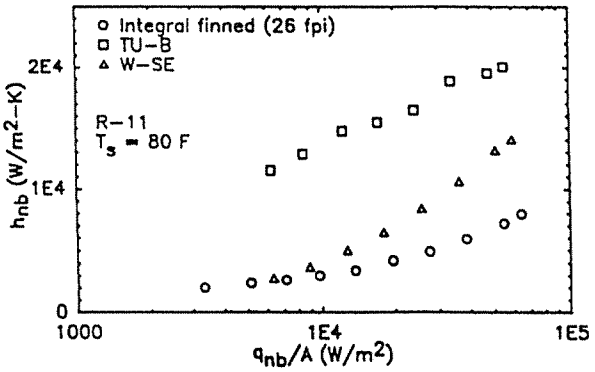
A variety of other surface treatments have been tested to determine their ability to enhance pool boiling. Porous metal meshes or wire screens applied to the surface of tubes will affect both the heat transfer coefficient and critical heat flux (e.g., Saaski and Franklin, 1977; Asakavicius et al., 1979; Rannenberg and Beer, 1980; Xin et al., 1984; Yamaguchi and James, 1988). The number of layers of mesh tended not to affect the heat transfer coefficient but did tend to decrease the CHF. Decreasing mesh size increased the heat transfer coefficient. However, there were contradictions in the literature; for example,

Yamaguchi and James (1988) found no improvement in the heat transfer coefficient with boiling R–113. Application of poorly wetting meshes such as PTFE also has been shown to improve the boiling of refrigerants (Leiner and Losing, 1986; Antonenko, 1988), though no explanation was offered as to why. The use of a composite surface has been shown to enhance nucleate boiling by a factor of six at low wall superheats and up to three at high wall superheats. Yang et al. (1991, 1992) prepared a graphite fiber reinforced copper composite and from boiling R–113 on it concluded that each fiber acts as a fin. Because of the improved heat conduction, transient conduction accelerated the bubble growth and departure cycle; the higher bubble frequency enhanced the heat transfer. Photomicrographs of the surface also revealed numerous microsized grooves and scratches on the surface that probably acted as nucleation sites.

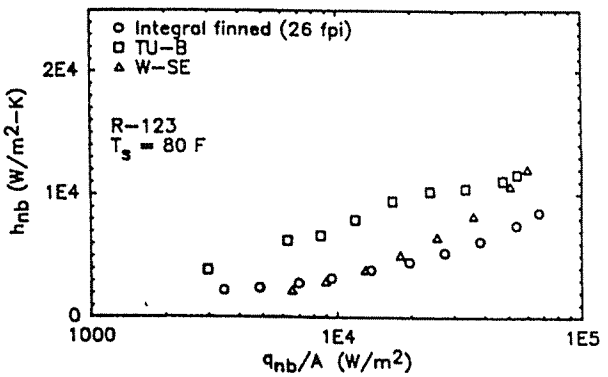
A number of studies have used precise arrays of numerous small pits or cavities on surfaces to examine nucleate boiling (Messina and Park, 1980, 1981; Bahhuth and Genetti, 1983; Kozawa et al., 1986; Danilova and Reznikov, 1987; Miller et al., 1990; Wright and Gebhart, 1992). The well–defined geometry can be used to examine the fundamental boiling processes on a surface since the surface geometry is accurately known. Messina and Park (1980, 1981) photoetched cavities with densities of up to 2742 pits/cm^2 on boiling surfaces and obtained improvements in the heat transfer in the order of three to four times that of a smooth surface (Fig. 5.10). Miller et al. (1990) photoetched hexagonal dimples and also obtained about a factor of three enhancement. In addition, the surface had superior incipient boiling and temperature overshoot characteristics. Wright and Gebhart (1992) propose a model for the enhancement process.

Rough Surfaces

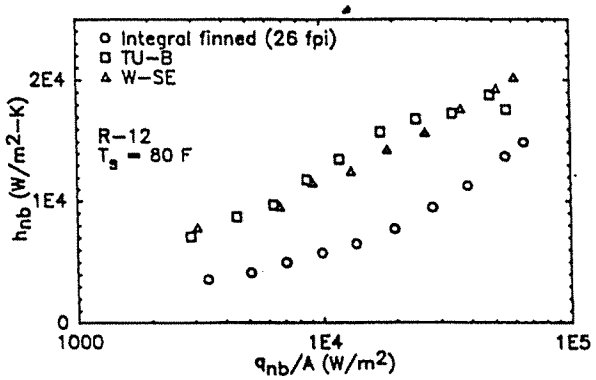
The surface finish of metals can vary from a mirror finish to a relatively coarse, rough surface. The roughness typically is small so that no additional surface area can be claimed (as with fins) but the heat transfer behavior in pool boiling can be affected



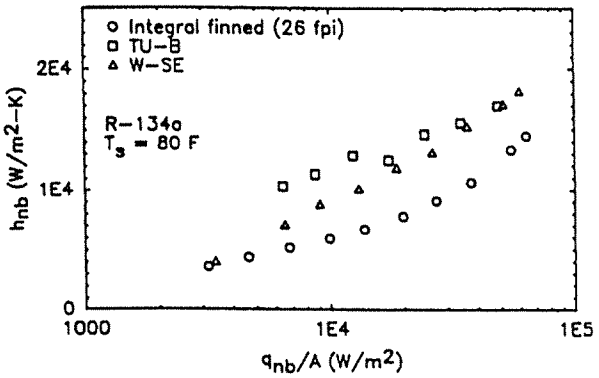
Comparison of boiling performance of the three tubes in R-11



Comparison of boiling performance of the three tubes in R-123



Comparison of boiling performance of the three tubes in R-12



Comparison of boiling performance of the three tubes in R-134a

Figure 5.9. Comparison of the boiling performance of an integral fin, the Gewa–SE, and the Turbo–B tubes (Webb and Pais, 1991).

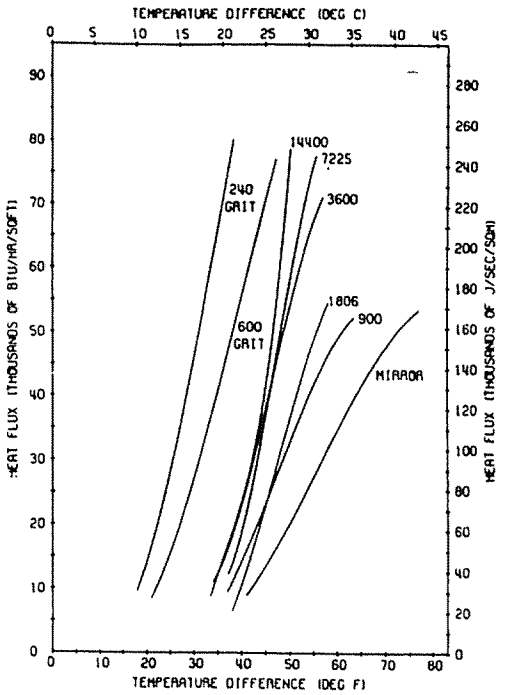


Figure 5.10. Effect of pit density on the nucleate boiling curve (densities in pits/in.^{2}) (Messina and Park, 1981).

significantly. The modification of the nucleation characteristics usually are attributed to changed surface cavity size, frequency and distribution; other pool boiling regimes are affected to some extent also.

Pinto et al. (1992) tested R–22 over a range of pressures and surface roughnesses and found that hysteresis can vary significantly. While they offer qualitative explanations, they could not quantify the results. They also have demonstrated that hysteresis can be eliminated by etching a surface such that the mean roughness does not change much; however, the heat transfer coefficient decreased by a factor of three.

More emphasis has been placed on determining the effect of surface roughness on fully developed nucleate boiling. Sauer and Medrow (1975) boiled R–11 on Inconel–600 whose surface finished varied from a mirror finish to a sand–paper roughened surface. No measurements of the roughness height were made. The heat transfer coefficients changed by about 20% over the roughness range. Bier et al. (1979) used R–11 and R–115 over a very wide range of pressures for five different surface roughnesses; they provided detailed descriptions and roughness measurements for the surfaces. The heat transfer coefficient's pressure dependence was the same for each roughness but the coefficient's magnitude increased with increasing roughness (Fig. 5.11). The heat transfer coefficient could not be correlated with roughness height. It was assumed that roughness height was not a good parameter to indicate which cavities on the surface will form active nucleation centers. Nishikawa et al. (1982) also studied a wide range of surface roughnesses for boiling R–11, R–21, R–113, and R–114 up to near the critical point. Results similar to Bier et al. were obtained. The effect of roughness decreased with increasing pressure, and a possible explanation related to heterogeneous nucleation theory was given. A simple correlation which takes into account both roughness and pressure was presented.

Ramilison et al. (1992) investigated the effect of receding contact angle and roughness on the critical heat flux. Contact angle had more of an effect than roughness and while the effects were relatively small (the CHF ranged up to 30–40% higher than that

predicted by the Zuber correlation depending on the combination of parameters), the authors concluded that these surface characteristics cannot be neglected. A correlation was presented that successfully predicted the data.

Roughness also affects film boiling behavior. Knoebel and Yeh (1977) obtained heat transfer coefficients in the film boiling region for R–11 that were up to 3.3 times that of a smooth surface. Different types of roughness elements (grooves, pins, and tetrahedral pyramids) resulted in different enhancement. Surface tension effects were credited with the differences. Shoji et al. (1988, 1990), for subcooled film boiling of R–113, found that increased roughness increases the heat flux near the minimum heat flux where liquid–solid contact is possible.

Extended Surfaces

Extended surfaces or fins are a commonly used enhancement technique for use with pool boiling of refrigerants. Early use was motivated by the additional surface area added when fins were incorporated onto smooth tubes; later investigations indicated that the heat transfer mechanisms could be modified through judicious choice of geometric parameters.

Circumferential fins have been studied extensively. Hesse (1973) studied the complete boiling curve of R–12, R–113, and R–114 on a low fin tube. For the one fin spacing, better heat transfer relative to a smooth tube was obtained at lower pressures. This was attributed to the size of departing bubbles in the interfin space; before a bubble departs one surface, if it touches the adjoining fin's surface it will disrupt the boundary layer on that fin thus improving heat transfer. The smooth and finned tubes had approximately the same CHF. The increased area evidently had little influence on the process and the vapor flow disrupted the flow of liquid into the interfin spaces. From the data of boiling water and R–113 from a series of fins, Rubin et al. (1979) developed an expression for a critical gap width between fins that depended only on a dimensionless fin height. Depending on the critical gap width, the heat transfer from a finned surface could

be improved or degraded; there was an optimum gap width. Gogonin and Silkachev (1991) obtained similar results and also concluded that the CHF depended on a critical gap width. The CHF for the finned surface ranged from 40% to 125% greater than that of a smooth tube depending on the gap width.

Carnavos (1981) studied a wide range of externally finned tubes in pool boiling of R–11. However, the inside surfaces were also enhanced, and he only reported overall boiling performance. The combination of internal and external enhancement resulted in performance improvement (relative to a smooth tube) ranging from 159 to 715% (Figs. 5.11 and 5.12). The external pool boiling coefficients were not explicitly given nor was any physical explanation of the process given. Webb et al. (1989) Webb and Apparao (1990) present the results of a computer simulation of a R–11 flooded refrigerant chiller that evaluates the use of doubly enhanced tubes, such as described by Carnavos. Chen et al. (1988) do propose a physical model and a correlation based on that model to describe boiling on low finned tubes, but the model contains several empirical constants that vary depending on the fin geometry. Little guidance is given as to how to evaluate these constants.

Circumferentially finned tubes have been tested in tube bundles by Hahne, Müller and co–workers (e.g., Müller and Hahne, 1981; Hahne and Müller, 1983; Windisch et al., 1985; Müller, 1986). At lower heat fluxes, the heat transfer coefficients for the tubes in the top row of the six–row bundle were up to 100% higher than those in the bottom row. At higher heat fluxes, the boiling curves of each tube in the bundle converged to a single curve representative of fully developed nucleate pool boiling (Fig. 5.13). Both nucleation and convection govern the heat transfer behavior in the bundle. At lower heat fluxes, convective effects had a very strong influence on the results and nucleation played only a small role; at higher heat fluxes, nucleation dominated. Hahne et al. (1991) compared the results of a single finned tube with those from two finned tubes, one above the other. The lower tube's performance was similar to that for a single tube while the upper tube's

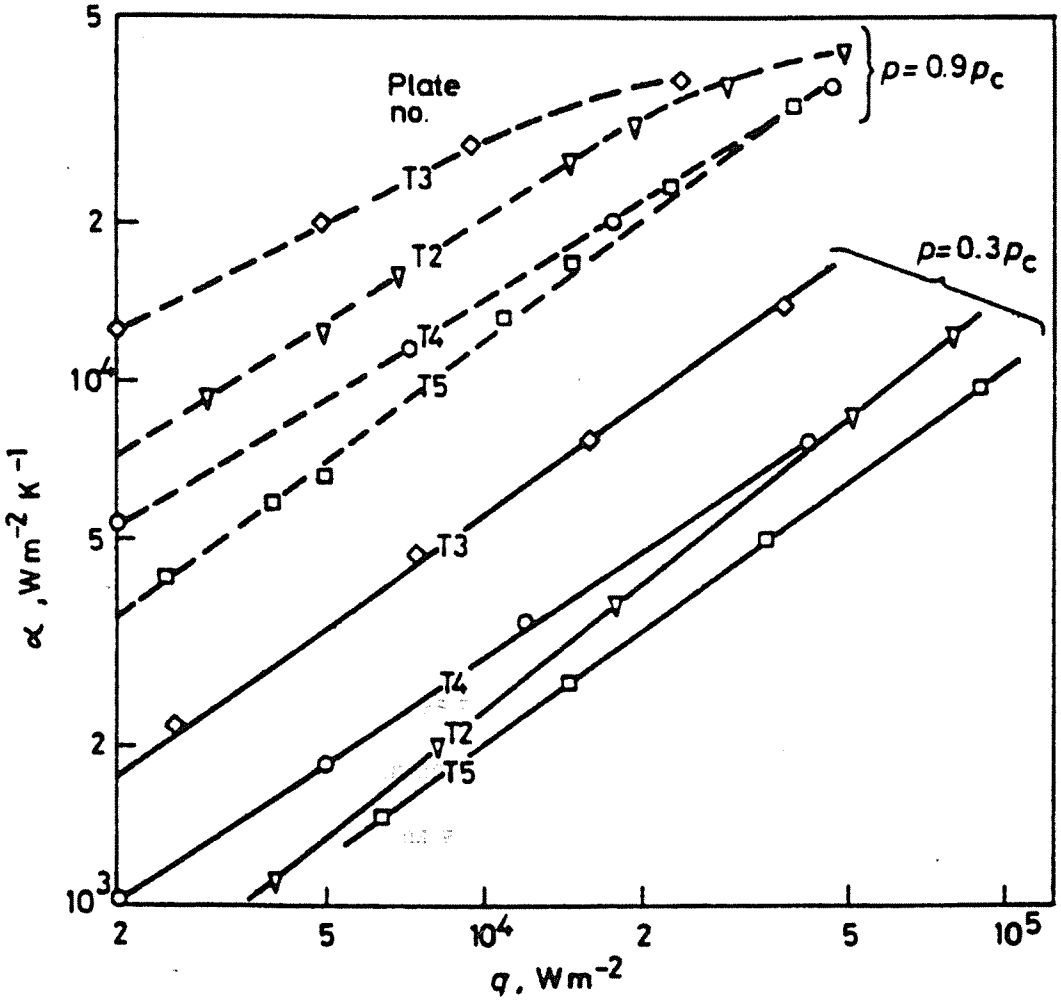


Figure 5.11. Comparison of the heat transfer measurements with R–115 for four of the investigated plates at two different saturation pressures. $p_c = 31.26 \times 10^5 Nm^{-2}$. For T2,T3,T4, and T5, the roughness varied from 1.1, 1.4, 0.5, and 0.1 μm, respectively. (Bier et al., 1979).

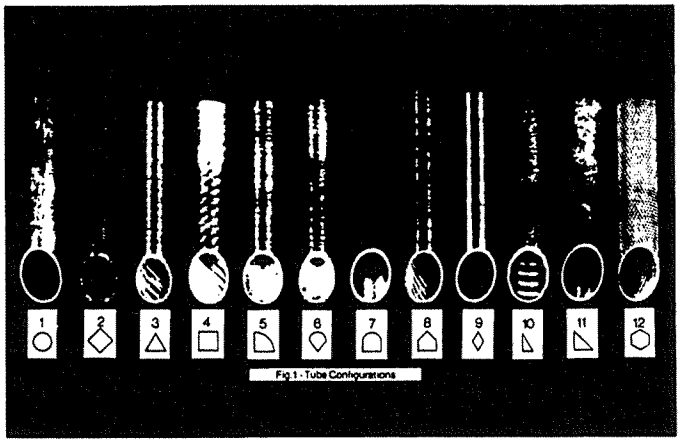


TABLE I — Tube Characteristics

Tube Number	1	2	3	4	5	6	7	8	9	10	11	12
Plotting Symbol	○	◇	△	□	◺	◇	⌂	⌂	◇	◺	◺	○
Nominal Tube O D * cm	1 90	1 79	1 88	1 90	1 90	1 89	1 84	1 81	1 82	1 89	1 88	1 95
Nominal Heat Transfer Area cm	776	731	768	776	776	772	751	739	743	772	768	796
Fin Count** Fins/cm			10 6	16 5	16 1	10 6						7 87
Fin Height** mm			1 30	813	914	1 32						508
Fin Thickness** mm			356	279	254	356						
Nominal Tube I D * cm	1 67	1 44	1 44	1 54	1 57	1 43	1 54	1 54	1 56	1 61	1 70	1 75
Nominal Flow Area cm	2 24	1 63	1 63	1 86	1 94	1 60	1 86	1 86	1 91	2 04	2 27	2 41
Number of Fins			10	10				20		1		38
Fin Height** mm			38	38				25		38		61
Helix Angle*** degrees			49	51				35		76		270

* Nominal Diameter: O D - over augmentation
I D - of tube wall

** Fin or Knurl or Ridge

*** Angle measured from tube axis to fin axis

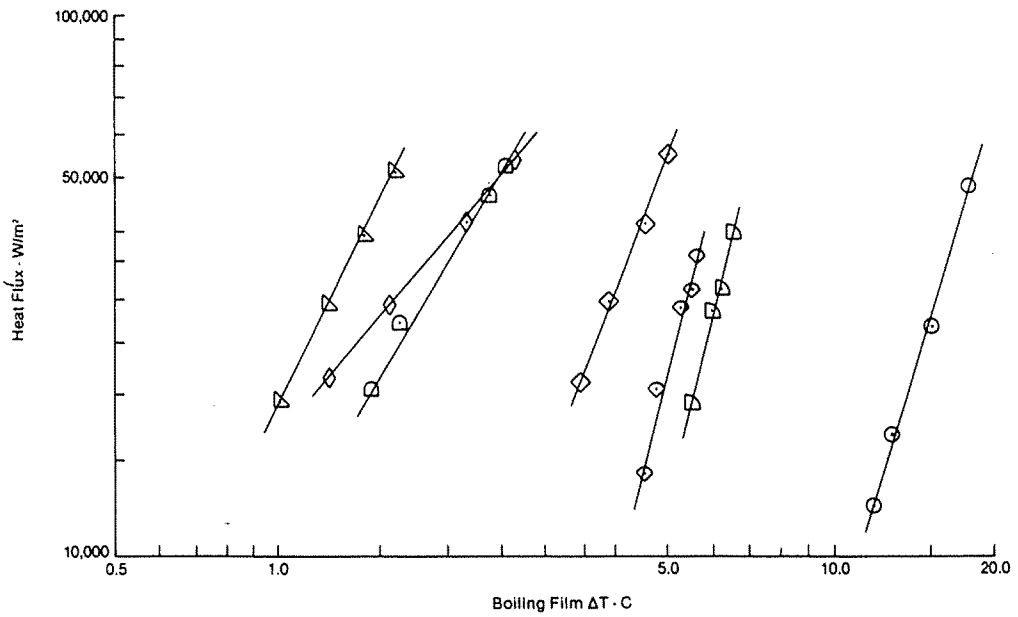


Figure 5.12. a. Finned tubes tested.
b. Comparison of boiling performance of R–11 at 35C (Carnavos, 1981).

performance was enhanced. The enhancement vanished at high heat fluxes. A theoretical model was developed that took into account nucleation, convection, and fin geometry. Experimental and predicted results agreed well.

Abuaf et al. (1985) tested short square fins in R–113. Both the nucleate boiling heat transfer coefficients and the CHF were improved relative to a smooth tube. On a projected area basis, the CHF was increased by a factor of between 2–2.5. The finned tube's CHF dependence on pressure was similar to that of a smooth tube. A numerical analysis of the conjugate heat transfer between the fin and the various modes of boiling heat transfer along the fin was performed and reasonable agreement was obtained between the experimental and numerical results. Anderson and Mudawar (1988) also tested small studs and found that the CHF was stongly dependent on the macro–geometry but was little influenced by the surface finish or artificial cavities.

Several investigations have focused on the optimum geometry of a fin in pool boiling. Westwater and co–workers (e.g., Haley and Westwater, 1966; Cash et al., 1971; Shih and Westwater, 1974) developed optimum fin shapes through the use of numerical analysis for conduction in the fin with the heat transfer coefficient varying along the surface; the local heat transfer coefficient was assumed to have the same value as that obtained from an isothermal surface having the same temperature. The resulting complex shapes demonstrated significant improvements compared to simple geometry (cylindrical or rectangular) fins; however, practical considerations due to the difficulty in manufacturing these complex fins preclude their wide spread use. The methodology used to produce the shapes demonstrated that reasonably accurate predictions of the fin performance could be obtained for a single fin in pool boiling. (Shih and Westwater (1972) applied a low thermal conductivity coating to a fin to suppress film boiling by lowering the surface temperature. The performance of this fin also could be predicted with the above mentioned methodology.) For six different fin geometries in boiling R–113, Bondurant and Westwater (1970) demonstrated that arrays of circumferential fins of constant cross section

also could be predicted adequately. Takeyama (1985) performed an analytic and experimental investigation to optimize an array of fins on a surface. Only qualitative agreement between the two methods was obtained. Bubbles flowing in the gaps between adjacent fins were blamed for the disagreement. At low heat fluxes the bubbles enhanced the heat transfer and at high heat fluxes the bubbles degraded the heat transfer. Biyikli (1985) presented design charts for rectangular fins which were optimized for several fluids including R–113.

Displaced Enhancement Devices

Chyu and Mghamis (1989, 1992) used a cylinder and a sphere in close proximity to a heated surface to enhance nucleate pool boiling on a horizontal and vertical heated surface. For boiling R–113, the only combination of test section orientation and surface attachment which enhanced the heat transfer was a horizontal cylinder applied to a vertical heated wall. Heat transfer was increased significantly at lower wall temperatures but the curves with and without the attachment approached each other at higher heat fluxes. Temperature overshoot at incipience was decreased with the attachment. The attachment promotes the formation of more frequent and larger bubbles compared to an open heated wall and it is these bubbles which enhance the heat transfer.

Additives for Liquids

Little research has been done on additives to refrigerants to increase the pool boiling heat transfer coefficient. Indeed, the only papers that have addressed the effect of an additive have been those studying the influence of oil (discussed in a separate section) on the boiling process. With small oil concetrations, the heat transfer coefficient tends to be increased. For example, Dougherty and Sauer (1974) and Sauer and Chongrungreong (1980) found that at less than 3% oil concentrations the heat transfer coefficient will increase slightly. Jensen and Jackman (1984) drew the same conclusions. Jensen (1984)

determined that a small amount of oil (1–2%) could increase the critical heat flux (CHF) by 50% and that further increases in oil concentration would raise the CHF more. However, the large increases in the CHF was accompanied by even larger increases in the wall superheat at CHF.

Mechanical Aids

Galloway and Mudawar (1992) investigated the critical heat flux condition in the dielectric fluid FC–72 for a heated surface mounted flush to the inside wall of a cylinder. A rotating stirrer with radial blades induced a high velocity past the surface. The CHF was significantly increase with increasing rotational speed and decreasing the radius of curvature of the cylinder. Centrifugal forces caused localized subcooling at the heater surface. A correlation is presented that predicts the data with sufficient accuracy.

Tang and McDonald (1971) boiled R–113 on a cylinder rotating about its own axis. Rotation had no effect on the nucleate boiling heat transfer coefficient at low to moderate rotational speeds but at very high rotational speeds boiling was completely suppressed and forced convection was the only mode of heat transfer. At intermediate rotational speeds, both modes of heat transfer contributed to the heat transfer process and there was a smooth and gradual transition from one mode to another as the rotational speed increased.

Fluid Vibration

Park and Bergles (1988) used ultrasonic vibrations to enhance pool boiling of R–113 on a small diameter tube. For saturated liquid, there was negligible temperature overshoot prior to incipient boiling but the heat transfer was degraded in fully developed nucleate boiling. However, for subcooled liquid, the ultrasonic vibrations contributed to a substantial enhancement in the boiling curve.

Electric or Magnetic Fields

Because refrigerants and similar fluids are dielectrics, there have been a number of investigations on the effect of an applied electric field on boiling heat transfer. Allen and Karayiannis (1989) briefly review the effect of applied electric fields on boiling and condensing heat transfer. Generally, researchers have concluded that electrohydrodynamic (EHD) enhancement can improve the performance of pool boiling heat transfer. Uemura et al. (1990) boiled R–113 on a flat surface, and their data showed that the heat transfer on all parts of the boiling curve was improved. While both the CHF and minimum heat flux increased, the film boiling heat transfer was raised by an order of magnitude. At high applied voltages, orientation (horizontal facing up to horizontal facing down) had no effect on the boiling curve. Jones and Hallock (1978) demonstrated up to a 70% increase in the minimum film boiling heat flux in their experiment with R–113 and developed a theoretical model which successfully predicted their data.

Using R–113 and R–21, Lovenguth and Hanesian (1971) obtained up to a factor of three increase in the CHF on a small diameter wire with increasing applied voltage. They explain this increase through the development of a model that suggests that the electric field stablizes the Helmholtz–Taylor hydrodynamic condition that normally governs film boiling. It was concluded that the only limitations to larger increases in the heat transfer were the applied voltage and dielectric strength of the liquid. On the other hand, Yabe et al. (1987) obtained only a 20% increase in the CHF of R–113 on a flat upward facing plate. The difference is due to the much greater applied voltage gradient used by Lovenguth and Hanesian (up to about 140 kV/cm) than that used by Yabe et al. (about 20 kV/cm). Karayiannis et al. (1989) obtained a factor of four increase in the heat transfer coefficient with a sufficiently high applied voltage. This enhancement was obtained with an EHD power consumption of less than 1 W. With R–113, Ohadi et al., (1992) achieved a factor of five increase in the heat transfer coefficient compared to nucleate boiling without an applied voltage (Fig. 5.14).

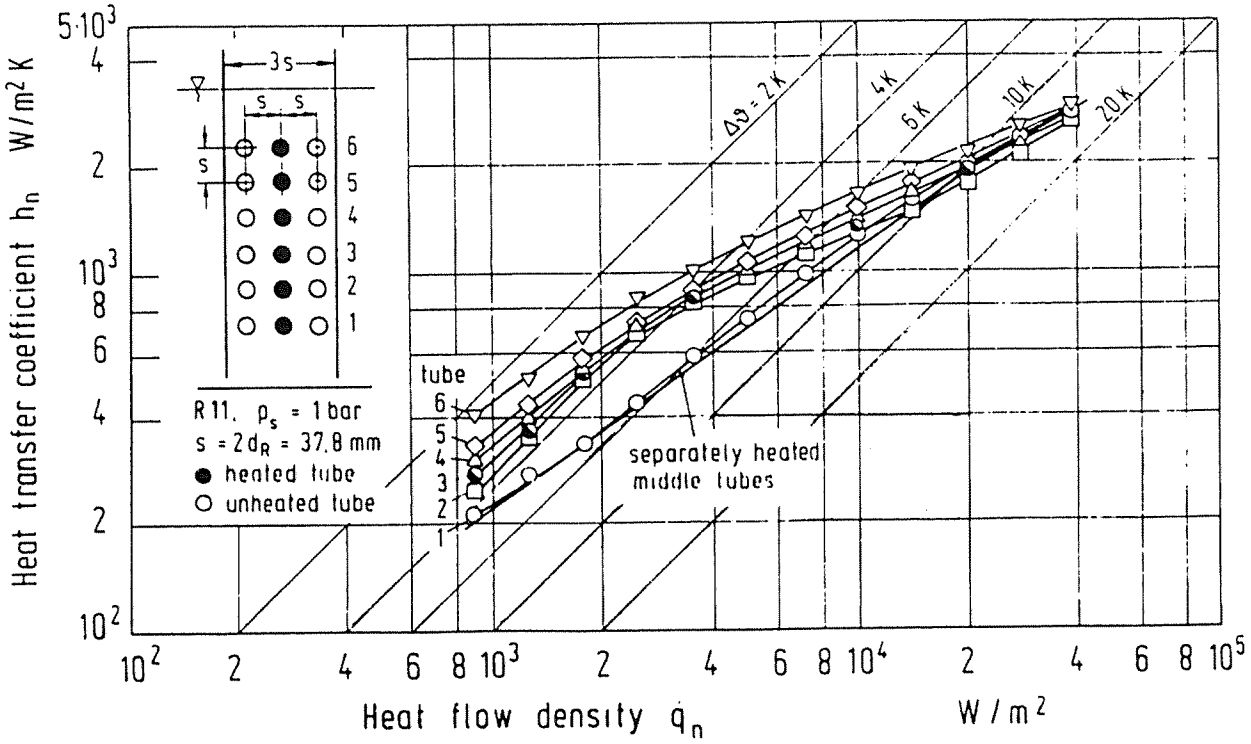


Figure 5.13. Heat transfer coefficient for simultaneously heated middle tubes (Hahne and Müller, 1983).

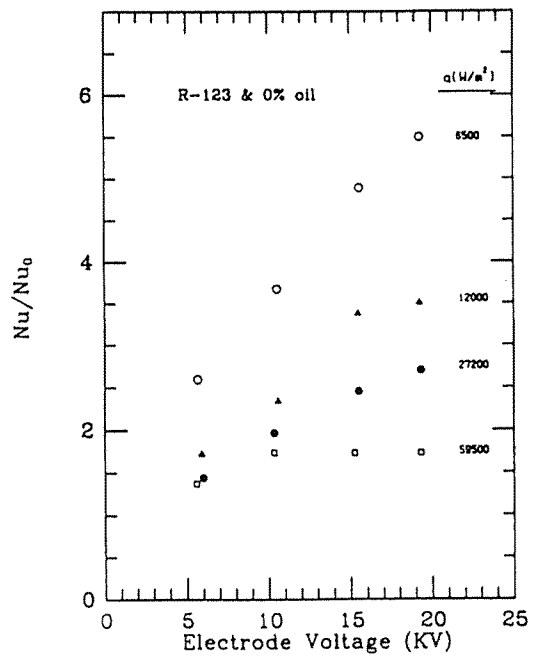


Figure 5.14. EHD Heat transfer enhancement of R–123 at 0% oil (Ohadi et al., 1992).

EHD has been combined with other enhancement techniques also. Yokoyama et al. (1987) used EHD on both a smooth and a porous surface with R–11. While the smooth surface's fully established nucleate boiling coefficient was increased by a factor of three to six depending on applied voltage, the porous surface's boiling heat transfer coefficient was unaffected by the applied voltage and was 10 to 15 times that of the smooth surface without an applied voltage (Fig. 5.15). Allen and Cooper (1987) and Cooper (1990) combined EHD and a low fin tube for boiling of R–114. Their results indicated that boiling hysteresis was eliminated with EHD and that the heat transfer coefficient could be increased by an order of magnitude; however, no comparison was made against smooth tube results so that it is difficult to evaluate the separate effects of the fins and the EHD.

Jet Impingement

High heat fluxes experienced by microelectronic chips have provided motivation to investigate jet impingement cooling. A number of studies have used R–113 and other refrigerants impinging on small surfaces (e.g., Ruch and Holman, 1975; Monde and Katto, 1978; Katto and Ishii, 1978; Ma and Bergles, 1983, 1986; Cho and Wu, 1988; Monde and Furakawa, 1988; Monde and Okuma, 1985; Monde, 1987; Katto and Yokoya, 1988). At low wall superheats there can be a substantial increase in the heat transfer coefficient (by a factor of two, depending on the jet velocity) but at higher superheats the boiling curves for the different velocities merge and essentially coincide with the fully developed nucleate pool boiling curve. Temperature overshoot at incipience is small. The CHF varies with the cube of the jet velocity (Fig. 5.16). Kandula (1990) proposes a physical model of the CHF condition for an impinging jet and presents a correlation which takes into account two different mechanisms for the CHF condition. Mudawar and Wadsworth (1991) studied a rectangular impinging jet of FC–72 flowing into a confined channel. At moderate velocities, increasing the jet velocity increased the CHF. At high velocities, increasing the jet velocity caused the CHF to level off and decrease; this was attributed to decreases in

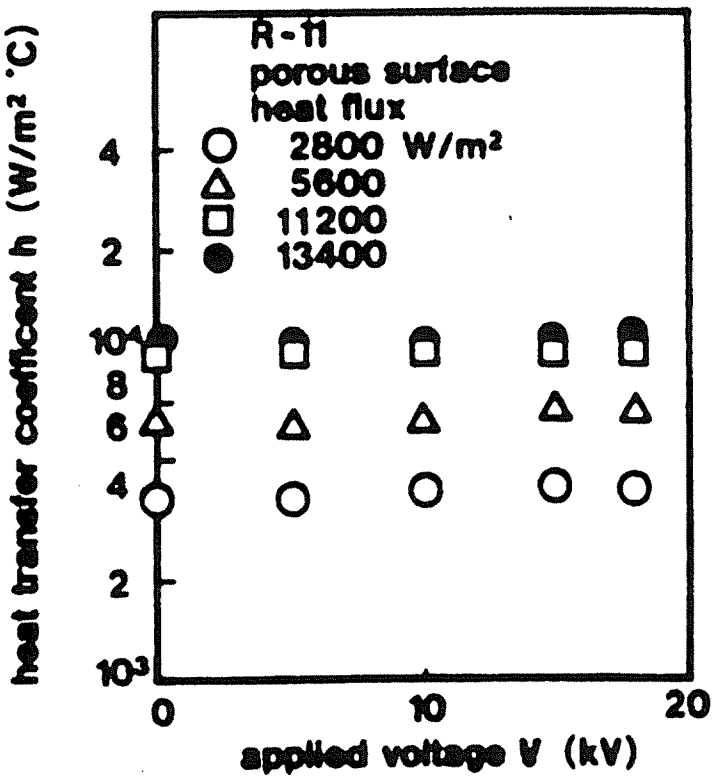


Figure 5.15. Effect of an applied voltage on the boiling heat transfer of the porous surface. (Yokoyama et al., 1987).

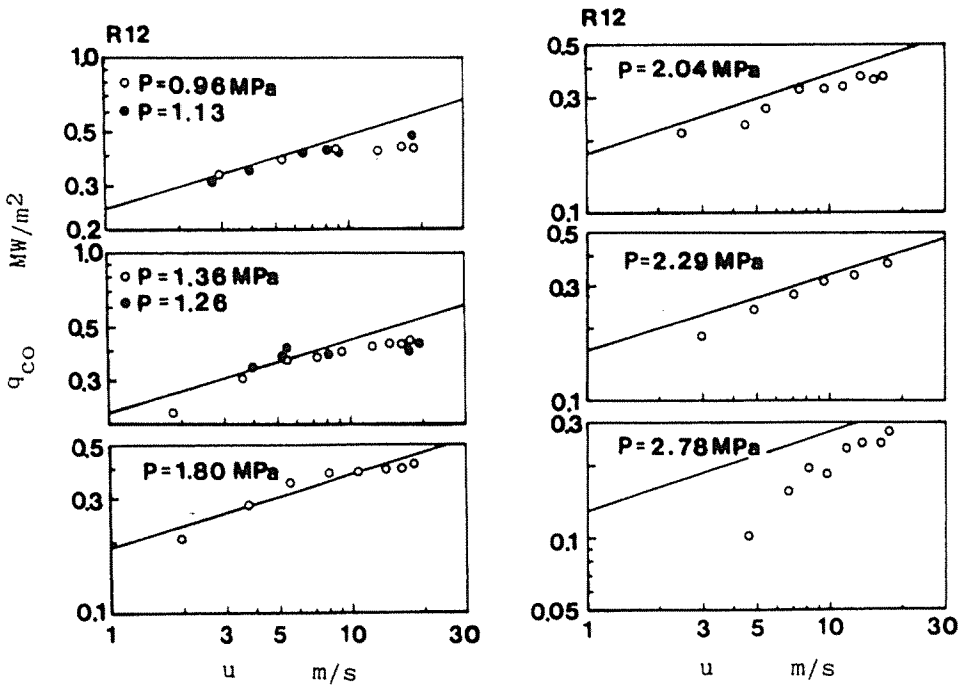


Figure 5.16. Relation between CHF and jet velocity obtained for R–12 (D = 0.04 m), (Monde, 1987).

the liquid subcooling as the liquid flowed through the test section. Multiple impinging jets were studied by Monde and Inoue (1991) who used a single jet correlation to successfully predict the multiple jet CHF. Yabe and Maki (1988) used both jet impingement and electrohydrodynamics (EHD) to enhance the boiling heat transfer on a surface. The CHF was increased by up to a factor of two when the EHD was used in conjuction with the impinging jet (Fig. 5.17), but jet speed is not given.

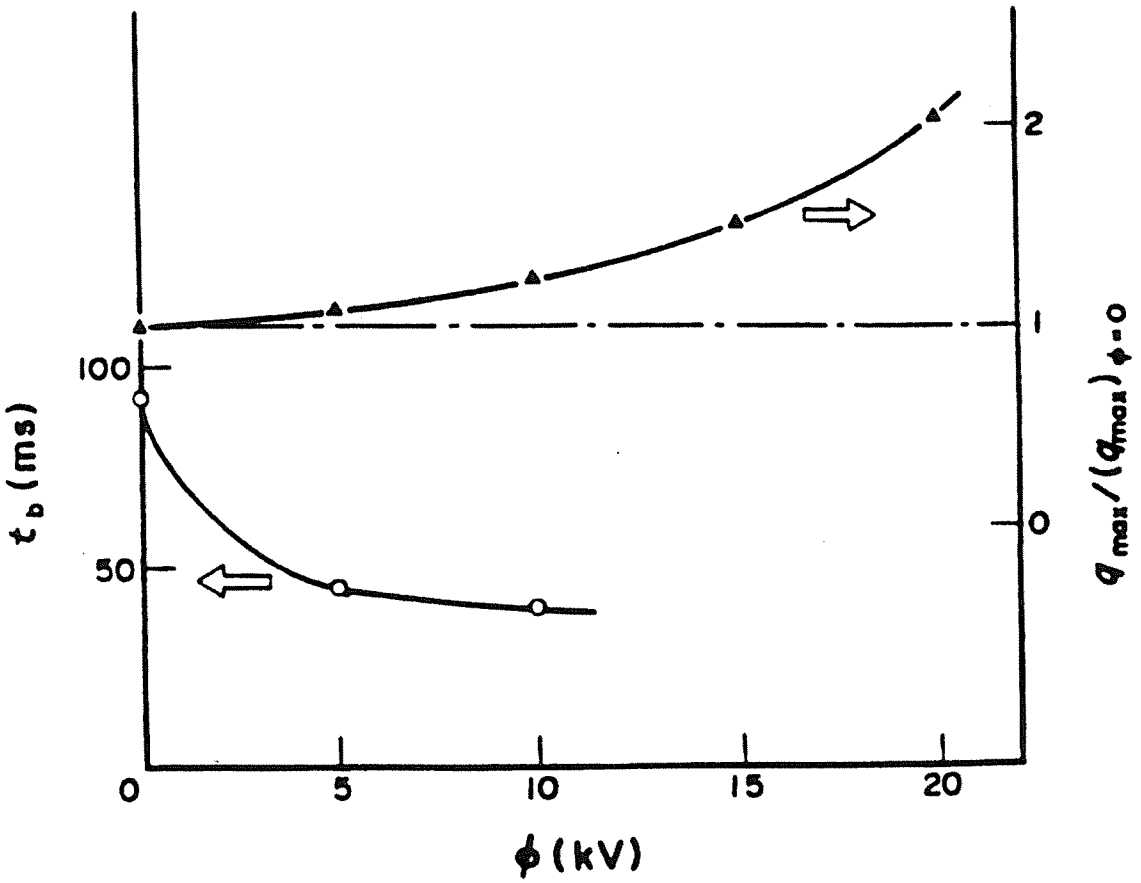


Figure 5.17. Augmentation of critical heat flux and mean bubble detachment period in a liquid jet when EHD enhancement is used (Yabe and Maki, 1988).

6. ENHANCED FLOW BOILING HEAT TRANSFER

The primary emphasis with flow boiling or evaporative heat transfer has been directed towards intube research. Very few shellside convective studies were found. While there has been a number of investigations of boiling on the shellside of enhanced tube bundles and there was significant flow past the tubes, the majority of those experiments have involved naturally induced circulation through the array of tubes; neither the mass flux nor the quality level is known in those tests so that the heat transfer characteristics cannot be quantified. Somewhat arbitrarily those studies have been included in the pool boiling papers.

Shellside Flow Boiling

Only three papers were found that had boiling of a forced flow which was perpendicular to an enhanced tube. Cornwell and Scoones (1988) tested low–fin tubes in R–113. They found the dominant heat transfer mechanism was nucleate boiling at low qualities (less than about 3%) and was forced convection at higher qualities. This transition was lower than that of a smooth tube bundle. A porous coated staggered tube bundle was studied by Tatara and Payvar (1986). They examined both the heat transfer and pressure drop in R–11. For qualities up to about 90% at very low mass fluxes (less than 13 kg/m^2s), the heat transfer coefficients could be described in terms of heat flux only; that is, the heat transfer coefficients was independent of quality. Comparisons of pressure drop data with smooth tube data were not made; a correlation was suggested that satisfactorily predicted the data.

Jensen et al. (1992) tested both a porous coated tube (Linde High Flux) and structured surface (Wolverine Turbo–B) in crossflow of R–113 and compared those results to a smooth tube bundle. Two different staggered tube bundles with tube pitch to

diameter ratios of 1.17 and 1.50 were tested for mass fluxes up to 500 kg/m^2s and qualities up to 80% for a wide range of heat fluxes. The surface roughness of the two enhanced tube bundles evidently was sufficiently small to have no discernible effect on the pressure drop characteristics of the flow compared to a smooth tube bundle. The enhanced tube bundle had significantly larger heat transfer coefficients than the smooth tube bundle as seen in Fig. 6.1. The enhanced coefficients were comparable to those obtained in saturated liquid pool boiling. Changes in mass flux, quality, and bundle geometry had negligible effect on the heat transfer coefficients. It was concluded that the heat transfer process on these type of enhanced tubes is governed by the subsurface heat transfer mechanisms because the external flow cannot intrude into the small surface cavities.

Tubeside Flow Boiling

Enhancement of tubeside flow boiling has been extensively studied in the past (Bergles, 1988) for both refrigerant and non–refrigerant applications. A review article by Lazarek (1980) describes some of the passive enhancement techniques for intube flow boiling of refrigerants. A more extensive review for both active and passive enhancement techniques for intube boiling of refrigerants and non–refrigerants has been presented by Jensen (1988). In this section, a brief summary of the heat transfer and pressure drop characteristics for each enhancement technique is discussed and representative performance data are shown.

Treated surfaces

The effect of surface finish on flow boiling is much less pronounced than for pool boiling. The study by Murphy and Bergles (1972), for boiling of R–113, indicates that a porous coating inside the tube could eliminate the hysteresis in the boiling curve; however, the heat transfer characteristics for high flux subcooled flow boiling showed no

improvement over that of a smooth tube. On the other hand, the study by Ikeuchi et al. (1984) for R–22 boiling in a tube with a inside microporous surface has shown that the heat transfer coefficient could be enhanced by about 650% for incomplete evaporation and by about 160% for complete evaporation over that of a smooth tube. As seen in Fig. 6.2, the difference between complete and incomplete evaporation is larger in microporous tube than smooth tube. This was attributed to the heat transfer mechanism in the microporous tube being strongly influenced by nucleate boiling. A similar study by Czikk et al. (1981) for boiling of ammonia and R–22 inside porous coated tubes has shown that the boiling heat transfer coefficient is enhanced by an order of magnitude over that of smooth tubes. However, for R–22 boiling in horizontal tubes, the heat transfer coefficient decreased rapidly at higher qualities and eventually approached the smooth tube values. This was attributed to partial dryout of the upper half of the tube.

Treated surfaces for enhancing flow boiling are not commonly used for intube flow due to manufacturing difficulties. Dyundin et al. (1990) has pointed out that enhancing effect of these microporous coatings may not be retained for long duration. This effect is more severe particularly for carbon steel tube, which corrodes during operation. They suggested that performance degradation also could result due to the presence of oil in a refrigerant.

Rough surfaces

A variety of surface roughness configurations has been developed for evaporator tubes. These include ribbed and corrugated tubes, coiled wire and slotted helical wire, inserts, and knurled or grooved surfaces.

Ohara et al. (1990) obtained an enhancement of 200% in the heat transfer coefficient for boiling of R–12 in a cross–ribbed flat channel. The enhancement was attributed to

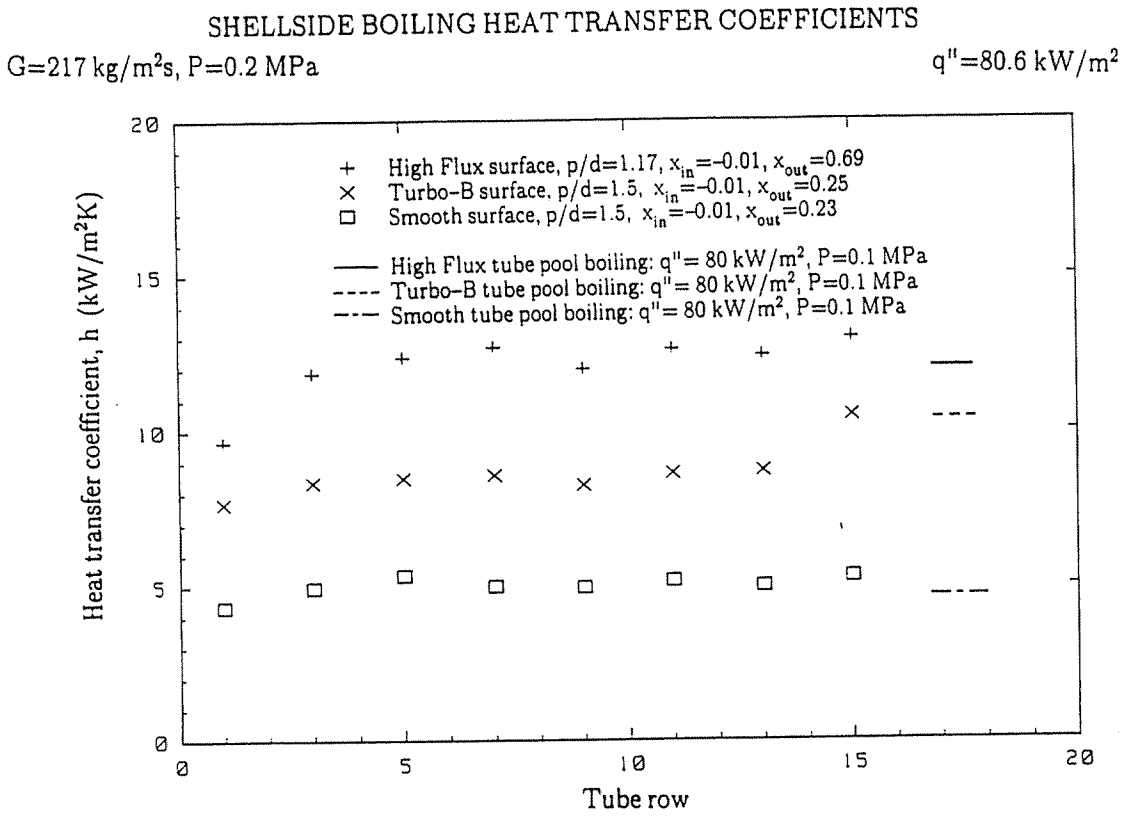


Figure 6.1. Effect of the heated tube surface on the heat transfer coefficient (Jensen et al., 1992).

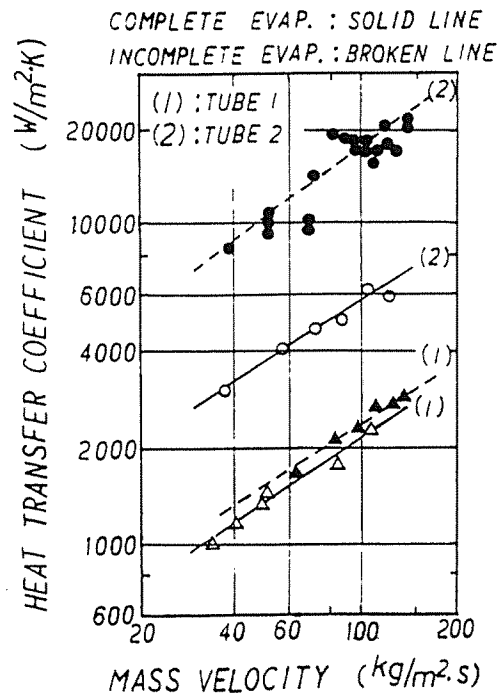


Figure 6.2. Heat transfer coefficient for intube boiling of R–22 in microporous tube (Ikeuchi et al., 1984).

increased mixing and swirling. The pressure drop in these cross–ribbed channels was as much as 30 times higher than that in the smooth channels. Some typical results for the upflow situation are shown in Fig. 6.3. However, an evaluation based on a "volume goodness" factor indicated that the heat transfer coefficient in the cross–ribbed channel is 1.2–1.8 times higher than the smooth channel for equal pumping power.

Due to spatial non–uniformity in the flow field, the dryout phenomena in these enhanced tubes could be quite different from that in a smooth tube. Shollenberger et al. (1992) investigated onset of dryout and post–dryout heat transfer for R–113 boiling in a cross–ribbed and a finned channel. For a given mass flux, the heat transfer coefficients for the ribbed channels were 1.5–2 times higher than the finned geometry. Furthermore, their observations indicated that the first appearance of dryout spots does not produce an immediate drop in the heat transfer coefficient but, rather, the heat transfer coefficient begins to drop only after a significant portion of the surface has been covered by dry spots. The onset of the dryout was observed to be weakly governed by the mass flow rate. They postulated a model based on a balance between surface tension and interfacial shear forces to predict the onset of dryout. A scheme for correlating the post–dryout heat transfer was also presented. However, due to large scatter in their experimental data, the correlation needs further evaluation.

A more satisfactory correlation is provided by Kandlikar (1991) for predicting flow boiling heat transfer coefficients in enhanced geometries. The additive model for convective and pool boiling contributions was extended to enhanced geometries by including the effects of augmented tube geometry. The correlation generally predicted flow boiling data for cross–ribbed and other enhanced geometry obtained with R–11, R–22, and R–113 to within 8%.

The recent study by Hinton et al. (1992) for boiling of R–22 inside a corrugated tube indicates that significant enhancement in the heat transfer coefficient could be obtained with these corrugated tube over a wide range of heat and mass fluxes, particularly

at low qualities. However, the heat transfer coefficient shows a decreasing trend with increasing quality, eventually approaching smooth tube values at a quality of 45–50%. This was attributed to the promotion of nucleate boiling by the corrugations. The pressure drop was, in general, 40–60% higher than that of the smooth tubes. Based on these results, they concluded that corrugated geometries should be used at low qualities and suggested use of a split evaporator which uses corrugated surface in the low–quality region and some other enhancement device in the high–quality region.

Extended surfaces

A variety of tubes with integral or attached internal fins are available for refrigerant evaporators. Some examples of attached internal fins are tightly packed offset strip fins inserts soldered to the tube or star–shaped inserts which are produced by a drawing process.

Kubanek and Miletti (1979) measured heat transfer coefficient and pressure drop for R–22 boiling inside three different integral spiraled internally finned tubes. The data were compared with smooth tube data with and without star–shaped inserts. Significant enhancement in the heat transfer coefficient for the internally–finned tubes (as much as 760%) over those for smooth tubes was obtained. Average heat transfer coefficients based on the surface area of a smooth tube of the same diameter for typical evaporator conditions are shown in Fig. 6.4. In general, the enhancement in heat transfer coefficient for the tubes with the star–shaped insert were lower and ranged from 40 to 370% for the entire mass flux range tested. The pressure drops associated with the internally–finned tubes were, in general, 10–290% higher than the smooth tube value, while those for tubes with star–shaped insert were significantly higher (over 2000% in some cases) than the smooth tube results. Thus, clearly the finned tubes have a superior performance than the tube with inserts. The superior performance of the finned tubes was attributed to the low fin height and the tight spiral which increases the length available for bubble nucleation, as

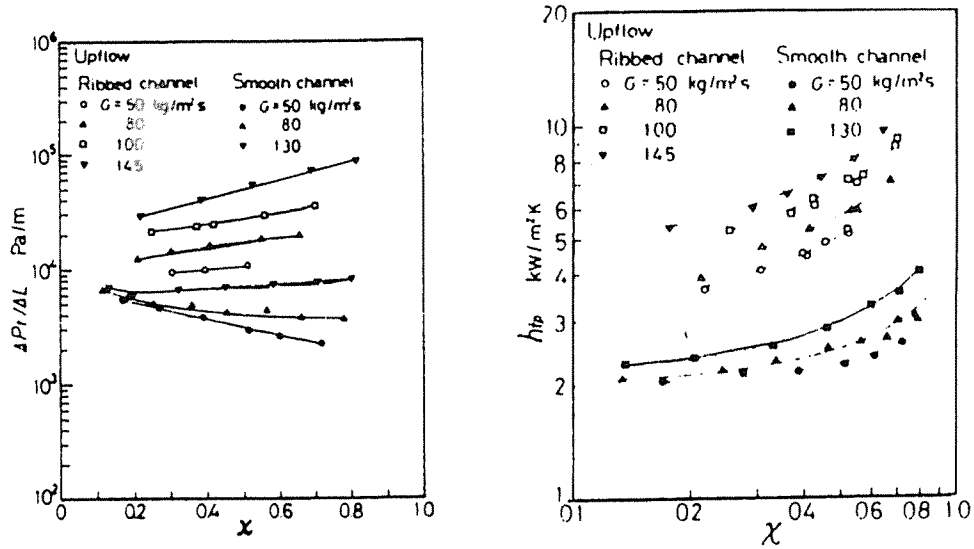


Figure 6.3. Measured pressure drop and heat transfer coefficient for flow boiling of R–12 in a cross–ribbed flat channel (Ohara et al., 1990).

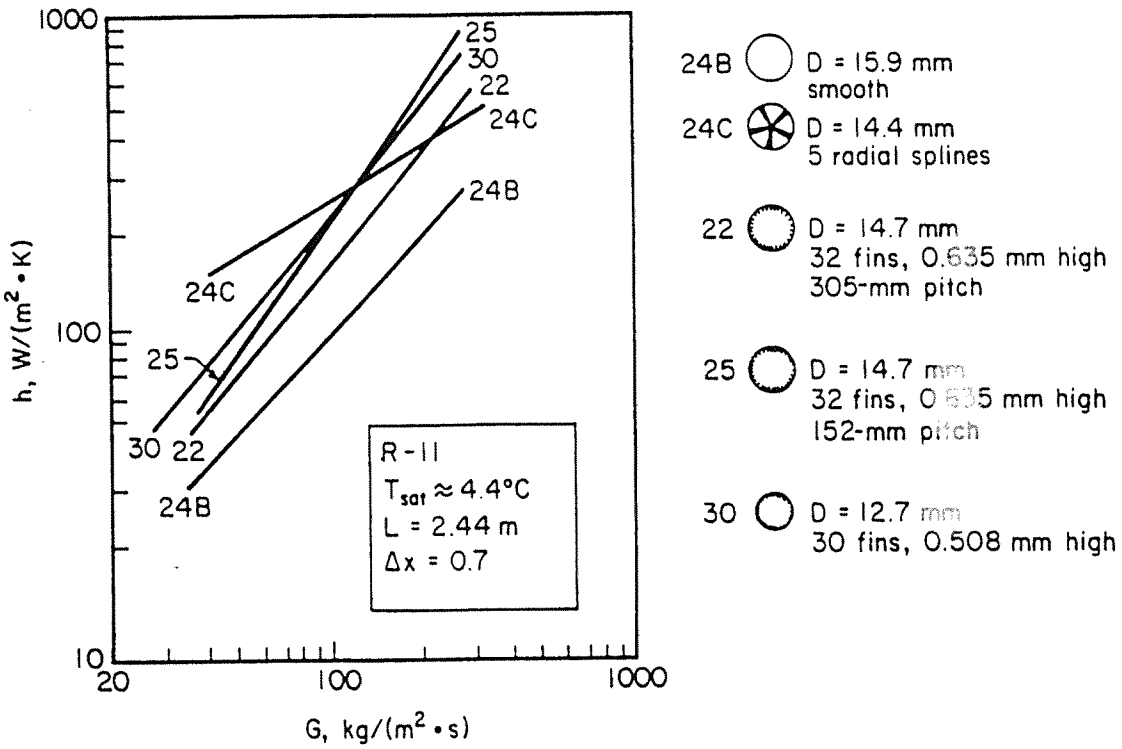


Figure 6.4. Average heat transfer coefficients for flow boiling in internally–finned tubes (Kubanek and Miletti, 1979).

well as due to increased turbulence. General correlations (Azer and Sivakumar, 1984) are available for predicting heat transfer coefficients and pressure drop in internally–finned tubes.

Sami et al. (1992) obtained enhancements of 200–230% in the heat transfer coefficient over that of a smooth tube for boiling of R–12, R–22, and R–134a in a horizontal double fluted annuli. The enhancement obtained with R–134a was comparable to those obtained with R–12 and R–22, indicating that it could serve as a potential alternative to R–12. However, the transition from nucleate boiling to forced convective boiling occurred at lower qualities for R–134a as compared to R–12. Also, the heat transfer coefficients of R–134a are less dependent on heat flux than for R–12 at the same mass flux and inlet pressure.

The more recent trend has been towards using micro–finned tubes which have smaller and more numerous internal fins than those with single–phase flows. These fins are typically spiraled to provide a further increase in heat transfer enhancement. A distinct advantage with these tube is the low pressure drop as compared to other enhancement techniques. Representative performance data and geometry of these micro–finned tubes are shown in Fig. 6.5.

Ito and Kimura (1979) used internally spiral grooved tubes for boiling of R–22. An enhancement of 100% in the heat transfer coefficient over that of smooth tube was reported. The pressure drop associated with the grooved tubes were about the same as in smooth tube for groove depth under 0.2 mm. An optimum groove pitch of 0.5–1.0 mm was observed.

Nishikawa et al. (1985) investigated flow boiling of R–22 inside three different helically grooved tubes. The tubes had 60 to 100 grooves of 0.15–0.24 mm height, spiraled at 10 to 15 degrees. The heat transfer coefficient was found to be significantly enhanced at low mass fluxes. The tube with cross–grooved surface was found to have a maximum enhancement of about 1200% at a mass flux of around 75 to 100 kg/m^2s. At higher mass

fluxes, the heat transfer coefficient decreased rapidly. The enhancement obtained was shown to decrease with an increase in heat flux level. However, no pressure drop measurements were made.

As indicated in the literature review by Schlager et al. (1987), micro–finned tubes have been mostly used to enhance flow boiling heating transfer coefficients for R–113 and R–22 applications. The enhancement factor obtained with these micro–finned tubes for R–22 and R–113 applications ranges from 1.5 to 2.7. However, studies with other refrigerants are lacking. Schlager et al. (1988a) used micro–finned tubes to enhance flow boiling of R–22, as well as with R–22 and oil mixtures. The micro–finned tube contained 60 fins with a fin pitch of 0.44 mm and a fin spiral angle of 18 degrees. The enhancement in the heat transfer coefficient for pure R–22 ranged from 90% at high mass flux to about 170% at low mass flux. However, no data on pressure drop were presented.

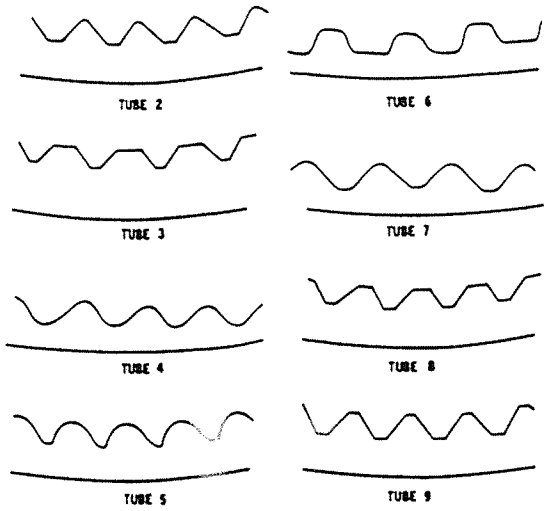
Schlager et al. (1989c) compared the evaporative performance of low–finned tubes with micro–finned tubes with R–22 as the working fluid. The low–finned tubes used had 21 fins of 0.38 mm height spiraled at 30 degrees. For pure R–22, the low–finned tube enhanced evaporative heat transfer by as much as 150% compared to a smooth tube. The enhancement factor for the low–finned tube was comparable to the micro–finned tubes, with values for micro–finned tube being 2% to 3% higher. The pressure drop in the micro–finned tubes is about 10 to 30 percent smaller than the low–finned tube. The results indicated that the micro–finned tube has a higher overall performance factor (defined as the ratio of the heat transfer enhancement to the pressure drop penalty factor) than the low–finned tubes.

A detailed investigation on micro–fin tubes was performed by Schlager et al. (1990a) using R–22 as the working fluid. Three micro–finned tubes with different fin heights and fin spiral angles were tested. The average heat transfer coefficients based on a nominal equivalent smooth tube are were 1.6 to 2.2 times larger than those in smooth tubes. The pressure drop increased by a small factor (a maximum of 40% at high flux)

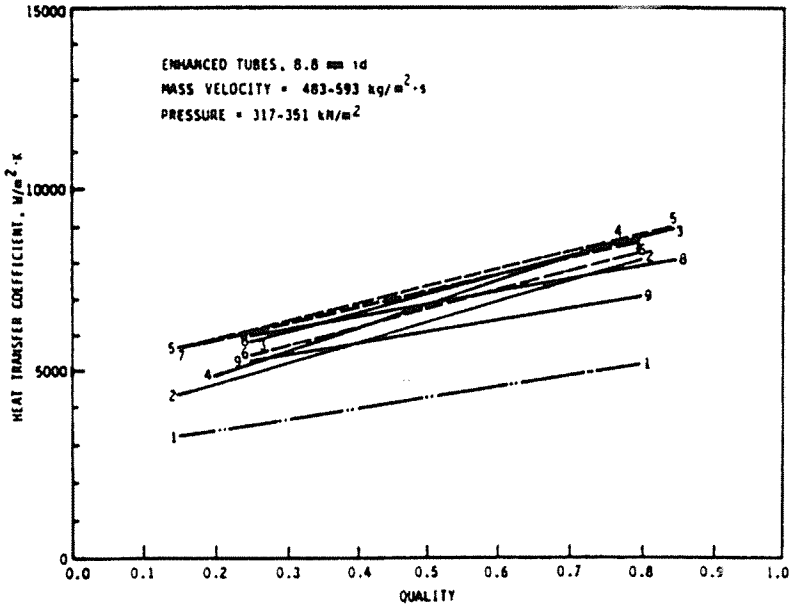
over that of smooth tube. As seen in Fig. 6.6, the evaporating performance of the three different micro–finned tubes lay within a narrow band indicating that the performance of the different tubes are similar. In addition, no significant differences in performance were observed between the 9.52 mm and 12.7 mm tubes. This led them to conclude that the results obtained with a particular micro–finned tube could be applied without modifications to a geometrically similar tube but having a somewhat different diameter. The last conclusion could be useful for formulating a general correlation for micro–finned tubes; however, further verification for a wider range of refrigerants and operating conditions is required.

More recently, Eckels et al. (1992) tested a series of micro–finned tubes of different geometries for evaporation of R–22. The heat transfer coefficients were enhanced 50–150% over smooth tube results with only a modest increase of 10–30% in pressure drop. Optimum tube and fin geometry associated with the maximum enhancement in heat transfer and lowest pressure drop penalty also was shown. Similar results for R–113 (Fig. 6.5) have been obtained by Khanpara et al. (1986b). The results of Khanpara et al. (1987a) indicate that the enhancement factor obtained with micro–finned tubes for R–22 are slightly lower (enhancement of 20–70%) than that obtained with R–113 (enhancement of 30–120%). Bergles (1988) has pointed out that the outstanding thermal–hydraulic performance of the micro–finned tubes is due to a plurality of factors including increased surface area, increased turbulence level, film dryout delay, flow pattern alteration, etc.

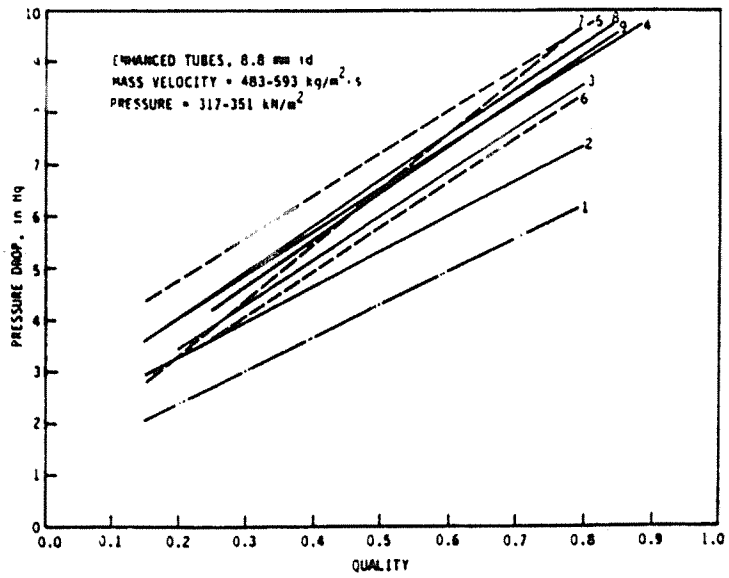
It is clear that significant heat transfer enhancement could be obtained at the expense of modest pressure drop penalty by using micro–finned tubes for intube flow boiling of refrigerants. The recent results seems encouraging and indicate that significant reduction in the heat exchanger size could be obtained by employing micro–finned tubes. Some guidelines are available for selection of optimum geometry; however, these are mostly limited to specific refrigerants (mostly R–113 and R–22). General design correlations for micro–finned tubes are not available yet.



(a)



(b)



(c)

Figure 6.5. (a) Fin profiles, (b) evaporative heat transfer coefficient, and (c) evaporative pressure drop for flow boiling of R–113 in micro–fin tube (Khanpara et al., 1986b).

Displaced enhancement devices

Fan et al. (1977) employed Kenics static mixers inside a smooth tube to augment boiling heat transfer of R–113. These static mixers consisted of short segments of right and left handed twisted tapes so arranged such that the leading edge of one segment is perpendicular to the trailing edge of the one ahead. Their preliminary results indicated that static mixers could augment the rate of heat transfer by an order of magnitude over that of smooth tubes with no mixers (Fig. 6.7). One major drawback is that the pressure drop associated with these mixers is very high. Thus, the ratio of the heat transfer per unit pressure drop is considerably higher (2–4 times) than that without static mixers. A more detailed study by Azer et al. (1980) for flow of R–113 undergoing transition from single phase forced convection to subcooled nucleate boiling indicated that mixers are more effective for enhancing single phase heat transfer, but they have a diminishing effect as the nucleate boiling regime is approached.

Another example of a displaced enhancement device is a wire gauze insert which has been used successfully by Styrikovich et al. (1982) for increasing the critical heat flux (CHF), particularly at high values of mass flux and vapor quality. For instance, at a vapor quality of 80%, the CHF is increased by around 60%. However, similar to the mixer inserts, the pressure drop in these tubes is also much higher, thereby restricting their applicability.

A novel heat transfer surface consisting of a perforated brass foil insert has been used successfully by Palm (1990, 1991a, 1991b) to augment tube side flow boiling heat transfer of pure refrigerants. This surface has the advantage of being used as a retrofit heat transfer enhancement device for existing evaporators. The actual enhancement in the heat transfer was shown to vary considerably with application, hole geometry, and pure refrigerants (Palm, 1991a). A 100% enhancement in heat transfer coefficient was reported by Palm for flow boiling of R–22 in tubes fitted with end inserts. A lower level of heat transfer enhancement was observed by Conklin and Vineyard (1992) in flow boiling of pure

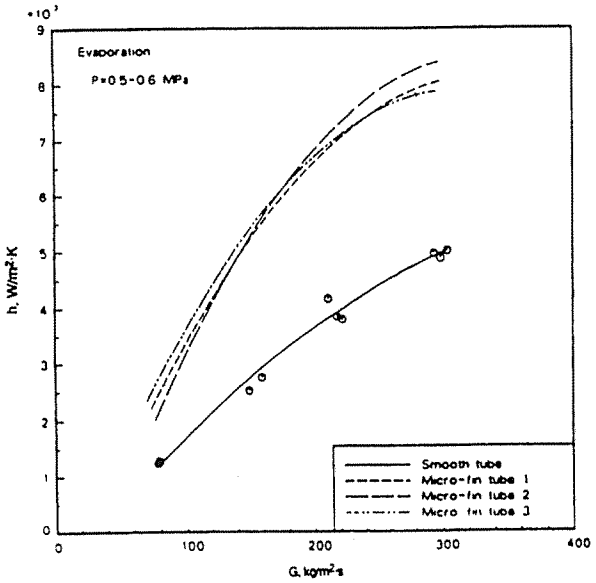


Figure 6.6 Evaporative heat transfer coefficients for flow boiling of R–22 inside micro–fin and smooth tube (Schlager et al., 1990a.)

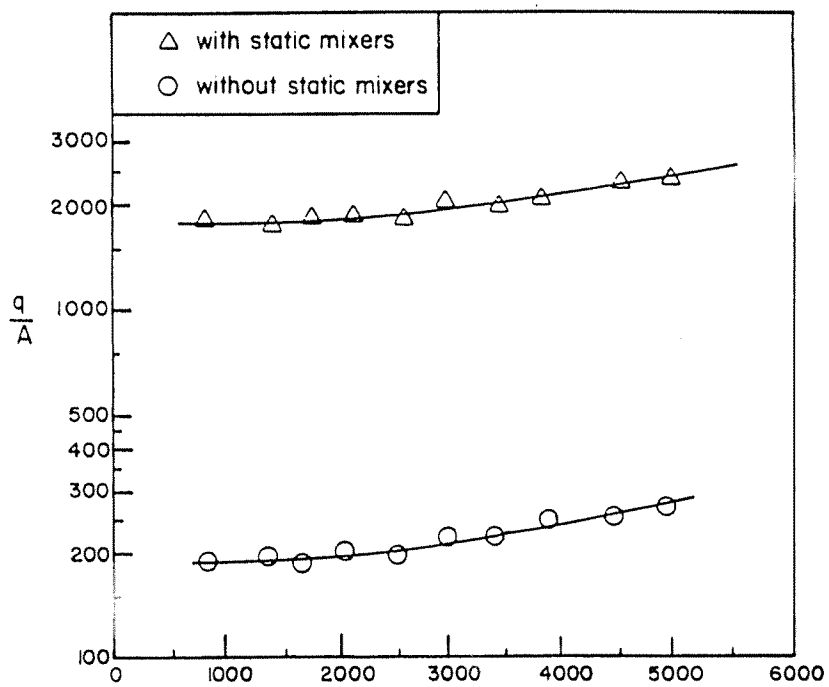


Figure 6.7. Effectiveness of in–line static mixers in augmenting the rate of forced flow boiling heat transfer of R–113 (Fan et al., 1977).

R–22. In general, the perforated foil inserts were observed to enhance the heat transfer particularly at lower qualities and heat flux, indicating augmentation of nucleate boiling. In addition, the presence of such inserts in half of the tube passes increased the pressure drop by a modest amount of 25% to 35% for the total evaporator length at a given mass flux.

Swirl flow devices

Twisted–tapes are commonly used swirl flow devices for enhancing flow boiling heat transfer. The critical heat flux is also enhanced due to the centrifugal action which forces the core droplets to the wall (Bergles, 1988), thereby delaying dryout. Lal et al. (1973) have reviewed the performance characteristics of swirl flow devices particularly for refrigerant evaporator applications. Jensen and Bensler (1986) tested three twisted tapes in a uniformly heated test section and determined that the swirl flow heat transfer coefficient were up to 90% larger than the axial flow heat transfer coefficient at the same flow conditions (Fig. 6.8). The study by Agrawal et al. (1982) for R–12 shows that the pressure drop associated with the twisted tapes could be significant (as much as 300% higher than smooth tubes at low twist ratios). General correlations for predicting overall heat transfer and critical heat flux exists (Jensen 1984a, 1985). The latter summary paper (Jensen, 1985) covers all modes of single– and two–phase heat transfer and predicted the performance of a fluid–to–fluid heat exchanger, with and without twisted–tape swirl generators, within reasonable accuracy. It was argued that since the greatest benefit from using twisted–tapes comes from the suppression of the CHF condition, it would be advantageous from the pressure drop point of view to employ twisted–tapes only in the high quality region to suppress the CHF condition.

The recent study by Agrawal and Varma (1991), which employed twisted tapes inside a horizontal R–12 evaporator, indicates that high values (as much as 3.5) of the ratio of swirl flow to plain flow heat transfer coefficient per unit pumping power could be

obtained for optimum conditions of twist ratio, heat flux, and mass flux. However, no attempt was made to correlate these optimum values.

Electrostatic and magnetic fields

The recent reviews by Poulter and Allen (1986) and Yabe (1991) indicate no recent work in electrohydrodynamic (EHD) enhancement of intube flow boiling for refrigerant or non–refrigerant applications. The primary reason is the difficulty in placing the electrodes inside the tube as well as maintaining adequate spacing between the electrode and the heat transfer surface, whereas for shellside boiling, the electrode can be suitably placed or wrapped around the tubes.

Injection or suction

Dhir and Scott (1985) have investigated the use of single and multiple tangential injectors to enhance the critical heat flux (CHF). An enhancement of up to 80% in the CHF was obtained for boiling of R–113 inside a circular tube by tangentially injecting liquid at the tube entrance. The enhancement was attributed to the flow swirl introduced by the tangential injection of the coolant. However, injection into an existing swirling flow was found to be less effective in increasing the CHF.

Coiled tubes

Coiled tubes are commonly used in vapor generators because of their compactness and high heat transfer performance. Research has been conducted for enhancing the heat transfer coefficient as well as the CHF. Hughes and Olson (1972) obtained substantial enhancement (as high as 60%) in the CHF for R–113 boiling on the concave surface of a coded tube. A more detailed study by Cumo et al. (1972) for flow boiling of R–12 in coiled tubes has shown that the ratio of the burnout power in the coiled tube to that in a straight tube increases with mass flux and pressure and could reach values as high as 500 to 600%.

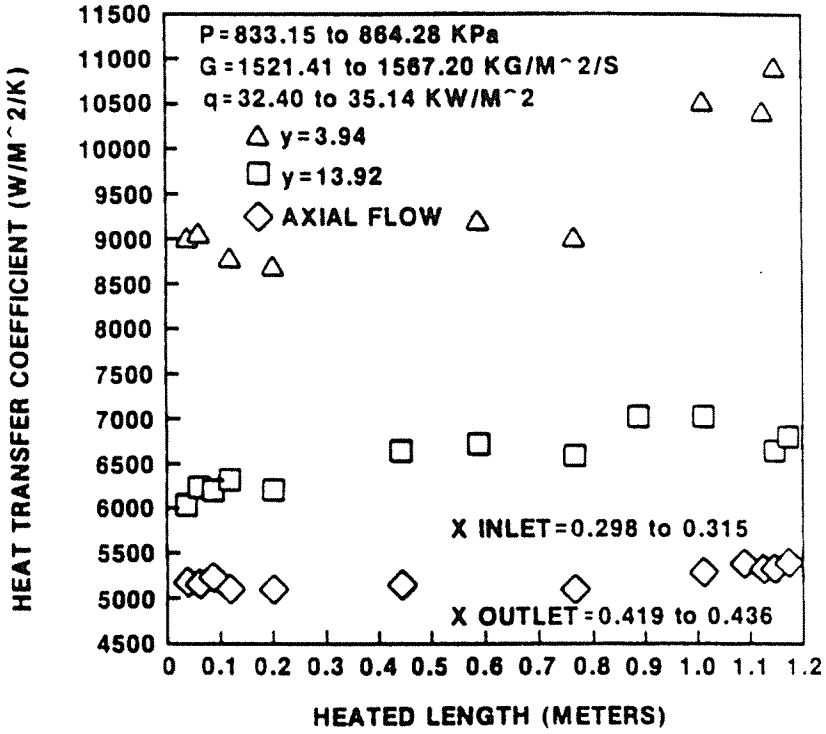


Figure 6.8 Effect of tape–twist ratio on heat transfer coefficient for flow boiling of R–113 (Jensen and Bensler, 1986).

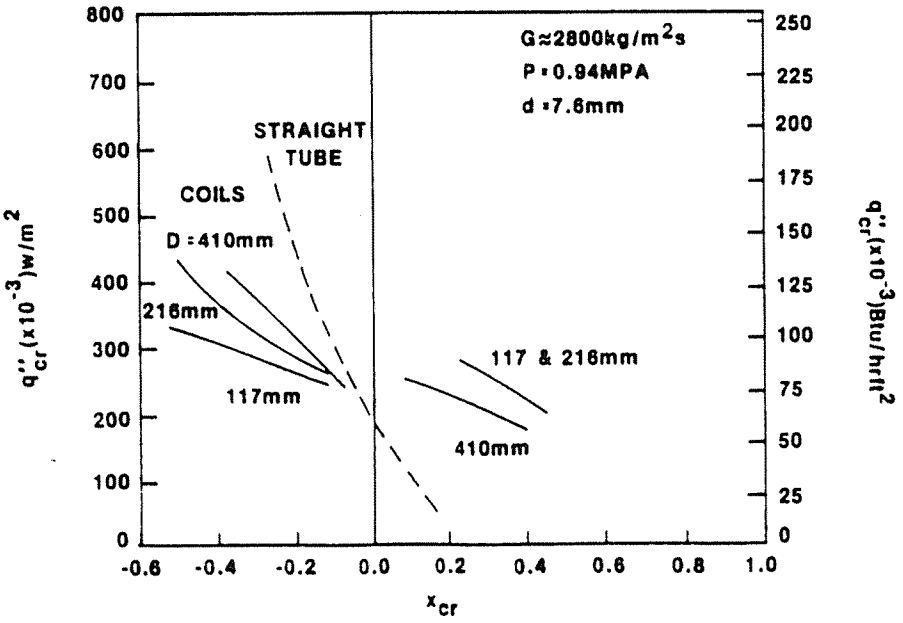


Figure 6.9. Effect of tube–to–coil diameter ratio on CHF for flow boiling of R–113 (Jensen and Bergles, 1981).

This indicates that the power exchanged along the boiling length up to the point of dry–out is much higher in coils, which has a more compact geometry.

Jensen and Bergles (1981) reported boiling of R–113 in heated coils of various diameters. For sub–cooled conditions, the CHF for coiled tubes was found to be lower than with smooth tubes (Fig. 6.9) and the difference between the CHF's increased with increasing mass flux and tube–to–coil diameter ratio. On the contrary, quality CHF was enhanced, and the enhancement increased with increasing the coil curvature. For instance, at vapor quality of 10% and a tube–to–coil diameter ratio of about 54, the CHF for the coiled tube was enhanced by around 150%. Due to this difference in CHF behavior for the sub–cooled and the quality region, they concluded that undesirable dryout could occur if helical coils are operated at low inlet qualities and moderate or high heat flux. Correlations for predicting the sub–cooled and quality CHF were also provided. In a subsequent paper, Jensen and Bergles (1982) discussed the effect of nonuniformity of heat flux on the CHF. The exact dependence of CHF on this non–uniformity is rather complex due to the interaction between mass flux, flux tilt, and curvature of the tube. Correlations for the CHF for both sub–cooled and quality regions that accounted for the flux tilt were provided.

The study by Barskii and Chukhman (1971) with R–12 as the working fluid and with various coil diameters indicated that the boiling heat transfer coefficient increases with increasing mass flux, heat flux, and ratio of tube–to–coil diameter. The heat transfer coefficient was typically enhanced by around 60% at high heat fluxes and tube–to–coil diameter ratio. However, the pressure drop increase was substantial and was about the same order as the increase in the heat transfer coefficient. A subsequent study by Chukhman (1972) for R–22 showed that the enhancement in the heat transfer coefficient is moderate (around 50%), especially for small values of tube to coil diameter ratio and high heat fluxes. The heat transfer coefficient followed the same trend as that presented earlier

for R–12. Correlations for Nusselt numbers as a function of physical properties of the fluid and coil curvature were presented. Similarly, post–dryout heat transfer coefficients are also higher for coiled tubes.

7. ENHANCED HEAT TRANSFER IN REFRIGERANT MIXTURES

Two recent state–of–the–art reviews (Stephan 1982 and Thome and Shock 1984) give excellent summaries of what is known about boiling and condensation in multicomponent mixtures. A lack of studies, analytic or experimental, on forced convective boiling of multicomponent mixtures was noted; much more research has been performed with forced convective condensation, and analytic methods have been proposed to estimate heat transfer coefficients. Because of the small number of papers which have addressed enhancement heat transfer of mixtures, this chapter is divided only into sections entitled Pool Boiling, Flow Boiling, and Condensation.

Pool Boiling

The only reference found that examined pool boiling of refrigerant mixtures was by Trewin (1992). He boiled mixtures of R–113 and R–11 on smooth, High Flux and Turbo–B surfaces. The performance of all three surfaces decreased in the fluid mixtures with the largest degradation occurring at a mixture of 25% R–11/75% R113 (Figs. 7.1 and 7.2), but the enhanced surfaces consistently performed better than the smooth tube. The High Flux surface performed slightly better than the Turbo–B tube, as also was the case for the pure fluid experiments.

Heat transfer in pool boiling of miscible mixtures (such as would be found with refrigerant mixtures) may be much lower than could be expected from a linear interpolation of the data for boiling of the individual components in the mixture. Stephan (1982) suggests several explanations for this phenomenon. One explanation is that depletion near the heated surface of the more volatile component of the mixture (leaving the less volatile component) results in a local increase in the saturation temperature; however, the heat transfer coefficient is usually based on the bubble point of the bulk fluid mixture and thus does not take into account local effects. Thome and Shock (1984)

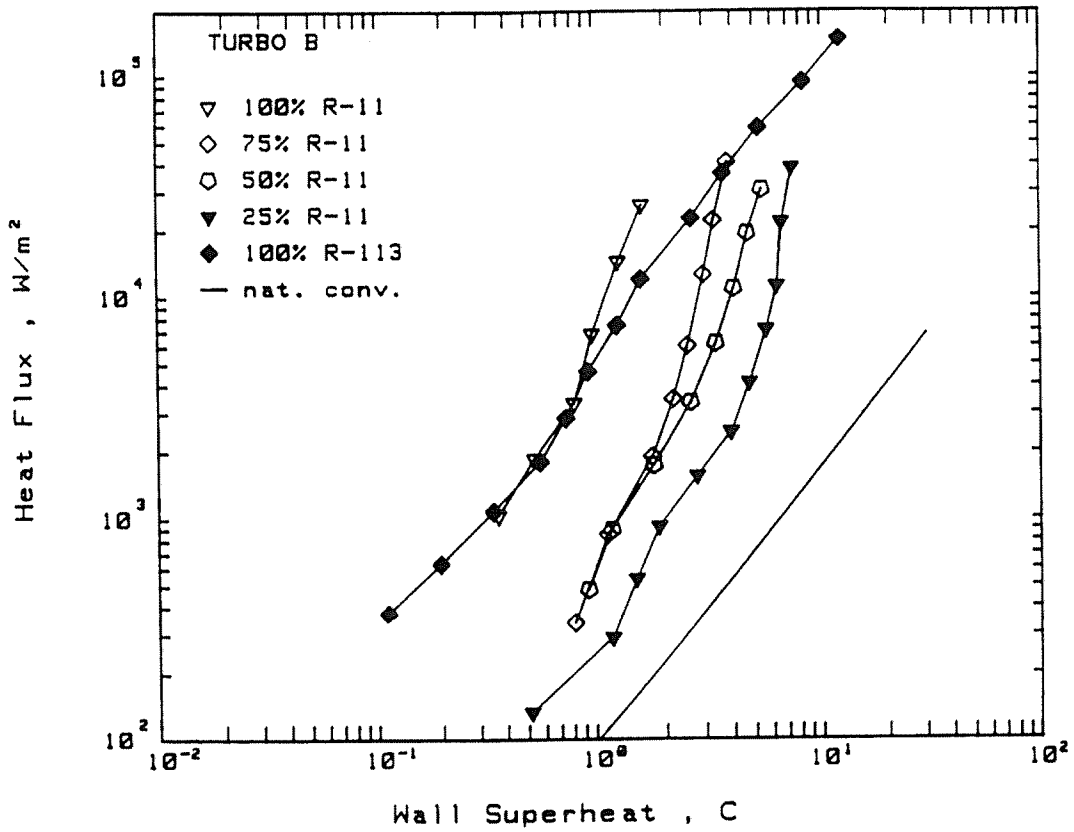


Figure 7.1. Saturated pool boiling curve for the Turbo–B tube in mixtures of R–11 and R–113 at P = 103 kPa. (Trewin, 1992).

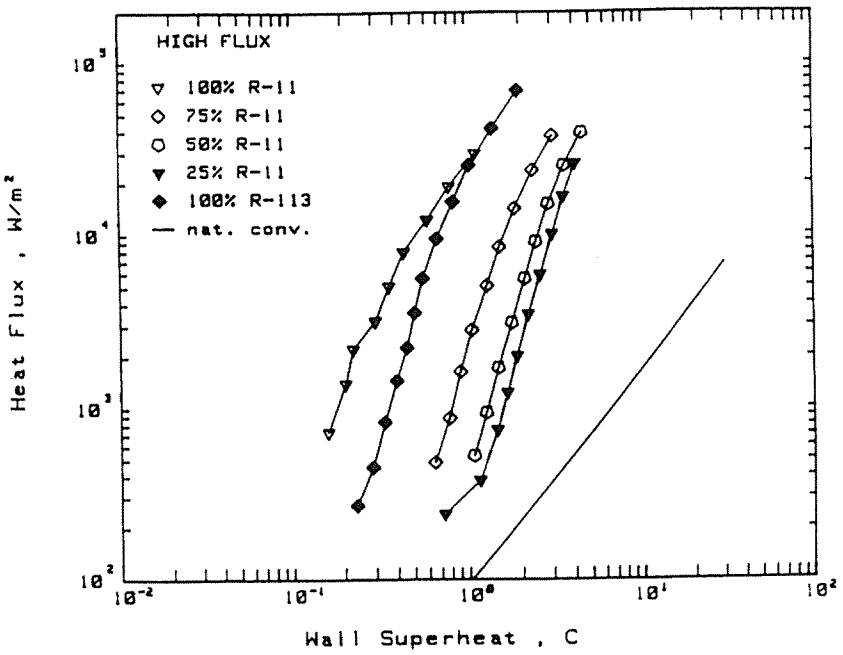


Figure 7.2. Saturated pool boiling curve for the High Flux tube in mixtures of R–11 and R–113 at P = 103 kPa (Trewin, 1992).

indicate that the bubble growth rate in binary mixtures decreases, the bubble radius increases, and the bubble frequency decreases relative to the pure liquid behavior; it is the combination of these three phenomena that contribute to the decreased heat transfer coefficient. No application of these ideas to enhanced surfaces has been made.

Flow Boiling

Takamatsu et al. (1990) studied forced convective evaporation of nonazeotropic refrigerant mixtures (NARM) of R22 and R114 in a spirally grooved tube. The experimental data for the pure refrigerant R–22 and pure R–114 were, respectively, 120% and 90% greater than that predicted by a smooth tube correlation. The NARM's results were between about 20 and 60% greater than that estimated by the smooth tube correlation, depending on the mixture concentrations. A correlation for the heat transfer coefficient is presented. Frictional pressure drop was found to be unaffected by the bulk concentration.

Hinton et al. (1992) tested a R143a/R124 NARM inside a corrugated tube. To achieve a given heat load, a significantly smaller refrigerant mass flux was needed with the corrugated tube compared to a smooth tube. However, at a mass flux of 328 kg/m^2s, the heat transfer coefficient of the corrugated tube was only 11% greater than that of the smooth tube while the pressure drop was 100% greater. The mixture heat transfer performance is poorer than that of a pure refrigerant. Through comparisons of their data against correlations, the authors conclude that because of the improved heat transfer performance of the corrugated tube, it negates the effect of the mixture when compared to smooth tube performance with a mixture.

Sami and co–workers have presented a series of studies of R–22/R–114 mixtures evaporating in the annulus formed between a smooth outer tube and a double fluted tube on the inside. Sami and Duong (1991, 1992a, 1992b) determined that while the length average heat transfer coefficient for the smooth tube varied nearly linearly between the

pure R–114 and R–22 values, for the enhanced surface the heat transfer was a strong function of mixture concentration; the enhanced heat transfer coefficient ranged from about 2 to 3.5 times that of the smooth tube (Fig. 7.3). A correlation for the heat transfer was presented in terms of the difference between the mixture composition in the liquid and the vapor. Pressure drop was significantly higher with the enhanced tube, and a correlation for the two–phase friction multiplier for the flows was suggested. Effect of mixture composition was not discussed. Sami and Schnotale (1992a, 1992b) presented data similar to that described above but for R–22/R–114 and R–22/R–152a NARMs. The R–22/R–152a mixture had slightly higher heat transfer coefficients in the enhanced tube than the pure R–22 had in the enhanced tube; both were considerably higher than the heat transfer in the smooth tube. A correlation for the mixture heat transfer was presented. In addition, they concluded that the pressure drop was a weak function of mixture concentration.

Conklin and Vineyard (1992) tested smooth tubes fitted with a novel heat transfer surface consisting of a perforated brass foil insert for flow boiling of a R–143a/R–124 NARM mixture. In contrast to the significant heat transfer enhancement obtained by such inserts for flow boiling of pure R–22 (Palm, 1990, 1991a, 1991b), Conklin and Vineyard observed no noticeable enhancement effects of these perforated foil inserts when used with 75% 143a/25% R–124 NARM mixture for the range of flow parameters investigated. In fact, the inserts degraded the heat transfer coefficient for most flow conditions as compared to a smooth tube with no inserts. The increased pressure drop caused by these inserts were, however, relatively small (around 25 to 30% higher than that of a smooth tube).

Trewin et al. (1993) examined shellside boiling in multitube bundles of smooth, High Flux, and Turbo–B tubes. Pure R–11, pure R–113, and mixtures of the two were tested. Both enhanced surfaces were far superior to the smooth surface. However, performance of all surfaces was degraded with the mixtures as compared to either pure fluid result (Fig. 7.4). The degradation due to mixture effects follows a similar behavior

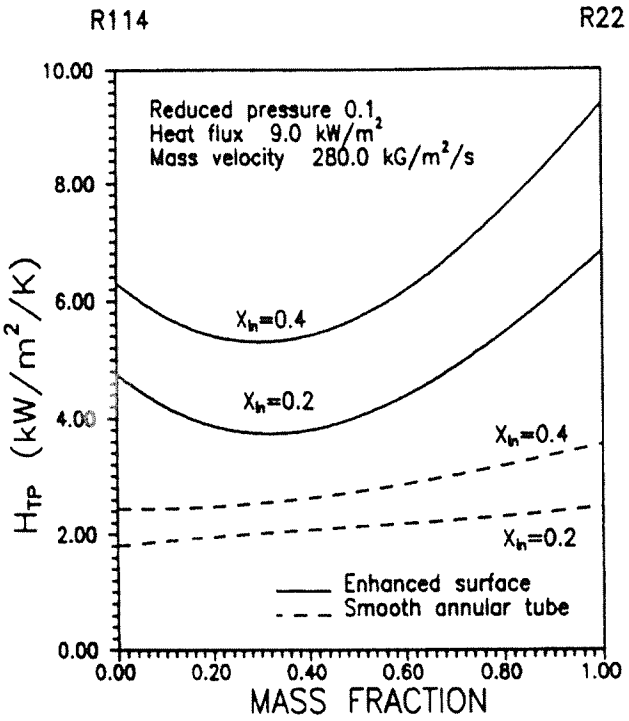


Figure 7.3. Comparison of two–phase flow boiling heat–transfer coefficients on enhanced surface tubing and on plain tube (Sami and Duong, 1992a).

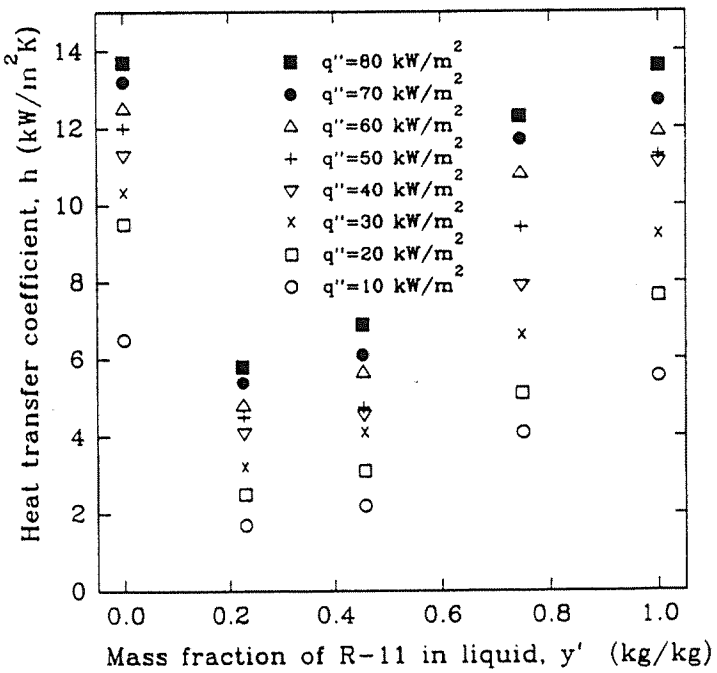


Figure 7.4. Effect of mixture concentration and heat flux on the High Flux heat transfer coefficients (Trewin et al., 1993)

for all three surfaces (Fig. 7.5). The degradation in the smooth tube heat transfer coefficients obtained in fluid mixtures was predicted fairly well using a correlation of the form given by Stephan and Körner (1970), which predicts the wall superheat as a function of the difference between the molar concentration in the liquid and vapor. However, experimental data for the enhanced surfaces were not well predicted using a correlation of the same form. This indicates that the heat transfer process has been significantly altered by the enhanced surface structure, possibly because of the inability of the free stream to affect the heat transfer process near the surface.

Condensation

As with enhanced boiling or forced convective evaporation of mixtures of refrigerants, the literature on enhanced condensation of refrigerant mixtures is small. Several papers have examined finned surfaces. Hijikata and Himeno (1987) also looked at vapor space condensation but on a vertical plate with longitudinal fins. Mixtures of R–113/R–114 and R–113/R–11 were tested. At low wall subcoolings, increasing the mass fraction of R–114 in the R–113 caused the condensing coefficient to decrease significantly; at 10% R–114 at a wall subcooling of about 1 C the decrease was by a factor of 20. (See Figs. 7.6 and 7.7.) However, as the wall subcooling increased the effect of the second vapor had less of an effect so that at 10 C subcooling, a 10% concentration of R–114 caused a factor of 2 decrease in the condensing coefficient relative to the pure R–113. They also tested this mixture in an internally finned tube. Comparable results were obtained. They explained this behavior with the following reasoning. At low wall subcoolings where the vapor flow toward the surface is small, the condensing rate apparently is controlled by the mass transfer diffusion layer. At higher wall subcoolings (or larger condensing rates), the mass transfer resistance in the diffusion layer becomes relatively less so that the condensing behavior more closely resembles that of a pure vapor. Because of improved mixing with

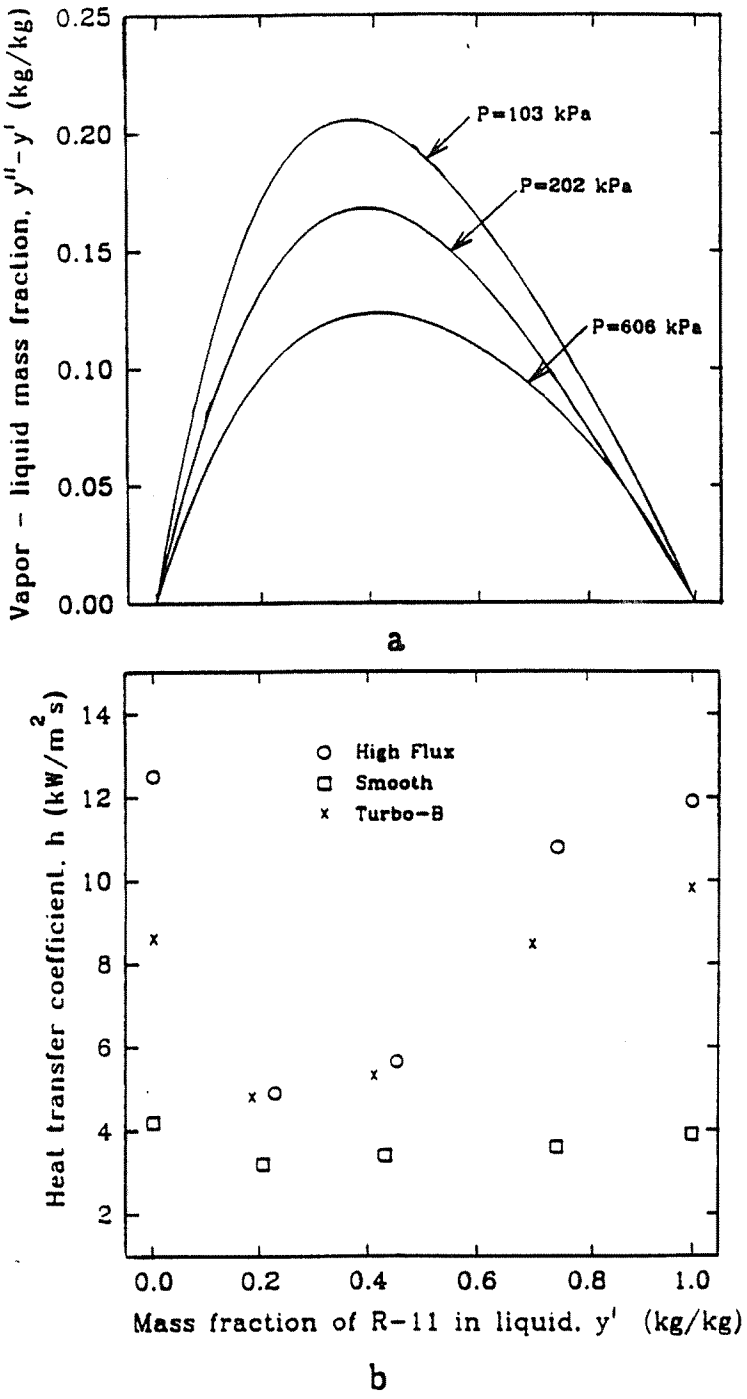


Figure 7.5. A comparison between (a) the difference between the liquid and vapor concentrations of R–11 and (b) experimental trends in heat transfer coefficients at $q'' = 60$ kW/m^2 and P = 200 kPa (Trewin et al., 1993).

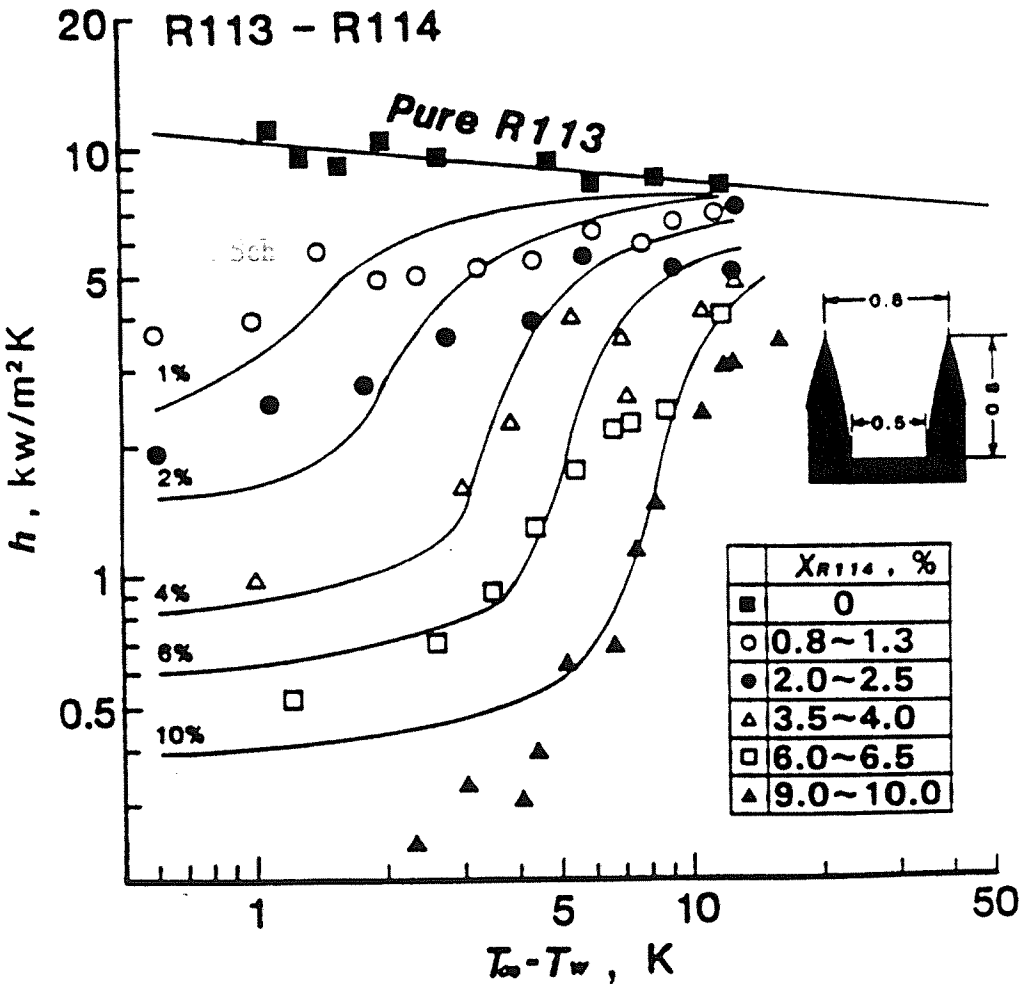


Figure 7.6. Free convective condensation on Surface 2 (Hijikata and Himeno, 1987).

some enhanced surfaces, the effects of the mass transfer resistance may be proportionately less with enhanced surfaces relative to smooth surfaces.

Smirnov (1976) presents data on vapor space condensation of R–12/R–22 on an externally finned tube. Using the actual heat transfer area, the heat transfer coefficient of the finned tube was 1.5 to 2 times that of a smooth tube. An analysis of the condensation of the refrigerant mixture on a finned tube was given that showed reasonable agreement with the data. Murphy et al. (1988) tested horizontal low–finned tubes in R–114/R–12 mixtures (Fig. 7.8). Pure refrigerant results on the finned surface agreed very well with a modified Katz–Keller equation (Katz et al. 1954). Degradation in performance was realized with even low amounts of a second vapor in the mixture; for example, with 5% R–12 a 55% decrease occurred in the performance relative to the pure refrigerant case. Koyama et al. (1990) condenser R–22/R–114 mixtures in micro–fin tubes and found a similar degradation

Fluted tubes have been examined in both vapor space condensation and forced convective condensation. Hijikata and Himeno (1987) compared the performance of a smooth and a low fluted tube with the tube orientation and flow direction varying. Flow direction did not affect the smooth tube performance but did affect the fluted tube heat transfer coefficients; the enhanced tube results varied by a factor of about 2 depending on whether the tube or the flow was vertical or horizontal (Fig. 7.9.). Kawano (1990) used a downward flow of R–114/R–152a mixtures on the shellside of a small bundle of fluted tubes. Good agreement was obtained between a correlation for the pure refrigerant condensing on a fluted surface. Very large differences were found between the pure refrigerant results and the mixture results at low temperature differences but only small differences were obtained at large wall subcoolings (large heat duties). Sami and Schnotale (1992c) also tested forced convective condensation on a fluted tube, which was the inner

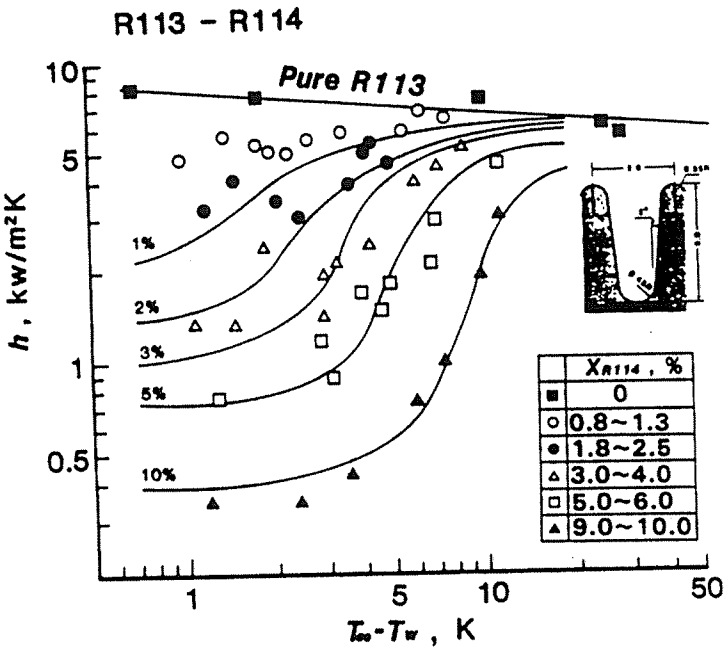


Figure 7.7. Free convective condensation on Surface 1 (Hijikata and Himeno, 1987).

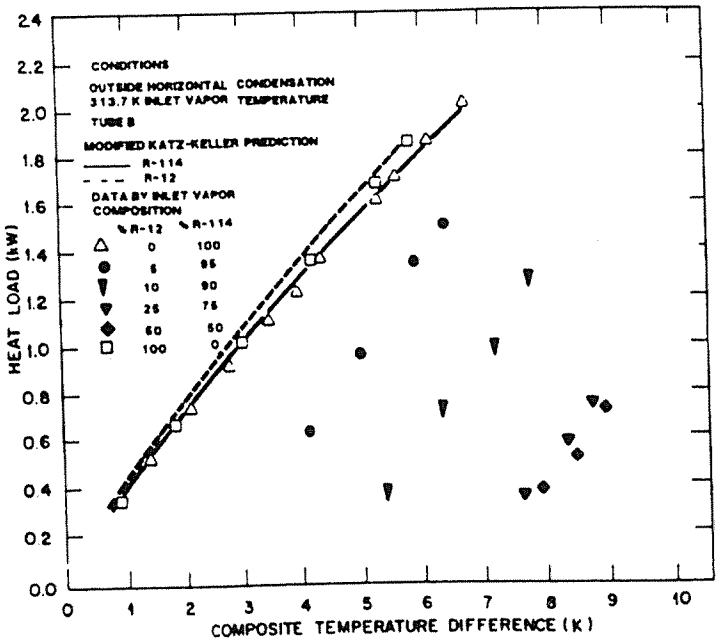


Figure 7.8. Measured R–114/R–12 mixture condensing performance on tube B (Murphy et al., 1988).

tube of a tube–in–tube heat exchanger. For pure R–22, the fluted tube enhanced the condensing coefficient by a factor of about 3.3 compared to a smooth tube, while for mixtures of R–22/R–114 the condensing coefficient varied nearly linearly with composition between the two pure refrigerant's performance on the fluted tube. For a mixture of R–22/R–152 the trend was not quite linear. A correlation for the mixture condensing coefficient is presented.

Nozu et al. (1991, 1992) condensed R–114/R/113 mixtures in the annulus of a tube–in–tube heat exchanger in which the inner tube was fluted and copper wire fins were soldered to the outer surface. No comparisons with smooth tube results were made. Heat transfer decreased relative to pure R–113. Both the pressure drop and heat transfer were correlated satisfactorily. Conklin and Vineyard (1991) condensed R–143a/R–124 mixtures inside an internally finned and a fluted tube. The finned tube had both a higher condensation coefficient (See Fig. 7.10) and a lower pressure drop than the fluted tube. They concluded that the enhancement geometry affects the condensing process in nonazeotropic mixtures.

Two papers have presented information on condensing in compact heat exchangers. Shohtani (1990) (for R–11/R–12) and Mitsuda et al. (1990) (for R–12/R–114 and R–22/R–114) studied plate fin heat exchangers in which the refrigerant mixtures flowed through serrated fins. Shohtani found only a small degradation in the condensing coefficient relative to a pure refrigerant and attributed this to the high turbulence level in the finned geometry. Contradicting this, Mitsuda et al. indicated that at low mass fluxes the heat transfer coefficient for the two mixtures were from 23% (R–22/R–114) to 45% (R–12/R–114) lower than that of pure R–22.

Bokhanovskiy (1980) presented a short paper on condensation of mixtures of R–12/R–22 in a coiled tube. No comparison was made with a straight smooth tube so that assessment of the enhancement cannot be made.

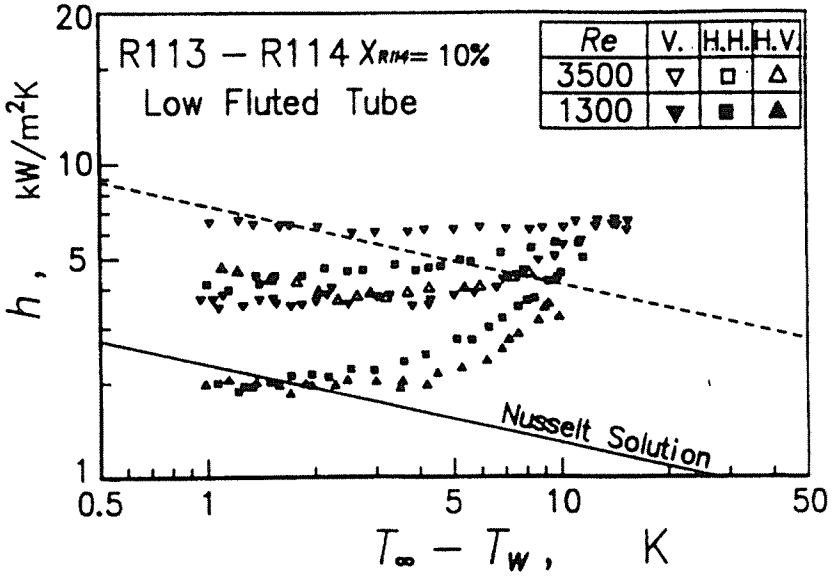


Figure 7.9. Condensation on finned tube. V indicates a vertical tube and horizontal flow, HH indicates a horizontal tube and horizontal flow, and HV indicates a horizontal tube and a vertical flow (Hijikata and Himeno, 1987).

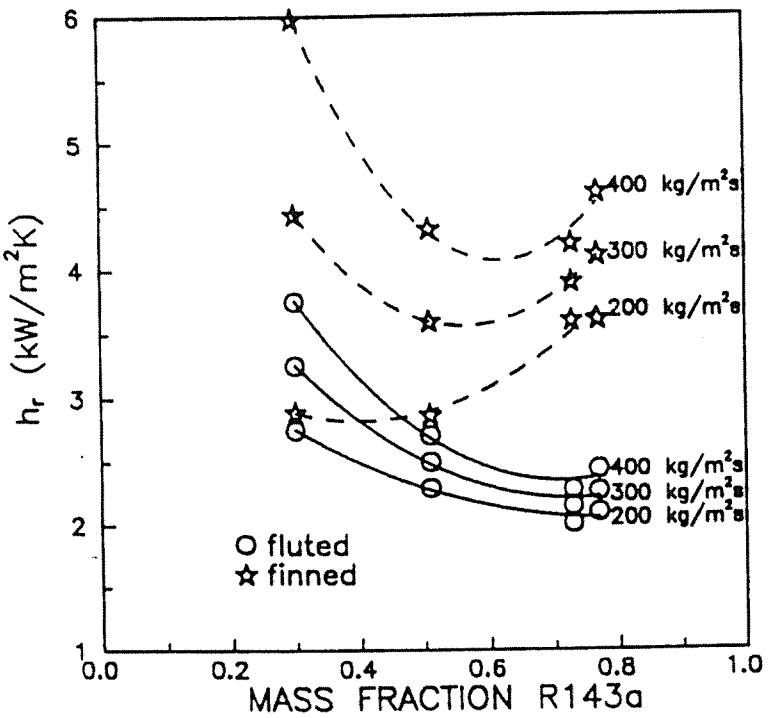


Figure 7.10. Average condensing coefficient for R–143a/R–124 mixtures computed from linear regression of data (Conklin and Vineyard, 1991).

8. EFFECT OF LUBRICANTS ON ENHANCED HEAT TRANSFER

Oil is usually present in refrigeration and air conditioning systems due to the lubrication requirements of the compressor. The oil concentration in the refrigerant will vary depending on the design of the system, but the usual oil concentration range is from about 1 to 5%. While this is not very much, it can and does have a significant effect on the heat transfer processes in the evaporator and condenser. Both the thermodynamic and transport properties of the refrigerant are changed by the presence of the oil (see, for example, Jensen and Jackman, 1984, McMullan et al., 1985, Baustian et al., 1986, 1987) and the heat transfer mechanisms governing the processes are modified such that the heat transfer coefficients are different between pure refrigerants and refrigerant–oil mixtures. Chaddock (1976) surveyed the pool boiling and in–tube forced convective evaporation literature on refrigerant–oil mixtures for smooth tubes. Schlager et al. (1987) have presented a comprehensive review of the literature concerning evaporation and condensation with and without oil in smooth and enhanced tubes. They found no papers that addressed the effects of oil on enhanced in–tube evaporation or condensation of refrigerants; a few papers had studied the effects of oil on enhanced pool boiling or vapor space condensation of refrigerants. Because of the small numbers of papers, this chapter is divided only into sections entitled Pool Boiling, Flow Boiling, and Condensation.

Pool Boiling

The effect of oil in a refrigerant has been studied on a variety of low–fin and treated surfaces in pool boiling. For low fin tubes, Sauer et al. (1980), using R–11, concluded that for up to about 3% oil concentration the heat transfer was either slightly improved or had no effect relative to a pure refrigerant; oil concentrations greater than 5% significantly degraded the heat transfer coefficient. Similar performance occurred with the smooth tube. Mori et al. (1975) investigated oil effects in a low–finned tube bundle (8 tubes) with R–22,

R–502, R–115, and R–11. Using oil concentrations from 0 to 10%, they found that with an increasing oil concentration, the heat transfer peaked at 1% oil for R–22 and R–502 and then decreased, such that at 7% with the R–22 and 3% with the R–502 the performance was below the 0% results. All increasing oil concentrations caused the R–115 heat transfer to continuously degrade while the R–11 performance was unaffected by the oil up to an oil concentration of 6%. Heimbach (1972) used a 10–tube low–fin bundle with R–12 and R–22 and concluded that increases in the heat transfer coefficient of up to 1.5 times relative to pure refrigerants may result at oil concentrations between 3 and 7% if the components are completely miscible. Partial miscibility will increase the heat transfer depending on the amount of oil that will saturate the refrigerant at the boiling temperature. Bell et al. (1987) measured a decreased heat transfer coefficient when boiling R–113 on a finned surface and attributed the decrease to preferential accumulation of oil at the interface.

In contrast to the very open surface of a finned tube, treated surfaces (such as the High Flux, Gewa–T, Thermoexcel–E, and Turbo–B tubes) have been designed with subsurface passages and cavities which contribute to their improved nucleate boiling performance relative to a smooth tube. Because of the small cavities and passages in these types of surfaces, there was early concern that the oil might have more of a detrimental effect on pool boiling heat transfer compared to finned surfaces. However, this concern has been somewhat allayed by a number of investigations. Czikk et al. (1970) studied a porous coated tube in R–11 at an oil concentration of 2%. They found no effect on the performance of the tube with this miscible oil but questioned the applicability of this enhanced surface for use with an immiscible oil.

Stephan and Mitrovic (1981,1982) boiled R–12 at two different saturation temperatures with concentrations of Shell Clavus 68 oil of 0 to 9% on a 7–tube bundle of Gewa–T tubes. Relative to the pure refrigerant results (Fig. 8.1), the heat transfer coefficient for the oil tests decreased with increasing mass fraction of oil. In their latter

paper, they offer a qualitative explanation of the mechanisms governing the boiling of refrigerant–oil mixtures.

Wanniarachchi et al. (1986) found that for pure R–114, the High Flux surface had a heat transfer coefficient about ten times that of a smooth tube and with up to 10% oil the factor was still about seven. A 3% oil concentration caused a 35% decrease in the heat transfer coefficients over all heat fluxes. Oil affected the porous surface proportionately more than the smooth surface. This was attributed to an increased oil concentration forming in the porous matrix. A later paper (Wanniarachchi et al., 1987) examined the influence of oil on the High Flux, Gewa–T, Thermoexcel–E, and Thermoexcel–HE surfaces. Oil caused a degradation in the performance of all the tubes. The High Flux showed the largest decrease while the Gewa–T experienced the least. Different enhanced surface structure (interconnected cavities versus circumferential channels, respectively) was credited with causing the differences. The degradation in the enhanced surface performance was greater than that of the smooth surface, though the enhanced surfaces still had significantly higher heat transfer coefficients than the smooth tube. Memory and Marto (1992) continued this research by examining the influence of oil on the hysteresis on enhanced surfaces. Using the results from the previous two studies and additional tests using R–114–oil mixtures on modified integral fin tubes (Gewa–K, Gewa–T, and Gewa–YX) and structured surfaces (Thermoexcel–E, High Flux, and Turbo–B), they concluded that not only did the oil degrade the nucleate pool boiling performance it also delayed incipient boiling on structured surfaces with increases in oil concentration. No systematic effect was noted with the modified finned surfaces. (See Figs. 8.2 – 8.5.)

Curcio and Somerscales (1991) examined the effect of several different pore sizes on the High Flux surface and several different gap sizes on the Turbo–B surface in R–113–oil mixtures. They concluded that no particular surface or geometry was more susceptible to improvements or degradations due to the presence of oil.

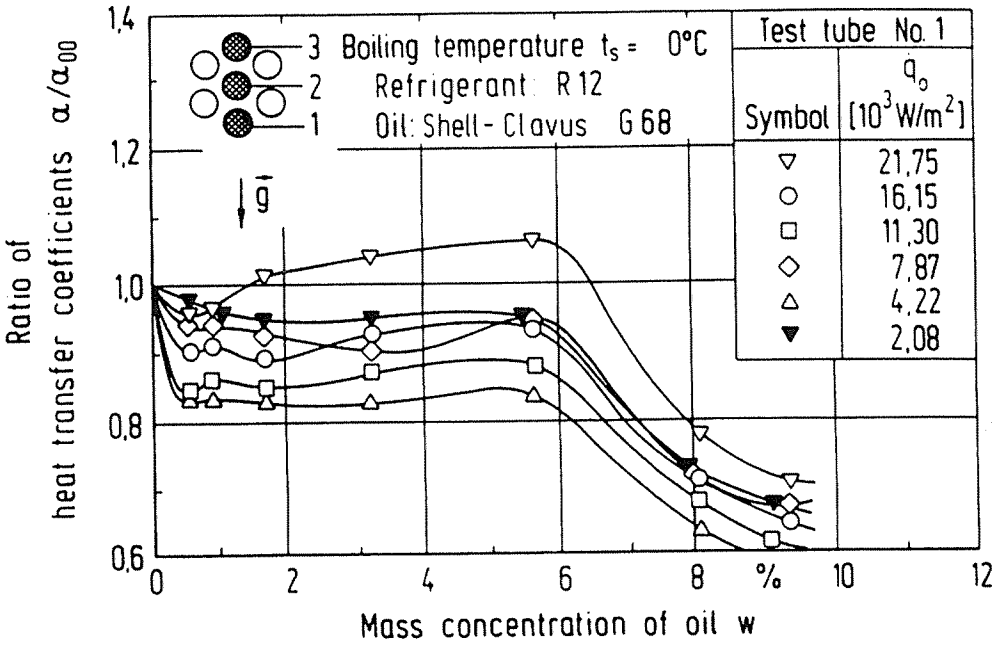


Figure 8.1. Ratio of heat transfer coefficients with and without oil present as a function of mass concentration of oil in the mixture (Stephan and Mitrovic, 1982).

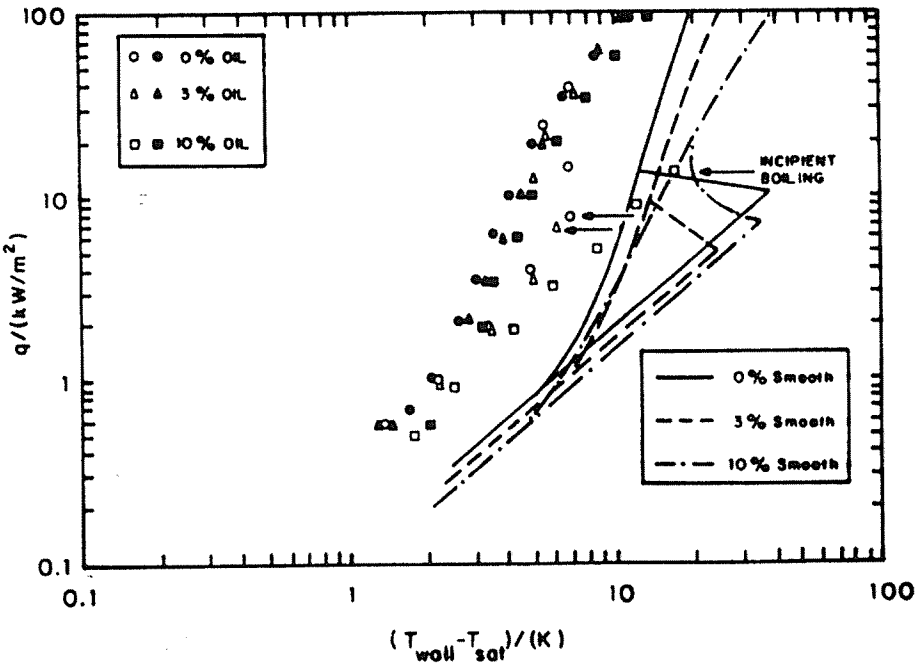


Figure 8.2. 26 fpi GEWA–K data for 0, 3 and 10% oil concentration (Memory and Marto, 1992).

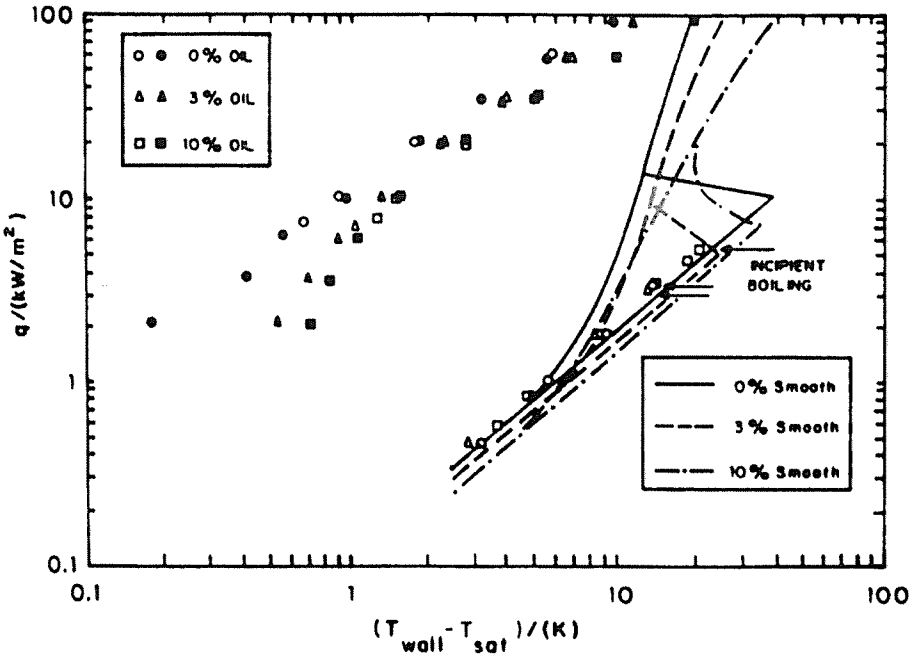


Figure 8.3. Thermoexcel–E data for 0, 3 and 10% oil concentration (Memory and Marto, 1992).

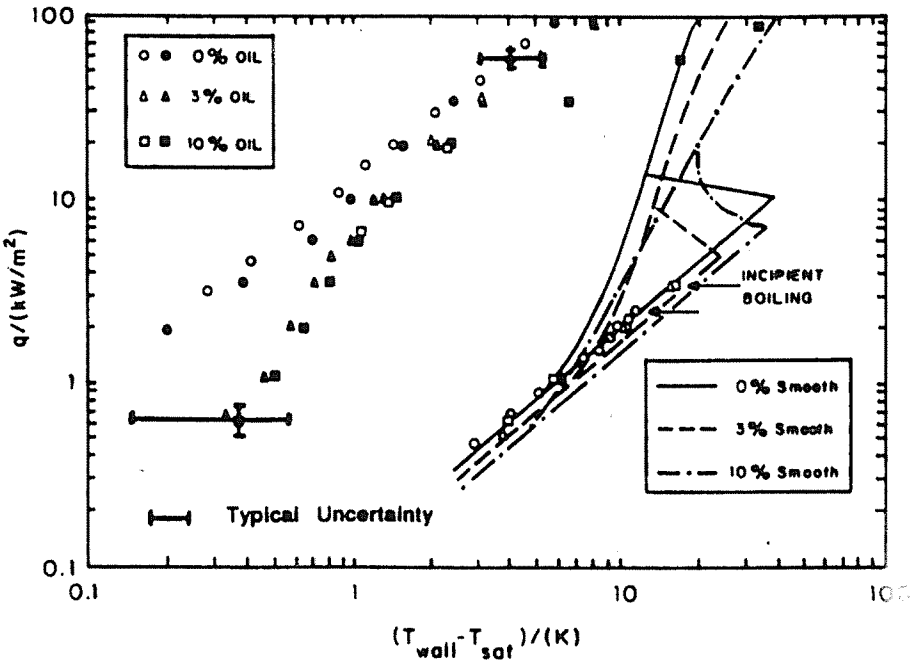


Figure 8.4. High Flux data for 0, 3 and 10% oil concentration (Memory and Marto, 1992).

Danilova et al. (1991) used an 8–tube bundle with porous surfaces to investigate boiling of R–717 and R–22 with oil. The oil and R–717 were immiscible and the oil and R–22 were partially immiscible. The porous surface had a heat transfer coefficient up to 3.5 to 4 times that of the smooth depending on fluid and heat flux. Relative to the smooth surface at the same oil concentration, they found that dramatic decreases in the porous surface performance occurred for both fluids at oil concentrations as low as 1% and suggested that the reason for this degradation was due to the pores filling with oil. Grant et al. (1989) concluded from High Flux surface tests with R–113 and Shell Clavus oil mixtures that the enhanced surface was more affected by the oil than was the reference plain tube; however, the enhanced surface still performed better than the smooth tube. Arai et al. (1977) used a structured surface (tunnel and pore) in a tube bundle evaporating R–12. For oil concentrations of up to 3.4%, they concluded that performance was lowered, but not much below that of a single tube. However, foaming occurred in the bundle with the refrigerant–oil mixture, and this was found to be beneficial to the overall heat transfer.

Murphy (1987) compared the performance of finned tubes with the Turbo–B surface in R–114–oil mixtures and concluded that the Turbo–B, at oil concentrations of up to 10%, always performed better than the finned surface. Comparison of the behavior of a finned surface and a porous sintered surface also indicated that the oil did not degrade the porous surface performance significantly more than the finned surface (Marvillet, 1989). McManus et al. (1986) also used a R–114–oil mixture to compare the performance of a spirally–roped High Flux tube and a Turbo–B tube. For the pure refrigerant, the High Flux tube performed better than the Turbo–B, but the decrease in heat transfer performance with increased oil concentration was less pronounced for the Turbo–B tube; at 6% oil the Turbo–B tube had a 23% decrease in the heat transfer coefficient relative to pure refrigerant while the High Flux had a 52% decrease. Both tubes' performance with the oil–refrigerant mixture was significantly better than the smooth tube.

Because these refrigerants are dielectrics, several studies have been performed to determine if an additional body force caused by electrohydrodynamic (EHD) means could enhance nucleate pool boiling. Allen and Cooper (1987) investigated the use of EHD on pool boiling of R–114–oil mixtures on a finned surface. For pure R–114 at low heat fluxes and an applied voltage of 27kV, the heat transfer was enhanced by about a factor of four or five compared to that obtained with zero applied voltage. Addition of 5% oil produced nearly identical results; 10% oil caused a significant degradation by about a factor of three. Cooper (1990) presents an analytic model which was used to help correlate the EHD nucleate pool boiling data. Ohadi et al. (1992) also used EHD enhancement for pool boiling of R–123–oil mixtures on smooth tubes. At higher voltages and lower heat fluxes the ratio of EHD boiling data to that with no voltage applied was as high as 5.5; this ratio decreased to about 4 at an oil concentration of 5%. (See Fig. 8.6). At higher heat fluxes the oil had little effect and the ratio was in the range of 1.5.

Flow Boiling

The literature on enhanced in–tube evaporation of refrigerant–oil mixtures consists only of studies with internally–finned tubes. Kubanek and Miletti (1979) performed evaporation tests of R–22 in internally–finned tubes. Using an oil separator, they reported that an oil concentration of 0.1% had no effect on the heat transfer compared to pure refrigerant results. Schlager et al. (1988a, 1988b, 1989a, 1989b, 1989c, 1990a, 1990b) have presented numerous reports addressing evaporation and condensation of R–22 with and without oil in low–fin and micro–fin tubes. Typical results are shown on Fig. 8.7. Their conclusions, based on length–average heat transfer characteristics, were that with pure refrigerants the micro–fin tube enhances both the evaporation average heat transfer coefficients by as much as 250%. Small amounts of oil enhance the evaporation heat transfer compared to evaporation of a pure refrigerant; the peak enhancement was obtained at a higher oil concentration (2.5%) in the

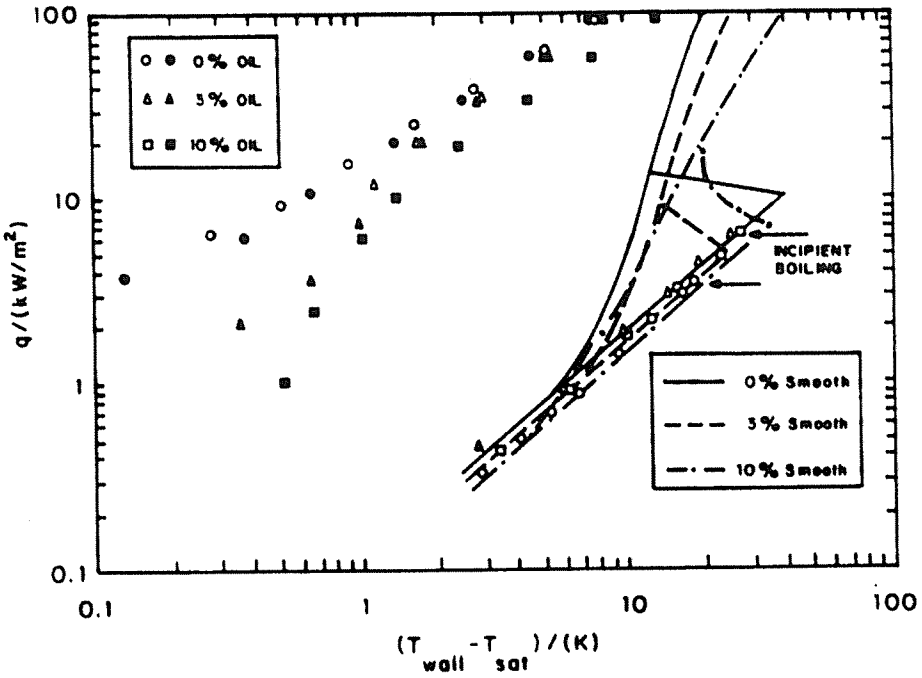


Figure 8.5. Turbo–B data for 0, 3 and 10% Oil Concentration (Memory and Marto, 1982)

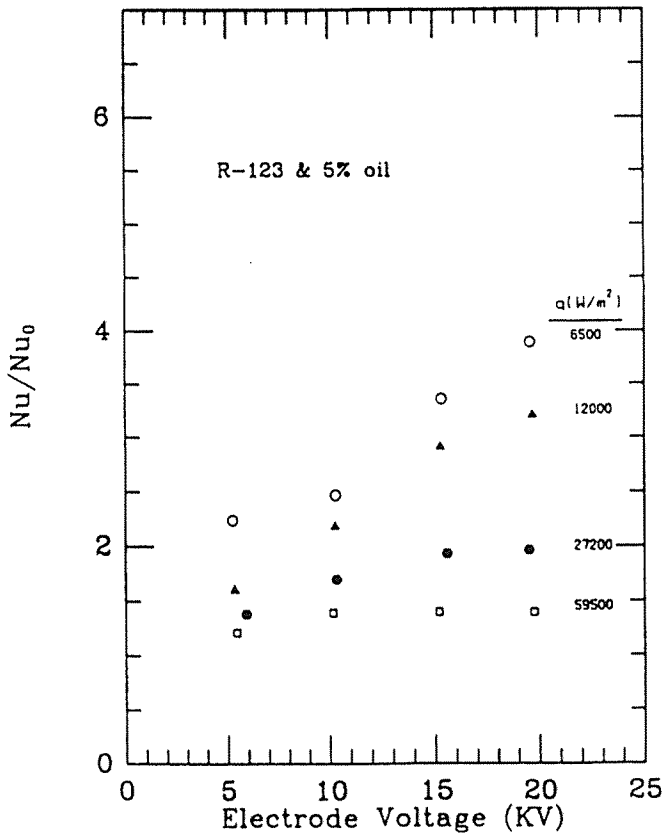


Figure 8.6. EHD heat transfer enhancement of R–123 at 5% oil (Ohadi et al., 1992).

smooth tube than was experienced with the micro–fin tube (1.5%). Increasing the oil concentration and mass flux resulted in a decreasing average heat transfer coefficient. A higher viscosity oil (300 SUS) did not enhance the evaporation heat transfer at all, and a 30% decrease in the heat transfer coefficient was obtained at a 5% oil concentration. In all situations, the micro–fin tube average heat transfer coefficient with oil was in the range of 1.8 to 2.7 times that in a smooth tube with oil, depending on the oil concentration and mass flux.

Yoshida and Matsunaga (1991) also studied evaporation of R–22 with oil in a micro–fin tube and obtained results that generally were similar to those of Schlager et al. (1989b). A few minor discrepancies were attributed to different oil viscosities, the geometry of the micro–fins, and the heating method.

Recently, Manwell and Bergles (1990) clarified the mechanisms of heat transfer enhancement in an evaporating refrigerant in a micro–fin tube by visually examining the gas–liquid flow patterns. Oil–induced foaming washes the side walls of a smooth tube, thereby increasing the wetted area. For both pure R–12 and R–12/oil mixtures, the micro–fin surface promoted thin films on the sides and top of the tube. The modification of the stratified flow pattern, as formally documented in flow pattern maps, is responsible for the increased heat transfer coefficients.

Ha (1992) studied R–12 evaporating in micro–fin tubes and measured a decreased heat transfer coefficient, particularly at higher qualities, with addition of oil. Visual observations indicated that a oil–rich film existed around the entire circumference of the the horizontal tube.

Condensation

Sauer and Williams (1982) examined vapor space condensation of R–11 and oil on low–fin tubes. For oil concentrations up to about 12% (Figs. 8.8 and 8.9), the condensing

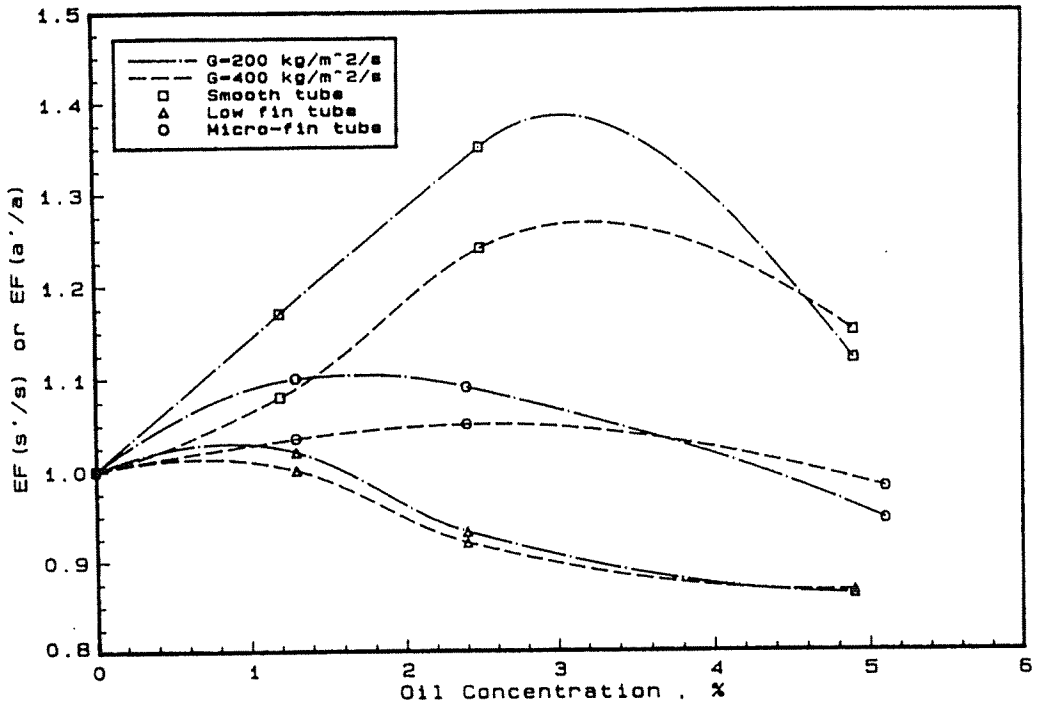


Figure 8.7. Evaporation enhancement factors due only to the effects of oil for the micro–fin tube in addition to the smooth tube and the low–fin tube (Schlager et al., 1988b).

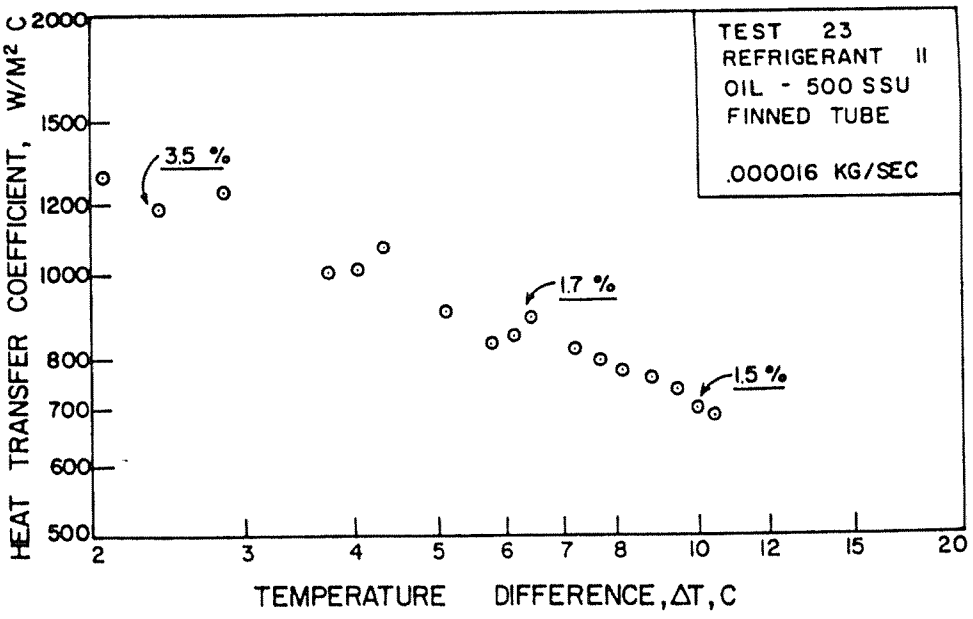


Figure 8.8. Experimental results with low oil concentrations (Sauer and Williams, 1982).

curve did not vary appreciably between the pure refrigerant results and the oil–refrigerant results. Visual observations indicated that the condensation behavior was different when oil was present, and that the oil tended to flow into the channels between fins. Yamashita (1972) used a low–finned coil to study condensation of R–22 and oil but the oil concentration was not specified. They concluded that the Nusselt analysis could be adapted with satisfactory results. Wang et al. (1989) used oil in condensing R–12 and R–22 on finned tubes. Oil decreased the condensing coefficient but had no appreciable effect on the pressure drop. Because of scatter in the data, the authors could not definitively state that increasing oil concentration caused a decreasing condensing coefficient.

Schlager, Pate, and Bergles have presented a series of papers dealing with enhanced in–tube condensation of refrigerants. The effect of oil on R–22 condensing in a micro–fin tube was demonstrated in Schlager et al. (1988a, 1990a). Oil decreased the condensing coefficient relative to the pure refrigerant in both the smooth and micro–fin tubes by the same amount. At 1.2% oil the ratio of heat transfer coefficient with oil to that without (enhancement factor, EF) was 0.94 and at 5% oil it was 0.87; these ratios remained nearly constant over all mass fluxes. For a low–fin tube (Schlager et al., 1988b, 1990a), the addition of oil did not have as much as an effect as with the micro–fin tube; the EF at 1.2% oil was 0.99 and at 5% oil it was 0.96. A comparison of the smooth, low fin, and micro–fin results is given on Fig. 8.10. No physical explanation of these results was offered. The previous three papers used a naphthenic mineral oil with a viscosity of 150 SUS. A comparison of the heat transfer and pressure drop effects of oil with 150 SUS versus 300 SUS was presented in Schlager et al. (1989a,b). Generally, there were few differences in the heat transfer results between the 300 SUS oil and the 150 SUS oil: the addition of oil decreased the heat transfer. Oil increased the pressure drop in the augmented tubes (low fin and micro–fin) by 10 to 20% at 5% oil. To assess the effects of both heat transfer and pressure drop, the ratio of the heat transfer enhancement factor was

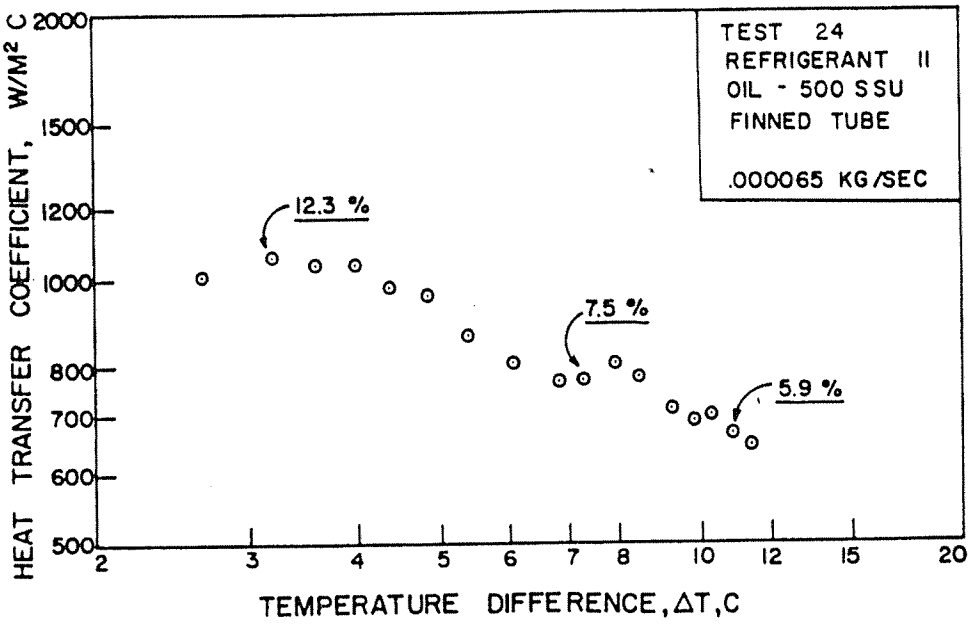


Figure 8.9. Experimental results with high oil concentrations (Sauer and Williams, 1982).

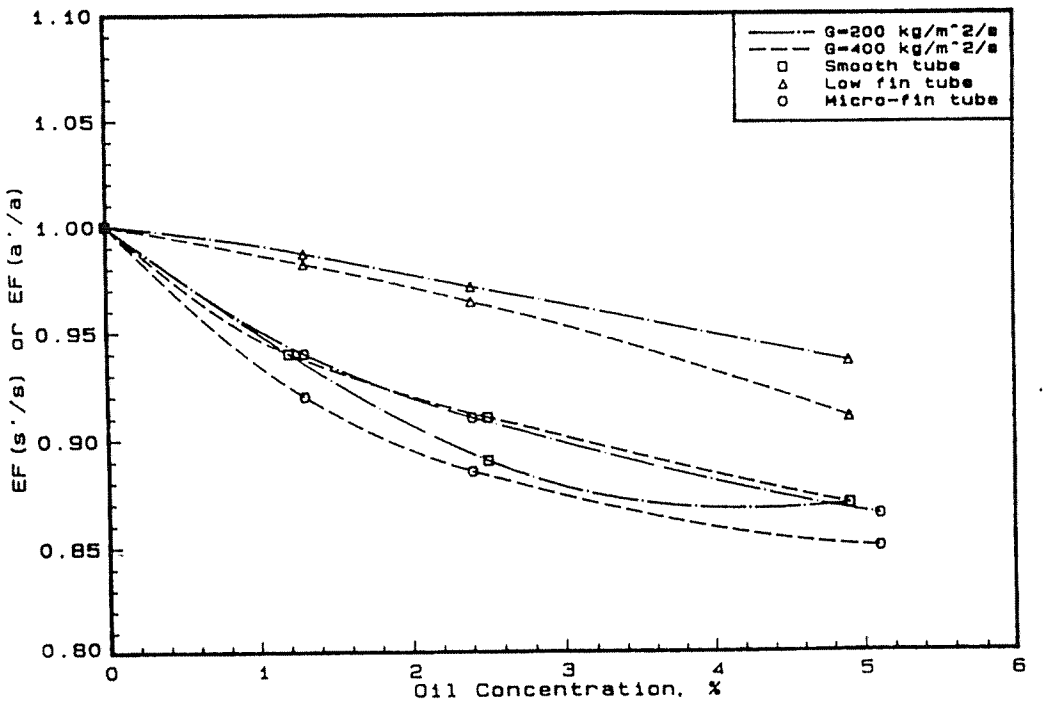


Figure 8.10. Condensation enhancement factors due only to the effects of oil for the micro–fin tube in addition to the smooth tube and the low–fin tube (Schlager et al., 1988b).

divided by the pressure drop enhancement factor (pressure drop with oil to that without). For the two augmented tubes, this ratio decreased with increasing oil concentration; at 5% 150–SUS oil the ratio was between 0.8 and 0.85 but for 300–SUS oil the ratio was about 0.65 for the micro–fin tube. It was noted that these results should only be interpreted for use with fully miscible oils; partially miscible or immiscible oils may have different results. This series of papers was followed by two papers, one that reviewed the literature for correlations and/or predictions schemes for both pressure drop and heat transfer (Schlager et al., 1990b) and the other that proposed new correlations (Schlager et al., 1990c). The literature survey showed that existing correlations were primarily for pure refrigerants in smooth tubes. Hence, the authors presented new statistical correlations whose predictions satisfactorily agreed with the experimental results.

Sur and Azer (1990, 1991) tested several low–fin tubes with R–113–oil mixtures and found heat transfer behavior comparable to that reported by Schlager et al. However, pressure drop was not affected by the presence of oil.

9. SUMMARY REVIEW OF THE PATENT LITERATURE

The following sections of this report describe the patents that are particularly appropriate for boiling and condensation enhancement with refrigerant applications. A large number of patents dealing with enhanced evaporators or condensers, but with enhancement on the air side (typically used for air conditioning applications), were found during the course of the patent literature search; the air side is where the greatest improvements occur in refrigerant–air heat exchangers. These patents are not included in this report. In this section, the enhancement technique as described by the patent, performance data, and the manufacturing technique of the enhancement is discussed. Representative surface geometries and performance data also are shown.

The discussion on the patents is arranged according to the mode of heat transfer and further categorized according to the location of the enhancement; namely, shellside and tubeside enhancement used in shell–and–tube heat exchangers and enhancement used in plate–type heat exchangers. Division of this section according to each type of enhancement technique was not done due to the small number of patents which were found in each category. The review is focused for patents issued after 1983. However, some earlier patents also are discussed for the sake of continuity and completeness.

Pool Boiling

Shellside enhancement

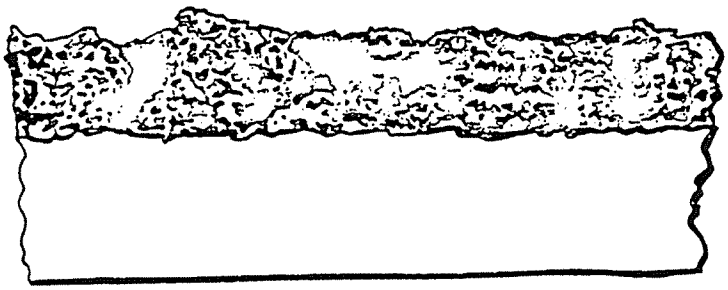
A large number of patents have been issued which propose surface treatment for enhancing pool boiling on a tube outer surface. The most usual form of treated surface include the porous coatings that are typically flame–sprayed or chemically etched onto a surface. Some representative and commonly used treated surfaces are shown in Fig. 9.1. U.S. patent no. 4,354,550 describes a porous, open–cell coating at least 15 mils thick, of oxidized metallic particles which are flame–sprayed onto a metal substrate. The patent

claimed that their process creates a porous coating with substantially more nucleate boiling cavities of the required size for boiling of R–11. Performance data for R–11 boiling were provided to validate the claim. U.S. patent no. 4,846,267 describes a chemical etching process to provide nucleation pits on the metal surface. Performance tests, mostly with boiling nitrogen and water, indicate a 40–60% enhancement. The above technique was recommended particularly for refrigerants such as chlorofluorocarbons.

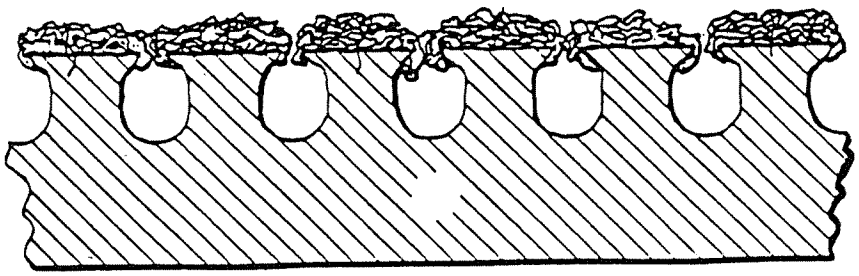
Another novel technique of producing a treated surface to enhance nucleate boiling has been described by U.S. patent no. 4,709,754. The technique consists of laminating metal foils containing a narrow entrance opening to one surface and a wider diameter cavity opening to the other side (see Fig. 9.2). In the completed structure, these cavities form nucleation sites and thus enhance pool boiling. The manufacturing technique is not limited to a particular class of metals, as is often with chemical etching techniques. The patent claimed that the invention is particularly useful for fins for cooling electronic devices that are immersed in dielectric refrigerants.

Rough surfaces, which are commonly used, include grooved, corrugated, or ribbed surfaces. U.S. patent no. 4,313,248 describes a manufacturing method for providing annular and spiral grooves extending along the tube surface, as well as narrow gaps extending along the grooves. The performance data for boiling of R–11 indicate that the boiling heat transfer coefficient is significantly enhanced over that of conventional heat transfer tubes. One of the proposed surface geometries and representative performance data are shown in Fig. 9.3. A manufacturing method for producing externally–corrugated tubes was described by U.S. patent no. 4,186,779.

A method for producing a heat transfer surface which includes a plurality of minute tunnels and pores spaced a small distance from each other is described by U.S. patent no. 4,653,163. These tunnels (see Fig. 9.4) are formed by forming a plurality of fins and then



(a)



(b)

Figure 9.1. (a) Cross section of flame sprayed treated surface (U.S. patent no. 4,354,550) and (b) heat exchange surface with porous coating and subsurface cavities (U.S. patent no. 4,359,086).

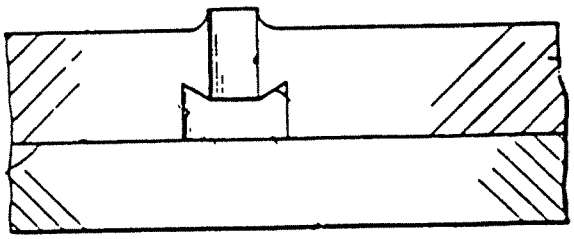


Figure 9.2. Cross section of two laminated foils showing a nucleate boiling cavity (U.S. patent no. 4,709,754).

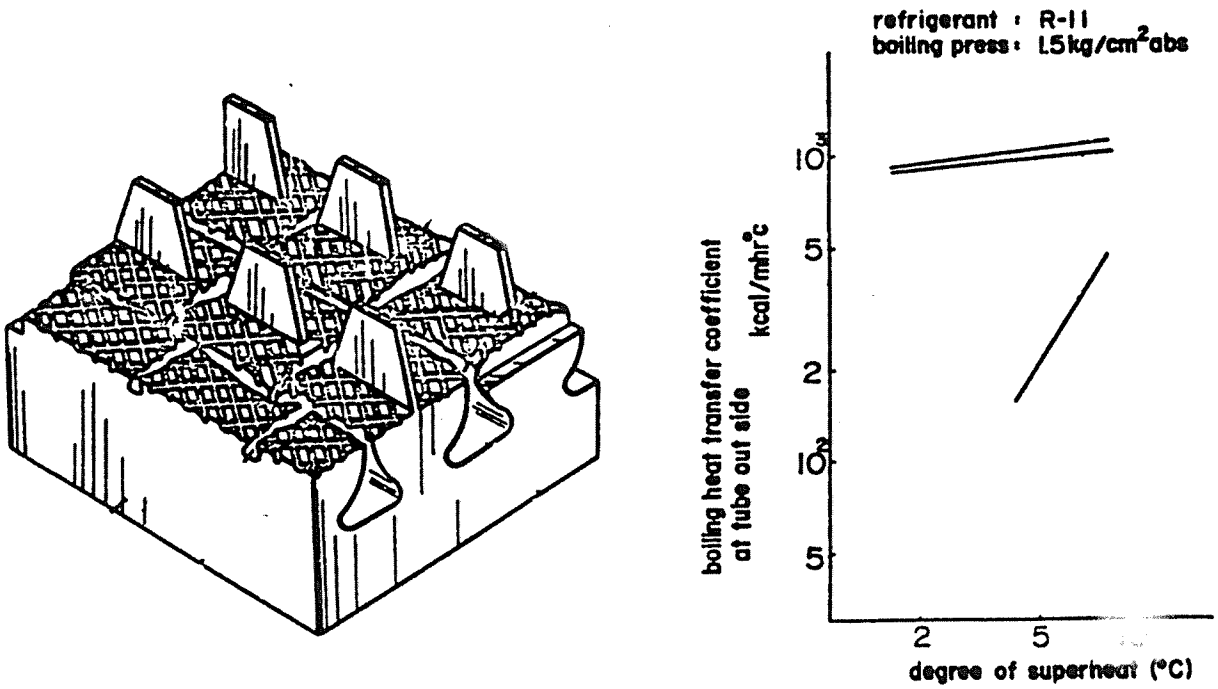


Figure 9.3. Enhanced surface geometry and boiling heat transfer characteristic on the outer tube surface (U.S. patent no. 4,313,248).

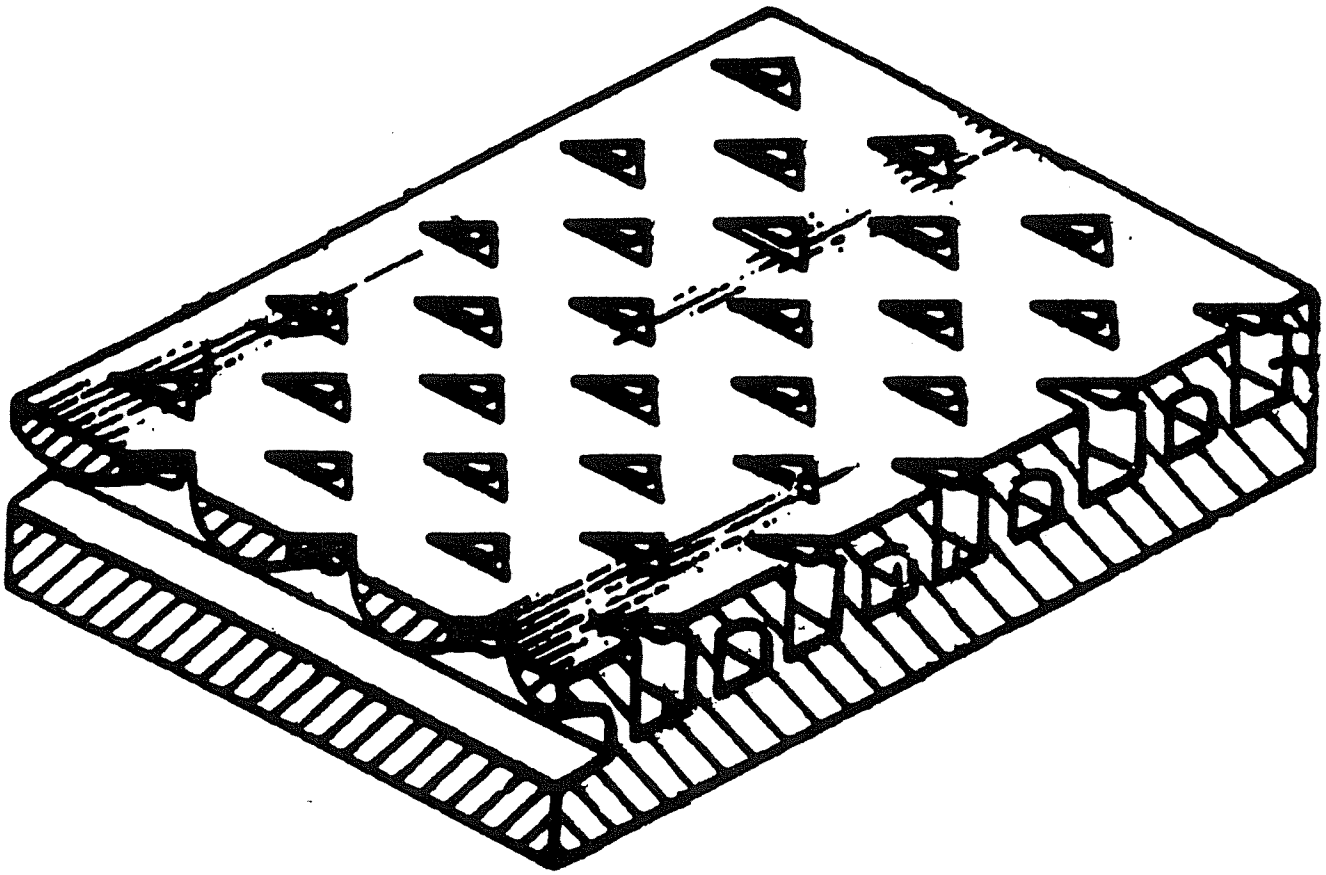


Figure 9.4. Schematic of the enhanced heat transfer surface (U.S. patent no. 4,653,163).

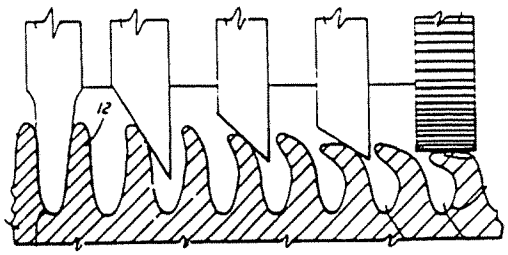
bending these fins, so as to bring each fin into contact with the next adjacent fin. Based on data obtained with R–11, significant improvements in boiling performance were claimed. U.S. patent no. 4,765,058 describes an apparatus for producing high performance evaporator tubes containing similar subsurface channels formed between adjacent helical fins, on the outside of tubes. An enhancement of about 300% in the heat transfer coefficient over that of the commercially available "TURBOCHIL" enhanced tube for boiling R–11 was claimed by the inventor. The tooling, surface geometry, and performance data are shown in Fig. 9.5.

Enhancement in plate–type heat heat exchangers and other geometries

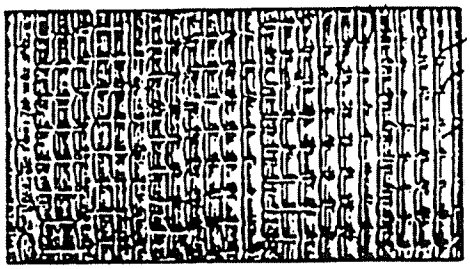
U.S. patent no. 4,767,497 describes a chemical etching process identical to the technique discussed in the preceding section. The process consists of the formation of nucleation pits on the surface of plate or fin–type heat exchangers using an etching process. However, due to the nature of the chemical reaction used in the etching process, the technique seems to be limited to aluminum and their alloys only.

U.S. patent no. 4,706,741 describes a falling film type evaporator comprising heat exchange plates with area enlarging corrugations. In addition to the area enlargement, uniform redistribution of the evaporating film was claimed to have been achieved by this invention. U.S. patent no. 4,216,825 describes a heat exchanger surface containing a number of grooves arranged in concentric circles. These grooves promote formation of boiling nuclei by turbulizing the liquid film. However, no performance data indicating the degree of enhancement obtained were provided.

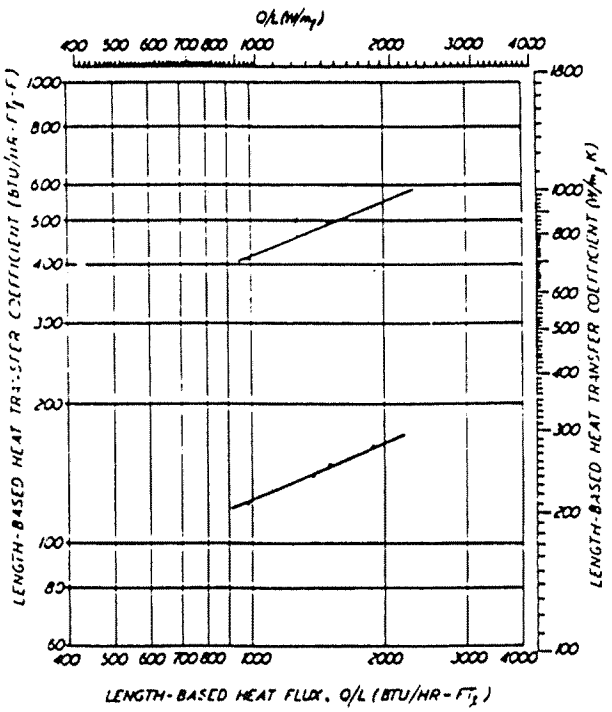
U.S. patent no. 4,741,385 describes means and method for cooling enhancement of electronic devices by gas jet impingement. The method consists of immersing the microelectronic device in dielectric coolant and utilizing a gas jet directly impinging upon the device as shown in Fig 9.6(a). The gas jet enhances pool boiling by agitating the coolant. The invention was claimed to be suitable for cooling microelectronic devices



(a)



(b)



(c)

Figure 9.5. (a) Tool gang arrangement, (b) sectional view of the enhanced heat transfer surface, and (c) comparison of the boiling performance with commercial TURBOCHILL tube (U.S. patent no. 4,765,058).

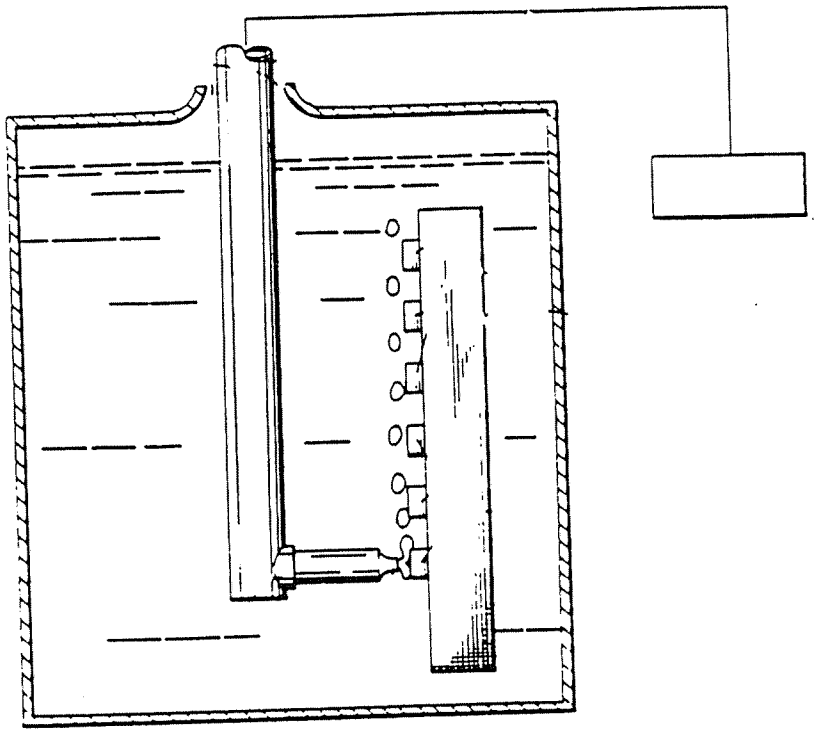
tested at high power levels. Representative data using a R–113 liquid bath were presented (see Fig. 9.6b).

U.S. patent no. 4,731,159 describes an evaporator comprising a plurality of parallel plates that rotate about a common axis and, in addition, the evaporator surface has protrusions and a surface coating that prevent formation of a continuous liquid film. The evaporator described in this patent is shown in Fig. 9.7 and was recommended for any general situation which might involve pure refrigerants (such as, R–22, R–12, R–115, and R–114) or azeotropic refrigerant mixtures. In addition to the protrusions, sand blasting of the surfaces was recommended to promote mixing action in the liquid to be evaporated.

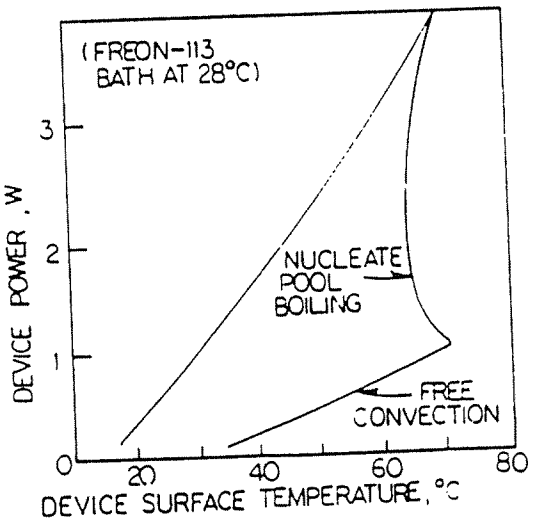
Surface tension device inside tube

This particular class of patents find application in heat pipe and thermosyphon applications. U.S. patent no. 4,515,209 describes heat transfer apparatus comprising an evaporator fabricated from capillary material permeable to the heat transfer fluid. The evaporator contains longitudinal radial vapor release passages and a longitudinal axial passage that communicate between two end cavities for transporting the heat transfer fluid via wicking action. Smooth annular projections are provided on the evaporator surface to prevent vapor from flowing into the two end cavities. It was claimed that the invention increases the heat flux capability by increasing the heat flux density conveyed, and reduces the hydraulic resistance over that of previous patents.

U.S. patent no. 4,819,719 describes an enhanced capillary assisted evaporative surface for use in heat pipe or related applications. The device includes rectangular grooves which are cut in a metal substrate and then plated by vapor deposition process. The process results in a dendritic porous surface deposition that improves both capillary pumping and heat transfer coefficients. Performance data (Fig. 9.8) obtained with R–11 and R–114 indicated that heat flux capability of the plated groove aluminum plate is



(a)



(b)

Figure 9.6. (a) Front view of the gas jet impingement system and (b) graph showing the cooling enhancement (U.S. patent no. 4,741,385).

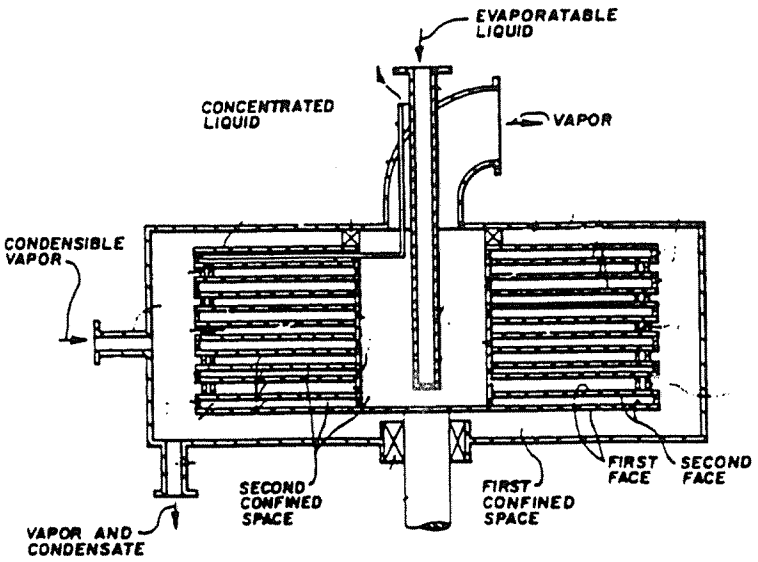


Figure 9.7. Schematic axial section of the rotary evaporator (U.S. patent no. 4,731,159).

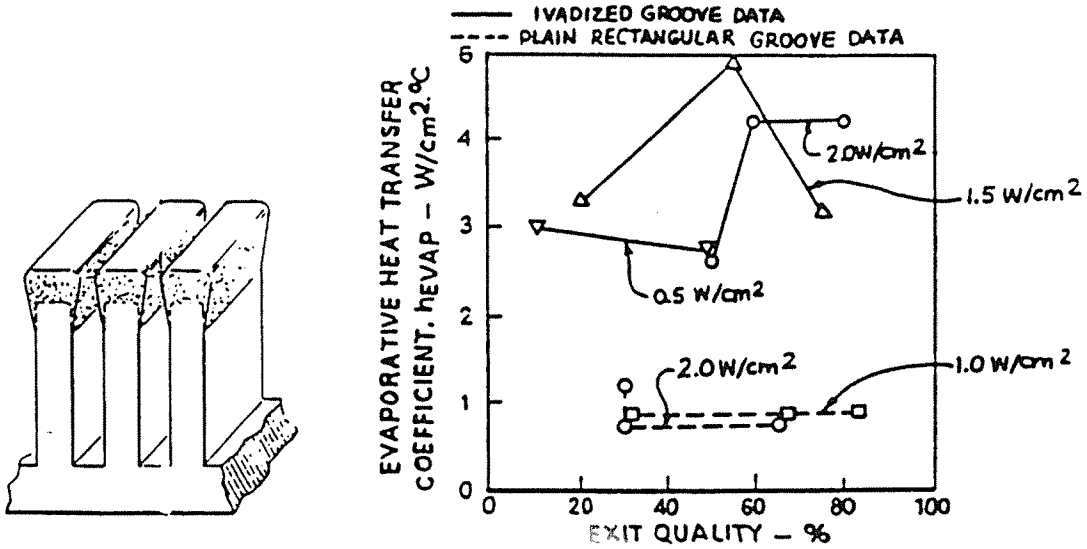


Figure 9.8. Schematic of the vacuum plated groove and boiling performance with R–11 (U.S. patent no. 4,819,719).

approximately five times that of a plain grooved plate. However, no details about the manufacturing technique were provided.

Another patent (U.S. patent no. 4,515,207) describes a heat pipe with a screen mesh artery supported concentrically in the evaporator. The artery retains liquid in the evaporator channel and assures continuous liquid feed to the evaporator during periods of excessive heat transfer required. However, the method described was claimed to be applicable to heat pipes having separate channels for transport of vapor and liquid phases. Both of the two patents described above do not cite any specific refrigerant applications or any performance data.

Flow Boiling

Tubeside enhancement

U.S. patent no. 4,733,698 describes an internally–grooved tube for enhancing boiling performance. The grooves are of rectangular and inverted trapezoidal cross section and cross each other to form tunnels. The ratio of groove depth–to–groove width varies between 0.5 to 0.75. The internal structure comprising the tunnels traps refrigerant vapor and serves as the nucleus for boiling, thereby accelerating the boiling process. Performance data obtained with boiling refrigerant indicted that the heat transfer coefficient is improved by at least 90% as compared to a standard internally–grooved tube. The geometry and performance data are shown in Fig. 9.9. An added advantage of the tube is that it could be used for both boiling and condensation applications.

U.S. patent no. 4,373,366 describes an improved manufacturing technique and machine for forming a plurality of thin, spiral grooves inside a tube. The inventors claimed that unlike previous manufacturing methods, their method results in an increased speed of forming grooves particularly in thin walled, small diameter tubes. One cited application of such grooved tubes is air conditioning tubes.

U.S. patent no. 4,938,282 described a high performance internally–grooved evaporator tube for air conditioning and refrigeration applications. The tooling and tube cross section are shown in Fig. 9.10. The enhanced tube has 60 to 90 grooves which are spiraled at a helix angle of 18 degrees. The grooves are arranged at a sufficiently small pitch so that the groove spacing is about 2–5 times the refrigerant film thickness (usually very small for refrigerants which have high wettability). Furthermore, the groove spacing is of the same order of magnitude as the groove depth to prevent flooding. Even though no performance data were provided in the patent, it is generally well known that a distinct advantage with these micro–grooved tubes is the low pressure drop. In addition, the manufacturing method, which permits use of thinner walled tube as well as provides unworked portions at the tube ends to facilitate flaring into tube sheets, was described.

A doubly enhanced tube is described by U.S. patent no. 4,660,630. The internal enhancement comprises a plurality of closely spaced helical ridges so designed as to provide an extended area as well as to swirl the flow. The external surface is enhanced by successive cross–grooving and rolling operations. The grooving and rolling operation produces cavities or channels which are formed under the flattened fin tips. These cavities serve as boiling nucleii and a efficient pumping system so that vapor bubbles can be readily carried away from the tube and fresh liquid be circulated to the nucleation sites. Thus, the boiling performance, as seen in Fig. 9.11, is enhanced. The patent claims that such tubes could be manufactured by standard finning machine in a single pass. Furthermore, by providing the surface with cavities which are both larger and smaller than the optimum value, a variety of working fluids as well as tolerances in the fabrication process are allowed. The performance data obtained with R–11 indicated that 40–60% savings in the tube material could be accomplished over standard enhanced tubes for the same heat duty. In addition, the performance data showed that the heat transfer coefficient could be significantly enhanced without an substantial increase in the pressure drop. This is probably due to the small size of the extended surface.

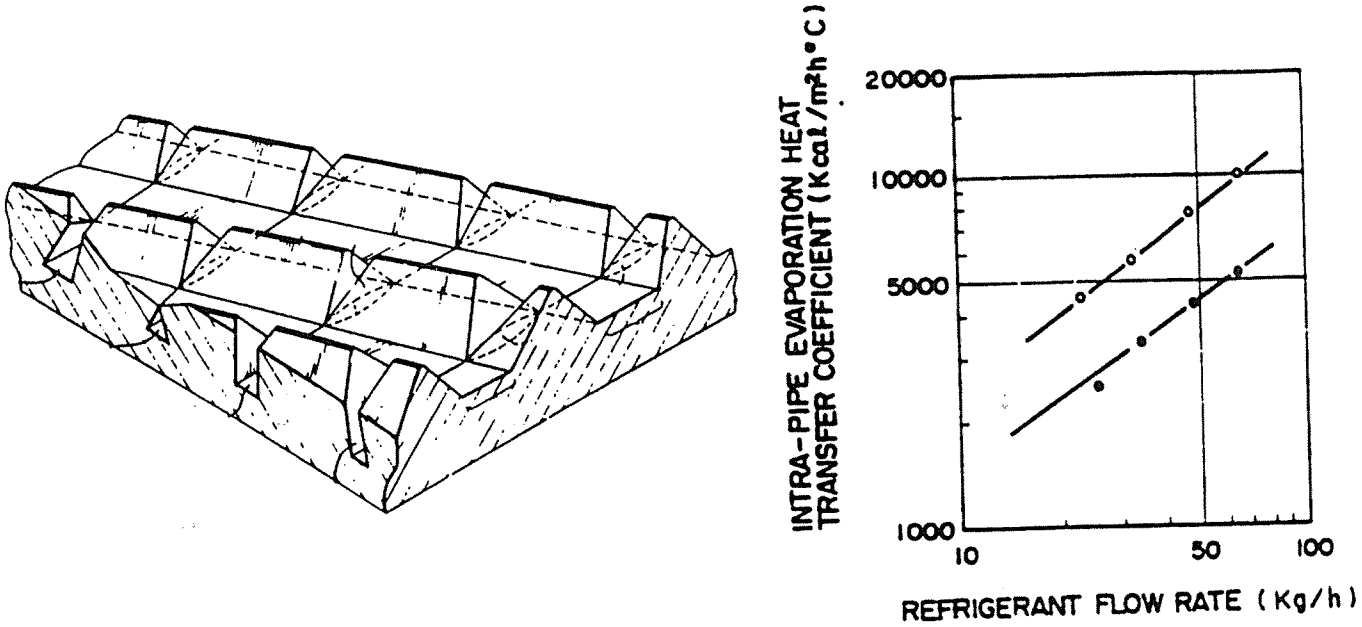


Figure 9.9. Perspective view of the enhanced surface and performance data obtained (U.S. patent no. 4,733,698).

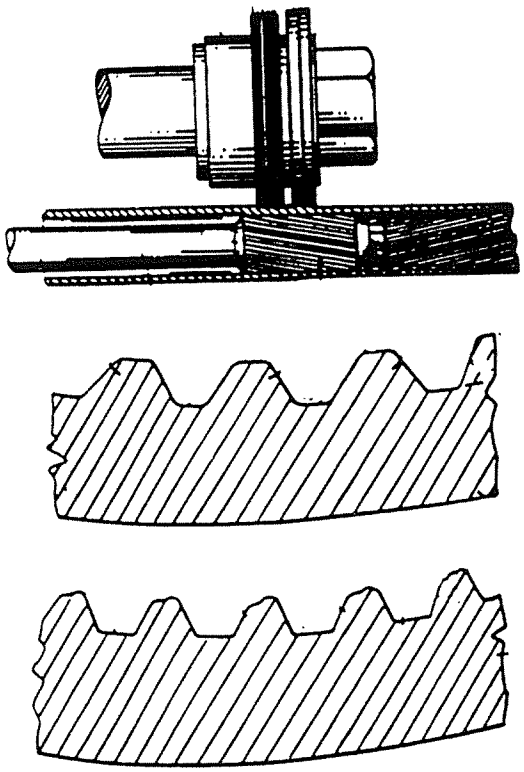
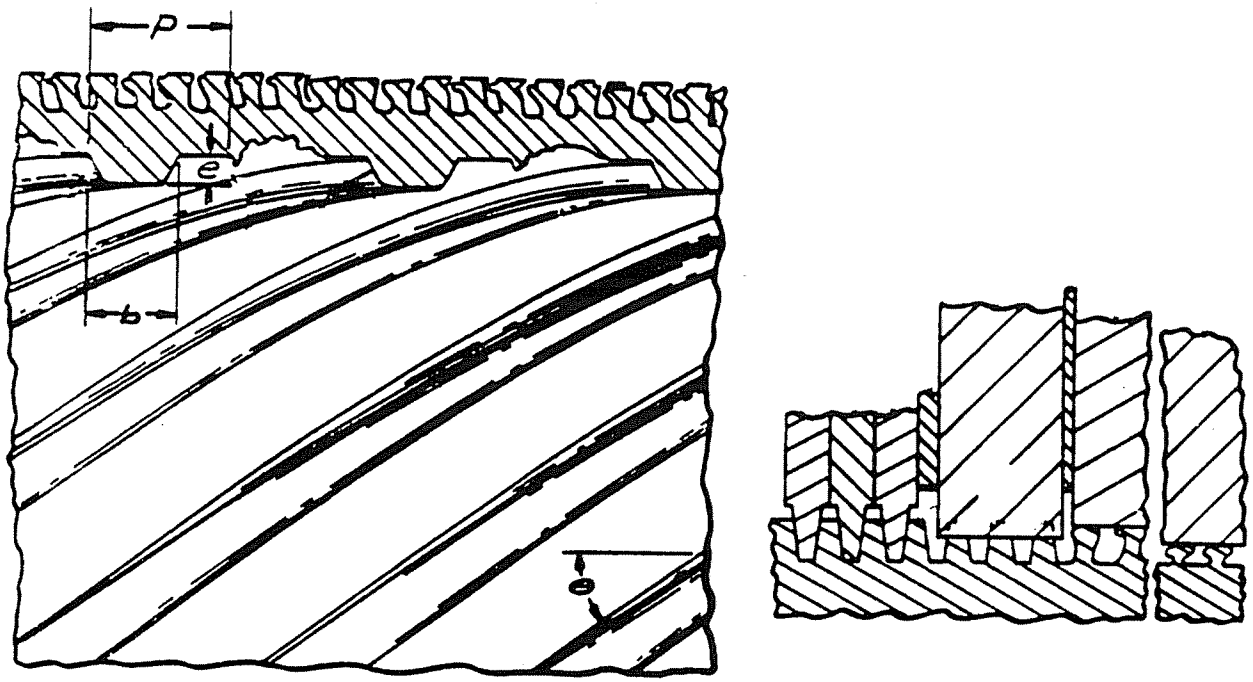


Figure 9.10. Tooling arrangement and cross sectional view of the enhanced tube geometry (U.S. patent no. 4,938,282).



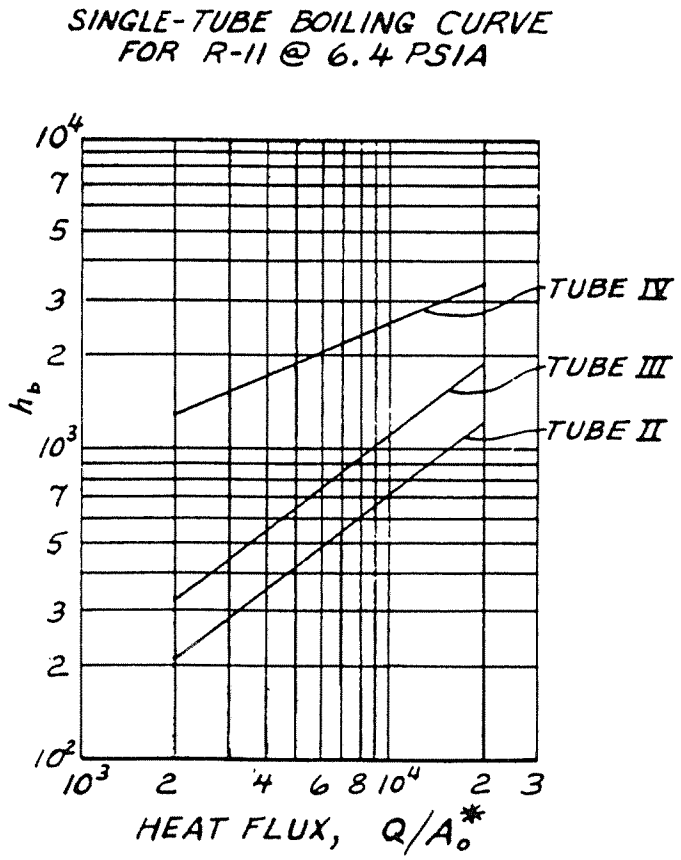


Figure 9.11. Boiling heat transfer performance obtained with internally enhanced tube (U.S. patent no. 4,660,630).

U.S. patent no. 4,353,415 describes a heat pipe or thermal syphon having an internally–ribbed surface. The inner surface consisted of equi–spaced longitudinally extending ribs which defined grooves between them (Fig. 9.12). These grooves were of triangular, semi–circular, or rectangular cross section. The ribs described in the patent were of 0.55 mm height and had a pitch of around 1.5 mm. The patent claimed that the ribs encouraged thin film evaporation by utilizing the surface tension forces transverse to the flow direction rather than surface tension effect acting in the flow direction which is more commonly used in grooved heat pipes. Due to the thin film evaporation, the heat transfer coefficient is enhanced. However, the exact magnitude of the enhancement was not reported. A brief description of the manufacturing process was included in the patent.

Another patent (U.S. patent no. 4,971,139) describes using tubes whose inner walls are provided with grooves of rifled or cross–hatched patterns. In addition to the spiral grooves, circumferentially extending screens were used (see Fig. 9.13) to provide improved capillary or "thermosiphoning" pumping action. It was claimed that these screens further enhance the heat transfer performance by providing an even distribution of the working fluid on the inner wall surface. The patent cited air conditioning system as a potential application for their invention; however, no performance data or any specific working fluid were mentioned to validate or quantify their claim.

Enhancement in plate–type heat exchangers

U.S. patent no. 4,758,385 describes an plate–type evaporator whose plates are stamped out from a laminate material that is lightweight, conductive, and formable. A series of ribs and recesses were stamped into the plate, with the ribs spaced apart in a parallel manner and were of semi–circular cross section. In addition to these ribs, corresponding recesses were cut out that sink into the other opposite side of the plate. The surface geometry of such plate is shown in Fig. 9.14. It was claimed that this rib–recess

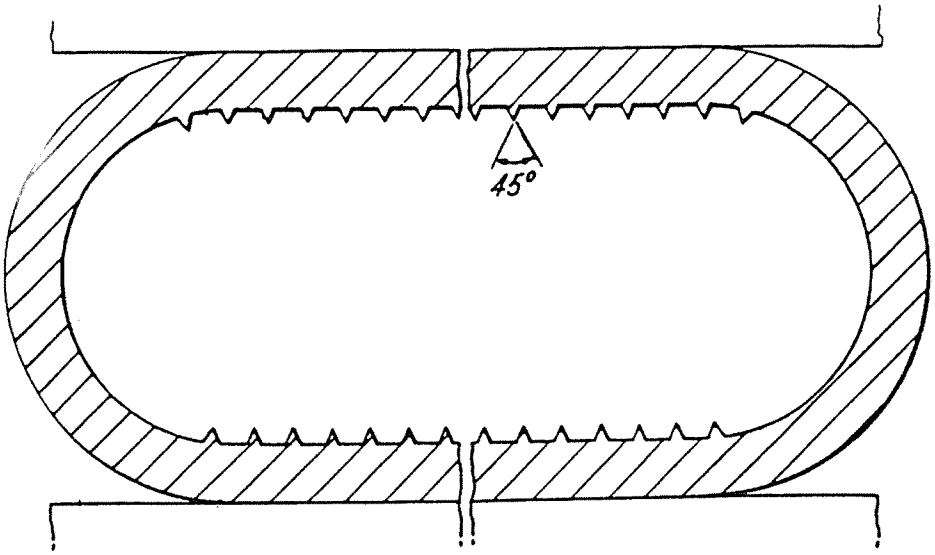


Figure 9.12. Cross sectional view of the internally–ribbed heat pipe (U.S. patent no. 4,353,415).

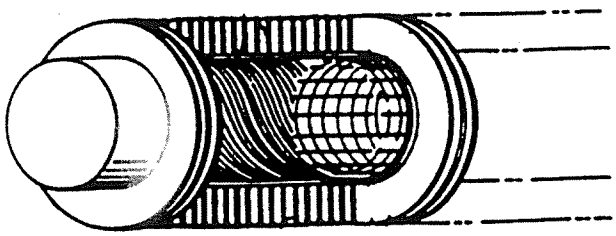


Figure 9.13. Perspective view of a cut away section of the heat transfer tube (U.S. patent no. 4,971,139).

combination provided extended area and thus enhanced heat transfer. It was pointed out that the recess which extends perpendicularly to the air flow, retards boundary layer growth and thus enhances the air side heat transfer coefficient also. The inventors claimed that such surface distortions increases the frictional pressure drop, but the enhancement in the heat transfer performance more than offsets the additional pumping power requirement. It was also claimed that such plates could be easily fabricated using standard tools and dies.

Another U.S. patent (U.S. patent no. 4,762,171) describes a plate evaporator with an increasing cross–sectional area by arranging the plates of the heat exchanger which forms the evaporator channel in a way that they diverge from each other in the flow direction. The inventors claimed that such an arrangement prevents thinning of the liquid film along the heat transfer surface and thus prevents occurrence of hot or dry spots. The patent also mentions that the heat transfer plates could be provided with patterns (such as corrugations, grooves, etc.) to further enhance the heat transfer. Neither performance data nor specific applications of their invention were mentioned in the patent.

A plate–type refrigerant evaporator in which the cross–sectional area of the fluid passage increases along the flow direction is described by U.S. patent no. 5,137,082. Large ribs were placed near the inlet to disturb the refrigerant flow thereby enhancing the heat exchange efficiency and smaller ribs were placed near the outlet to retard the increase in pressure drop of the refrigerant. The front view of the plate is shown in Fig. 9.15. The increase in flow area and the arrangement of the ribs was necessary to maintain a constant pressure drop in the entire flow passage area and as well as enhance the heat transfer coefficient. This is because the refrigerant in the inlet is in a liquid state and has a higher density than the refrigerant flowing out through the outlet which is in vapor state. Thus,

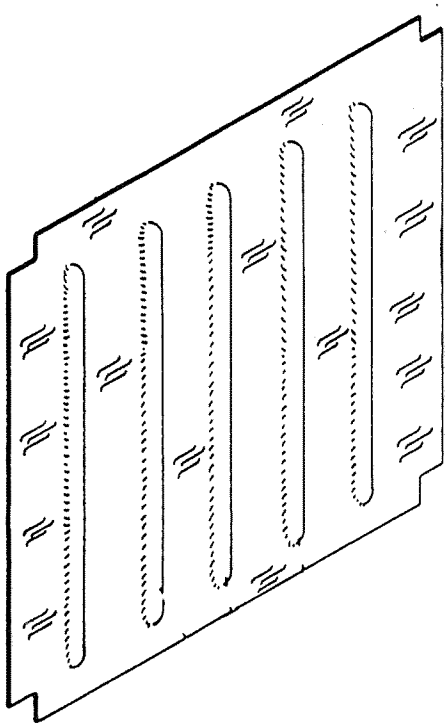


Figure 9.14. Perspective view of the enhanced plate for the evaporative heat exchangers (U.S. patent no. 4,758,385).

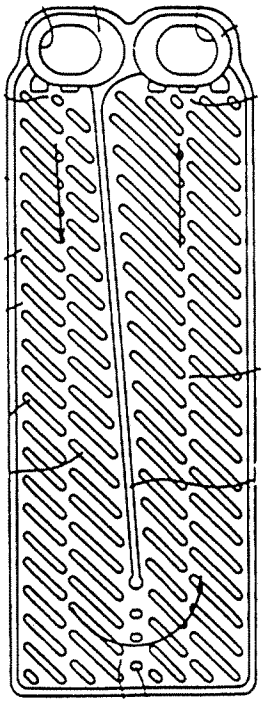


Figure 9.15. Front view of the enhanced plate–type refrigerant evaporator (U.S. patent no. 5,172,759).

by having an diverging flow passage area, the refrigerant flow velocity and the resulting pressure drop is maintained constant. The inventors claimed that the heat transfer efficiency of such evaporators is improved by 20–30% under the same flow conditions and with the added advantage of a constant pressure drop. However, the patent did not mention any performance data or any manufacturing technique. A similar device also was described in a subsequent patent (U.S. patent no. 5,172,759) by the same authors.

Condensation

Tubeside enhancement

U.S. patent no. 4,733,698 describes a heat transfer tube whose inner surface contains a plurality of grooves. The grooves are of rectangular and inverted trapezoidal cross section and cross each other to form tunnels which are in general triangular cross section (see Fig. 9.9a). The depth of the grooves is around 0.5–0.75 times the groove width. The projecting portions of the formed tunnels have a sharp edge which promotes a thin condensate film to be formed in its vicinity. Consequently, the heat transfer resistance is lowered and the heat transfer coefficient is enhanced. In addition, the internal structure in the pipe serves as a boiling nuclei by trapping refrigerant vapor. Thus, the tubes also exhibit a superior boiling performance. One of the main advantages of this invention is that the same tube could be used for both flow boiling and condensation enhancement. The performance data provided in the patent indicated that such tubes could enhance the condensation coefficient by about 80% (as seen in Fig. 9.16) over that of conventional internally–grooved tube. However, the patent does not specifically mention the working fluid used. A brief description of the manufacturing operation, focusing more on the tooling, was provided.

A detailed description of the method and machine used for manufacturing internal enhancement ribs inside a tube is described by U.S. patent no. 4,995,252. The method

consisted of sinking the tube into an internal enhancement mandrel by alternate squeezing and releasing operations. The method is superior to previous drawing operation which uses excessive axial force and avoids drastic throughput reduction that is characteristic of circumferentially rotating balls or rollers. The inventors claimed that their method results in increased production speed (as much as 150 fpm) and could be easily modified to provide enhancement on the tube outer surface.

U.S. patent no. 4,658,892 describes a heat transfer tube with grooved inner surface particularly for air conditioners and refrigeration applications. The inner surface of the grooved tube has about 60 spiral grooves. Each such groove has a height–to–tube inside diameter ratio of 0.02 to 0.03 and a helix angle of 7 to 30 degrees. The grooves formed were of triangular cross section and have a rounded apex with the apex angle ranging from 30 to 60 degrees. Performance data obtained with condensing R–22 indicate that enhancement up to 150% in the heat transfer coefficient over that of smooth tube is possible. The groove geometry and representative data are shown in Fig. 9.17. An attractive feature of this invention is the low pressure drop. For instance, the data obtained with R–22 show that the pressure drop is increased by around 25% over that of a smooth tube. In addition, the patent discusses the optimization of various geometric variables (such as shape and profile of grooves and ridges) to maximize the heat transfer performance based on the inner surface area, weight per unit length, and workability of the tube.

U.S. patent no. 4,705,103 describes an enhanced heat transfer tube for use in a refrigerant system condenser. The enhancement was provided by fine internal grooves having a maximum depth of 0.03 mm. These internally–grooved tubes were shown by the inventors to exhibit significant enhancement in the condensation coefficient over that of smooth tubes particularly for high values of refrigerant mass velocity (generally greater than or equal to 270 kg/ m^2s) and thermodynamic quality. Performance data obtained with condensing R–22 for tubes having 45–50 grooves spiraled at a helix angle of 15

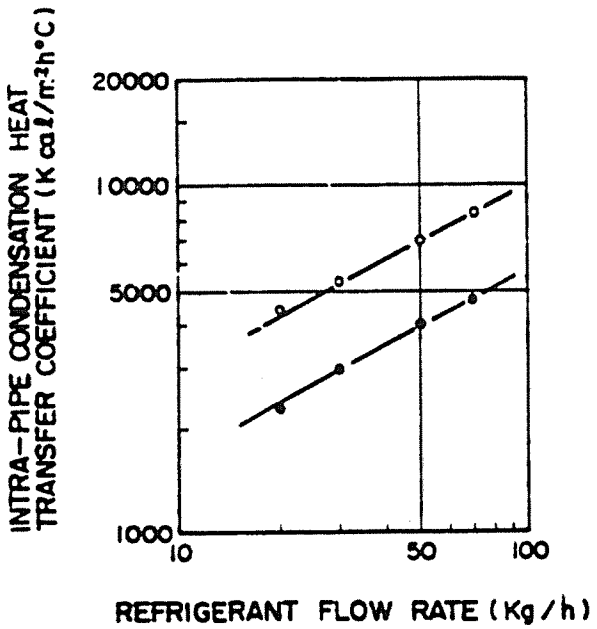


Figure 9.16. Comparison of the condensation performance of the enhanced geometry with that of a standard grooved tube (U.S. patent no. 4,733,698).

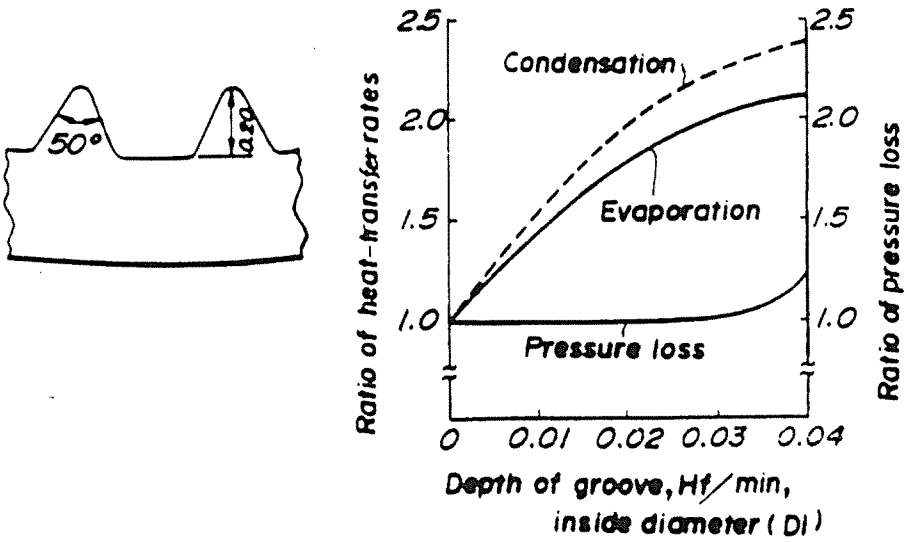


Figure 9.17. Groove geometry and representative performance data (U.S. patent no. 4,658,892).

degrees showed a low improvement of around 12 to 31% in the condensing coefficient over that of smooth tube (see Fig. 9.18). The inventors claimed that the pressure drop penalty and the increase in material content is almost eliminated with these grooved tubes. This is not surprising due to the small grooves used which typically increases the surface area by a mere 6 to 9%. In spite of these advantages, the enhanced tube is unattractive due to the low enhancement in heat transfer.

A tube with internal enhancement, which is useful for either condensation or boiling applications and formed with a plurality of closely spaced helical ridges that provide increased surface area and flow swirl, is described by U.S. patent no. 4,660,630. The patent also describes the enhancement provided on the outer surface of the tube by successive cross–grooving and rolling operations. The rolling operation is omitted if the tube is to be used for condensation applications. Even though the patent mentions condensation application of this device, the patent discusses and provides performance data on boiling of R–11 only.

U.S. patent no. 4,880,054 describes a heat exchanger comprising of projected parts containing cavities provided on both the inner and outer surface of the tube. The projected extensions increase the surface area and thin the condensate film by capillary action, thereby enhancing the condensation heat transfer coefficient. These projections could be arranged in staggered, spiral, or axial fashion. The inventors claimed that the same tube could be used for enhancing boiling heat transfer, since the cavities trap refrigerant vapor and act as nucleation site, thereby enhancing the boiling performance.

Shellside enhancement

The method of manufacturing a high performance heat transfer tube for use in condensers in an air conditioning or refrigeration system is described by U.S. patent no. 4,886,830 and 4,921,042. These tubes are doubly enhanced with fins of uniform height provided on the outer surface of the tube for enhancing condensation performance. The

tooling and the tube geometry are shown in Fig. 9.19. The inner surface contains 36 to 48 grooves with a helix angle of 30 degrees. The patent stated that conventional doubly enhanced tubes contains external fins of non–uniform height with a reduction in height at locations where the external fin crosses the internal grooves. It was estimated that such a reduction in fin height could lead to as much as 28% reduction in condensing efficiency as compared to uniformly finned tubes. The patent claimed that by increasing the number of grooves and reducing the groove pitch from the standard 14 grooves, 45^{O} helix to 36–48 grooves with a 30^{O} helix, the non–uniformity in the fin height could be eliminated. The uniformity in the fin height was reflected in the improved overall performance; however, the claim was not quantified by any performance data.

U.S. patent no. 4,305,460 described a spirally fluted heat transfer tube (seen in Fig. 9.20) for enhancing shellside condensation. The geometry of the multiple start helical flutes (i.e., the helix angle and flute height–to–tube diameter ratio) was designed to induce continuous swirling of the condensing fluid outside the tube as well as the coolant flowing inside the tube. It was claimed that such tubes improved the overall heat transfer coefficient without any added pressure drop penalty over that of a smooth tube. Furthermore, it was suggested that such tubes should have 20 to 40 multiple start flutes, spiraled at 25 to 50 degrees helix angle and the base of the flute should have a width equal to 3–6 times the tip width in order to optimize the heat transfer performance. The performance factor (defined as the ratio of the Stanton number divided by the friction factor and multiplied by the Prandtl number to the 2/3rd power) of these tubes were significantly greater than 1 for Reynolds number less than 60,000 as compared to smooth or standard fluted tubes. The manufacturing technique for these tubes was briefly discussed.

An electrohydrodynamically (EHD) enhanced condenser is described by U.S. patent no. 4,651, 806. The arrangement, which is suited to shell–and–tube heat exchangers, consisted of electrodes comprising a mesh–type member which surrounded the tube and a mesh–type or rod–type member which ran length–wise through the spaces between the

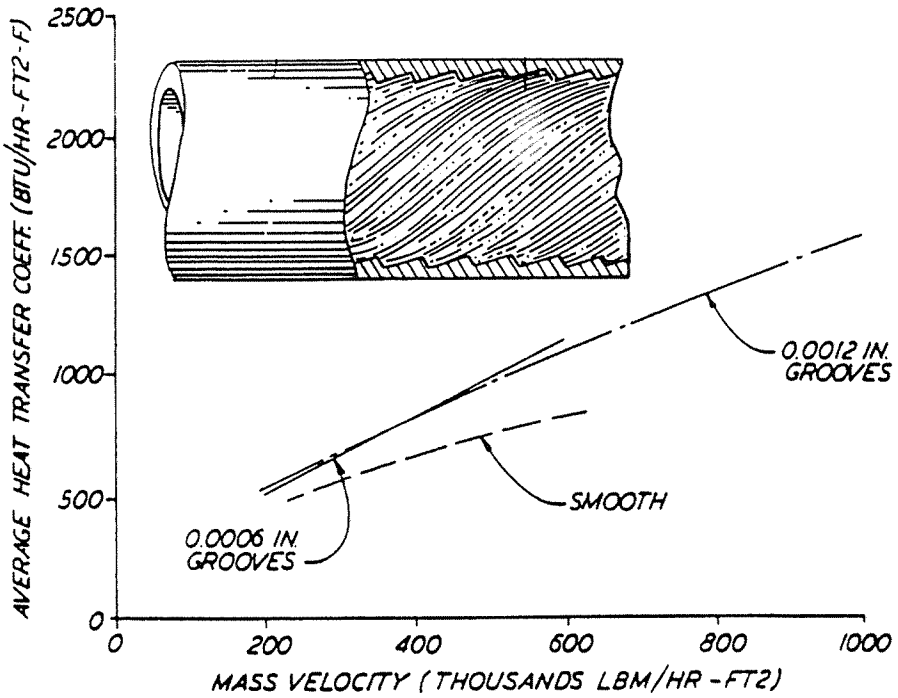
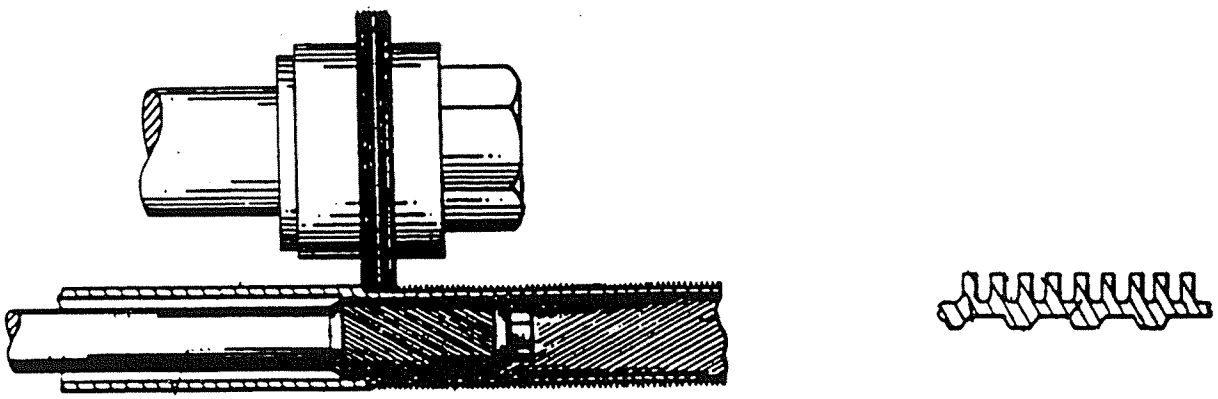


Figure 9.18. Cutaway view of the internally enhanced tube representative performance data obtained with R–22 (U.S. patent no. 4,705,103).



(a) (b)

Figure 9.19. (a) Schematic sectional view of the condenser tube in the process of production and (b) enlarged sectional view of the tube with fin and rib enhancement (U.S. patent no. 4,921,042).

tubes. These rod–type electrodes were used for making the electric field more uniform around the tubes. The electrodes were insulated from the shell and tube and were charged with a high electric potential, whereas the shell and the tubes were kept grounded. The axial section of heat exchanger and the elevation of the electrode used as shown in Fig. 9.21. The inventors claimed that by charging the electrodes with a potential of 15 to 25 kV, an enhancement of 150% in the shellside condensation heat transfer coefficient could be obtained for R–12 or R–114. It may be noted that EHD condensation is, however, limited to dielectric fluids such as refrigerants mostly.

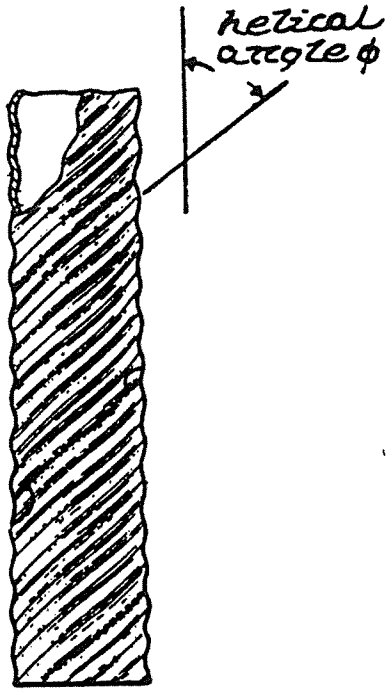


Figure 9.20. Partial elevation view of the spirally fluted tube (U.S. patent no. 4,305,460).

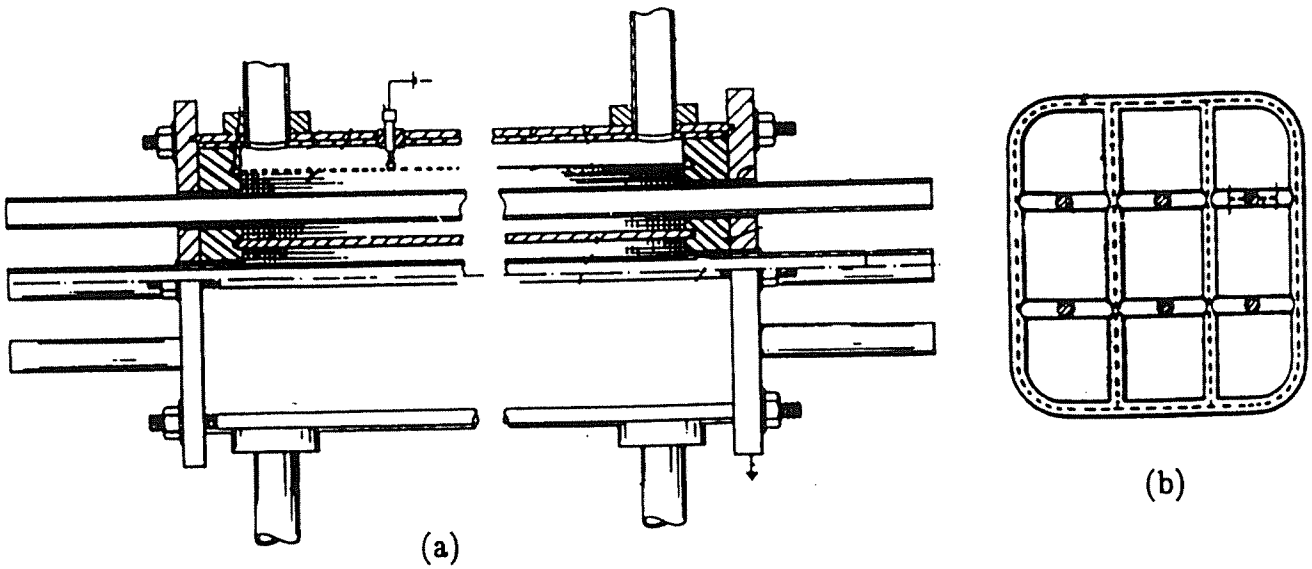


Figure 9.21. (a) Axial section of the EHD enhanced shell–and–tube heat exchanger and (b) elevation of the electrode used (U.S. patent no. 4,651,806).

10. CONCLUSIONS AND RECOMMENDATIONS

The technical literature and patents on enhanced heat transfer techniques as applied to boiling and condensing refrigerants has been reviewed. Enhanced pool boiling, flow boiling, and condensation were examined for pure refrigerants, refrigerant–oil mixtures, and refrigerant mixtures. Progress in the development of many of these enhancement techniques is noted, and heat transfer performance is discussed relative to smooth tube characteristics and/or pure refrigerant results. Two bibliographies of the citations and patents obtained are presented with the heat transfer mode and enhancement technique given.

Pool Boiling

Enhanced pool boiling has the largest number of papers of the three heat transfer modes reviewed. Significant increases relative to a smooth surface in the heat transfer coefficient have been obtained for many of the enhancement techniques. What is evident, though, is that different refrigerants have different heat transfer characteristics when used with a particular enhancement technique. Each enhancement technique should be optimized for the refrigerant and operating condition. This will require fundamental understanding of the mechanisms governing the heat transfer processes. For some enhancement techniques, progress is being made on the development of theory and phenomonological models to describe the heat transfer characteristics; however, much more research has been primarily of the parametric experimentation type of studies with minimal examination of fundamental processes involved with the heat transfer. While this type of research is valuable, it is insufficient to completely generalize or model the heat transfer.

Of the various passive enhancement techniques, structured and porous surfaces have received the most attention of the various enhanced pool boiling techniques. Depending on the operating conditions, increases in the heat transfer coefficient of 5 to 20 times that of a

smooth surface have been obtained. Data have been obtained for a wide variety of fluids (mostly around one atmosphere pressure) to determine their incipient boiling and fully developed nucleate boiling characteristics; fewer data on the CHF condition for the various surfaces are available, and even less study of film boiling has been made. Most of the studies have been performed in pools of saturated liquid; only a few studies have been made with thin film evaporation, where there is some evidence of improved heat transfer. Phenomonological models have been developed for specific structured surfaces and for porous surfaces.

Of the active techniques, electrohydrodynamic (EHD) enhancement demonstrates impressive improvements in the heat transfer coefficient at lower heat fluxes. Both the CHF and the nucleate pool boiling heat transfer coefficient were increased (by up to a factor of three to five depending on the applied voltage). These improvements were obtained at a relatively low power consumption. Boiling incipience, fully developed nucleate boiling, CHF, and film boiling have been experimentally studied with improvements in the performance (relative to zero applied voltage) obtained for all regimes of boiling heat transfer. Jet impingement also has received much attention, but the focus of those studies has been on its application to electronics cooling. Usage of jet impingement for large–scale applications, as opposed to point cooling, has not been examined.

The effect of refrigerant mixtures on enhanced pool boiling has not been studied extensively. On structured and porous surfaces, the mixture heat transfer behavior is similar to that on smooth surfaces. However, it is not clear that explanations for mixture boiling on smooth surfaces are completely transferable to enhanced surfaces. On the other hand, there has been a reasonable number of studies of the effect of refrigerant–oil mixtures on enhanced pool boiling. Small amounts of oil tend to enhance the heat transfer compared to pure refrigerants, but with increasing oil concentration (several percent) the heat transfer is degraded. Enhanced surfaces appear to be affected more than smooth surfaces, and different structured surfaces experience different degradations; nevertheless, the enhanced

surfaces still have higher heat transfer coefficients than the smooth tubes. A few studies have looked at the issue of miscible versus immiscible or partially miscible oils in boiling refrigerants, but the results are not conclusive about the effect of miscibility. Explanations/theories for the effect of oil in refrigerants typically are qualitative in nature rather than quantitative. Studies with EHD enhancement also have been performed with refrigerant–oil mixtures. Oil had little effect at higher heat fluxes with the applied voltage, but there was some degradation at lower heat fluxes.

Structured and porous surfaces appear to be the favored passive enhancement technique, and EHD has potential for active enhancement. There are several areas of pool boiling associated with these techniques that could benefit from additional research. Generally, there needs to be more effort to examine the fundamental processes governing the heat transfer. Models need to be developed that incorporate the various processes involved with the boiling; this generalization is needed so that optimization of surfaces can be done for different refrigerants and operating conditions. The preceding statement is applicable to pure refrigerants, refrigerant mixtures, and refrigerant–oil mixtures. There also is a lack of experimental data in certain aspects of pool boiling. Many more experimental investigations should be performed for refrigerant mixtures and for refrigerant mixtures with oil with enhancement techniques. The CHF condition has received inadequate study generally. Thin film evaporation also should be investigated.

Flow Boiling

Impressive improvements in the enhanced flow boiling heat transfer coefficients have been obtained relative to smooth tube results, but this benefit is offset, in some cases, by very large pressure drop increases. Many of the comments on pool boiling are applicable to flow boiling also. There have been a number of investigations that have experimentally determined the parametric effects of a variety of variables on enhanced flow boiling. Correlations have been developed to describe the heat transfer behavior, but there

has been little examination/modeling of the fundamental processes governing the heat transfer.

Shellside flow boiling has received little attention. Results have been obtained for structured, porous, and low–fin surfaces. For the structured and porous surfaces, the data indicated little difference between the flow boiling and pool boiling characteristics; evidently, the external flow field did not intrude into the subsurface cavities and tunnels and the heat transfer was governed by the subsurface heat transfer mechanisms. The finned surface experienced a trade off between convection and nucleation, similar to that noted with smooth surfaces. Pressure drop for the structured and porous surfaces was no different than the smooth tube results.

Tubeside flow boiling has been studied extensively. More length–averaged than axial local heat transfer coefficients have been obtained. The use of porous surfaces for intube evaporation shows improvements similar to that obtained with pool boiling; the heat transfer coefficient decreases rapidly at higher qualities (due to dryout). A variety of rough surfaces (cross ribs, corrugated tubes, wire inserts, etc.) also provide increases in the heat transfer coefficient, but the pressure drop penalty can be quite substantial (up to 30 times that of a smooth tube). Extended surfaces, in particular the micro–fin tube, have received the most research. For the micro–fin tube, increases in the heat transfer coefficient of up to a factor of about three have been obtained. However, the pressure drop penalty associated with the micro–fin tube is rather modest, being in the range of 10 to 40% greater than that of a smooth tube. The majority of the micro–fin tube data have been obtained with R–22 and R–113 only. Very little is known about the heat transfer enhancement or pressure drop penalty that would result when these tubes are used with a different refrigerant. Even for the commonly used R–22 and R–113, correlations for predicting the heat transfer and pressure drop are not available yet. Few investigations have focused on the CHF condition in micro–fin tubes. Swirl flow devices such as a twisted–tape insert improve the heat transfer coefficient also, but the pressure drop can be

large. The greatest benefit of twisted tapes appears to be their ability to suppress the CHF condition. Coiled tubes also have very good CHF characteristics relative to straight smooth tubes.

A few studies have looked at the effect of flow boiling with enhanced surfaces and refrigerant mixtures. Heat transfer decreased relative to either pure refrigerant, similar to what occurs in pool boiling for all of the enhanced surfaces studied. Mixed results have been obtained with correlating the data using the difference between the mixture concentration in the liquid and vapor. There is insufficient information known about the governing mechanisms with enhanced refrigerant mixtures (particularly NARMS) to model the process. Enhanced flow boiling with refrigerant–oil mixtures has been the object of significant study only over the past five years or so, only with finned and micro–fin tubes. As with pool boiling, small oil concentrations tended to enhance the heat transfer slightly, but higher concentrations degraded the performance. Some examination (visual observation of flow patterns) of the processes governing the heat transfer in refrigerant–oil mixtures has occurred.

There are similar research needs for both shell and tube side enhanced flow boiling of refrigerants. Little fundamental research has been done; parametric studies and correlation of the resulting data have been the main focus of the research. Phenomonological/theoretical models should be developed for the enhanced surfaces; these models could serve both to optimize a surface/refrigerant combination or to screen proposed new refrigerants or mixtures for their possible performance. Axially local heat transfer data should be obtained to facilitate model development. For micro–fin tubes, more investigations are required for different refrigerants, as well as with different fin/tube geometries to build a wider data–base. Experimental data also are needed on the CHF condition and post–CHF heat transfer for micro–fin tubes. More investigations are required for the enhanced flow boiling behavior of refrigerant mixtures and refrigerant mixtures with oil; pure refrigerant results will provide the reference for mixture studies.

Condensation

Enhanced condensation of refrigerants have heat transfer coefficients which are as much as ten times that of a smooth surface. Unlike pool and flow boiling, enhanced condensation has been addressed both experimentally and theoretically/phenomonologically in numerous papers. Modeling vapor space condensation on some enhanced surfaces is much simpler than modeling boiling because all the condensation investigations have focused on film condensation; the effects associated with nucleation are not present in condensation as they are in pool or flow boiling. Data have been obtained for many enhancement techniques (both shellside and tubeside), modeling of shellside condensation has been performed, and correlations of forced convection condensation have been developed. No dropwise condensation studies with refrigerants could be found; no surface has been developed that cannot be wetted by refrigerants.

For shellside condensation, rough surfaces have been effective in increasing the condensing coefficient when the condensate film thickness is thin relative to the roughness height; thick films result in a hydraulically smooth liquid surface. Finned tubes enhance condensing coefficients by facilitating film thinning and condensate drainage. Many models have been developed that take into account variables such as fin geometry, curvature, surface tension and condensate retention, etc. and the models agree with the experimental data reasonably well. However, most of these phenomonological models are limited to single tubes only. Enhanced shell–side condensation in tube bundles has received much less attention than that on single tubes. In particular, little is known about the interaction between the type of enhancement and the row effect. Little effort has been expended to develop any phenomonological model that accounts for this row effect or for vapor shear. Both two– and three–dimensional extended surfaces have been tested. Almost all of these investigations lack fundamental understanding of the mechanisms governing the heat transfer process. As a result, generalized models for these two– and three–dimensional extended surfaces are not yet available. EHD has been used with good results compared to

smooth tubes without EHD. Refrigerants are good dielectrics and make EHD enhancement attractive. Pseudo–dropwise EHD enhanced condensation seems to be quite promising. The recent technical literature indicates growing popularity of this enhancement technique. The literature also indicates that in the near future, EHD enhancement could become competitive with the more conventional techniques such as treated or extended surfaces. Other enhancement techniques (both active and passive) have been used with varying success.

Many of the shellside enhancement techniques also are applicable to intube condensation. Overall, most of the data obtained with enhanced heat transfer have been length–averaged heat transfer coefficients; no local or quasi–local condensing coefficients have been obtained. Various rough surfaces (repeated rib roughness, spiral flutes, etc.) have demonstrated a 100% increase in the condensing coefficient. Conventionally finned tubes have obtained increases in the condensing coefficient of from 50 to 300% with pressure drop increases ranging from small to over 200%. Micro–finned tubes tend to produce larger heat transfer enhancements with smaller pressure drop penalties; heat transfer enhancement factors of up to three have been obtained with pressure drop increases of 20 to 40%. As stated earlier, micro–fin tube condensation data are mostly limited to R–22 and R–113. No correlations are available yet Other enhancement techniques have been tested; these typically gave smaller heat transfer improvements with larger pressure drop increases. One typical example is an in–line static mixer insert. Other enhancement techniques, for instance injection or suction, have been pursued for academic interest only. Due to the inherent difficulties in these techniques, they are not commercially viable. Correlations have been presented for intube condensation, particularly for low–finned tubes and tubes with twisted–tape inserts; no phenomonological modeling has been performed.

Few studies on enhanced condensation of refrigerant mixtures or refrigerant–oil mixtures have been performed. For vapor space condensation, a small amount of a second

refrigerant can cause a very large decrease in the condensing coefficient at low wall subcoolings; as the subcooling increases (increasing condensing rate) the degradation decreases. Orientation of an enhanced tube and the flow direction have an effect on the condensing coefficient. Enhanced intube condensation has been studied in fewer investigations than vapor space condensation. However, degradation (compared to a pure refrigerant) in the condensing coefficient was obtained similar to that of vapor space condensation. There is some evidence that the enhancement geometry affects the condensing process of refrigerant mixtures differently than a smooth tube. Vapor space condensation with refrigerant–oil mixtures have shown only small or negligible decreases in condensing coefficient on finned tubes. For condensation in micro–fin tubes, similar results were obtained. Pressure drop was not affected significantly. Correlations have been presented that agree with the experimental data with reasonable accuracy. Compound enhancement utilizing a different enhancement techniques has been actively pursued. The most popular technique seems to be a porous extended surface or an attached drainage pipe, particularly for shellside condensation applications.

Modeling of shellside condensation is well developed. Comparable work has not been performed on tubeside forced convection condensation of refrigerants. This should be done. To assist the modeling efforts, local (as opposed to length–averaged) condensing coefficients should be obtained through experiments with a variety of fluids and enhancement techniques. Micro–fin tubes appear to be the favored geometry at this time; because of success with vapor space condensation, the use of internally structured surfaces for flow condensation should be explored. However, due to manufacturing constraints this could be difficult. As with pool boiling and flow boiling, there is need of additional study of condensation of refrigerant mixtures and refrigerant mixtures with oil.

Concluding Remarks

Numerous studies of enhanced boiling and condensing of refrigerants have demonstrated the excellent heat transfer performance which can be obtained with a variety of enhancement techniques. Indeed, many have been commercialized. The benefits of using enhancement technology often greatly outweigh penalties associated with their adoption. Whether or not an enhancement technique is ultimately commercialized will depend on many market factors beyond the scope or control of the heat transfer engineer. To facilitate greater widespread use of enhancement technologies, sufficient data should be obtained so that a complete performance evaluation can be obtained. A quantitative evaluation of the heat transfer benefits must be balanced against the pressure drop/pumping power penalty subject to whatever specific constraints are needed in a particular application. Likewise, the enhancement technique should be optimized for the specific fluid and operating conditions. To do this, experimental data need to be generalized through the development of models which accurately describe the governing heat transfer mechanisms. More research into the fundamental mechanisms is needed before these models can be constructed. Finally, there needs to be more interactions between researchers and designers so that each group understands the capabilities and needs of the other; if the additional research recommended above is performed, it will be wasted if that information is not transferred to those who use these types of data.

REFERENCES

Abuaf, N., Black, S.H., and Staub, F.W., 1985, "Pool Boiling Performance of Finned Surfaces in R–113," International Journal of Heat and Fluid Flow, Vol. 6, No. 1, pp. 23–30.

Afgan, N.H., Jovic, L.A., Kovalev, S.A., and Lenykov, V.A., 1985, "Boiling Heat Transfer from Surfaces with Porous Layers," International Journal of Heat and Mass Transfer, Vol. 28, No. 2, pp. 415–422.

Agrawal, K.N. and Varma, H.K., 1991, "Experimental Study of Heat Transfer Augmentation Versus Pumping Power in a Horizontal R12 Evaporator," International Journal of Refrigeration, Vol. 14, pp. 273–281.

Agrawal, K.N., Varma, H.K., and Lal, S., 1982, "Pressure Drop During Forced Convection Boiling of R–12 Under Swirl Flow," Journal of Heat Transfer, Vol. 104, pp. 758–762.

Allen, P.H.G. and Cooper, P., 1987, "The Potential of Electrically Enhanced Evaporators," 3rd International Symposium on the Large Scale Applications of Heat Pumps, Oxford, England, March 1987, Paper P2, pp. 221–229.

Allen, P.H.G. and Karayiannis, T.G., 1989, "Electrohydrodynamic Enhancement of Boiling and Condensation of Dielectric Fluids," Advances in Pool Boiling Heat Transfer, Paderborn, FRG, May 1989, Eurotherm No. 8 pp. 98–110.

Anand, G., Christensen, R.N., and Richards, D.E., 1988, "Forced Convection Condensation of Ammonia Inside Coiled Fluted Tubes," ASHRAE Transactions, Vol. 94, Part 2, pp. 1132–1158.

Anderson, T.M. and Mudawwar, I., 1988, "Microelectronic Cooling by Enhanced Pool Boiling of a Dielectric Fluorocarbon Liquid," ASME Proceedings of the 1988 National Heat Transfer Conference, ASME, New York, HTD–96, Vol. 1, pp. 551–560.

Antonenko, V.A., 1988, "Causes of Enhanced Boiling Heat Transfer on Surfaces Covered with Perforated Polymer Film," Journal of Engineering Physics, Vol. 54, pp. 391–393.

Arai, A., Arai, N., Fushima, T., and Fujie, K., 1977, "Heat Transfer Characteristics of "THERMOEXCEL" Tubes in Heat Exchangers of Turbo–Refrigerating Machines," IIF–IIR Commissions B1, B2, and B3, Belgrade, Yugoslavia, pp. 15–20.

Arai, N., Fukushima, T., Arai, A., Nakajima, T., Fujie, K., and Nakayama, Y., 1977, "Heat Transfer Tubes Enhancing Boiling and Condensation in Heat Exchangers of a Refrigerating Machine," ASHRAE Transactions, Vol. 83, Part 2, pp. 58–70.

Asakavicius, J.P., Zukauskas, A.A., Gaigalis, V.A., and Eva, V.K., 1979, "Heat Transfer from Freon–113, Ethyl Alcohol and Water with Screen Wicks," Heat Transfer – Soviet Research, Vol. 8, No. 4, pp. 1–15.

Ayub, Z.H. and Bergles, A.E., 1985, "Pool Boiling from GEWA Surfaces in Water and R–113," Augmentation of Heat Transfer in Energy Systems, ASME, New York, HTD–Vol. 52, pp. 57–66.

Ayub, Z.H. and Bergles, A.E., 1987, "Pool Boiling from GEWA Surfaces in Water and R–113," Wärme– und Stoffübertragung, Vol. 21, 209–219.

Ayub, Z.H. and Bergles, A.E., 1990, "Nucleate Pool Boiling Curve Hysteresis for GEWA–T Surfaces in Saturated R–113," Experimental Thermal and Fluid Science, Vol. 3, pp. 249–255.

Azer, N.Z., Fan, L.T., and Lin, S.T., 1976, "Augmentation of Condensation Heat Transfer with In–Line Static Mixers," Proceedings of the 1976 Heat Transfer and Fluid Mechanics Institute, Stanford University Press, pp. 512–526.

Azer, N.Z., Lin, S.T., and Fan, L.T., 1980, "Augmentation of Forced Flow Boiling Heat Transfer with Kenics Motionless Mixers," Industrial and Engineering Chemistry Process Design and Development, Vol. 19, No. 2, pp. 246–250.

Azer, N.Z. and Sivakumar, V., 1984, "Enhancement of Saturated Boiling Heat Transfer by Internally Finned Tubes," ASHRAE Transactions, Vol. 90, Part 1A, pp. 58–73.

Bahhuth, A. and Genetti, W.E., 1983, "Nucleate Boiling Heat Transfer Enhancement with Heat Transfer Surface Cavities," AIChE Symposium Series No. 225, Vol. 79, pp. 28–33.

Bambach, G., 1955a, "The Behavior of Mineral Oil – R12 Mixtures in Refrigerating Machines," Deutsche Kaltetechnische Verein, No. 9, Karlsruhe: C.F. Muller, pp. 1–103.

Bambach, G., 1955b, "Thermodynamische Eigenschaften und Viskositatsverhalten von Mineralol–F12–Gemischen," Kaltetechnik, Vol. 7, pp. 187–191.

Barskii, M.A. and Chukhman, G.I., 1971, "Study of Heat Transfer in Boiling of Freons in Spiral Tubes," Kholodil'nava Tekhnika, Vol. 48, No. 2, pp. 18–21.

Baustian, J.J., Pate, M.B., and Bergles, A.E., 1986, "Properties of Oil–Refrigerant Liquid Mixtures with Applications to Oil Concentration Measurement: Part I – Thermophysical and Transport Properties," ASHRAE Transactions, Vol. 92, Part 1, pp. 55–73.

Baustian, J.J., Pate, M.B., and Bergles, A.E., 1987, "Real Time Determination of Concentration of Oil Dissolved in Refrigerant Flow Stream Without Sample Removal," Heat Transfer Laboratory Report HTL–48, ISU–ERI–Ames–88199, Iowa State University, Ames, IA.

Beatty, K.O. and Katz, D.L., 1948, "Condensation of Vapors on Outside of Finned Tubes," Chemical Engineering Progress, Vol. 44, No. 1, pp. 55–70.

Bell, K.I., Hewitt, G.F., and Morris, S.D., 1987, "Nucleate Pool Boiling of Refrigerant–Oil Mixtures," Experimental Heat Transfer, Vol. 1, pp. 71–86.

Bergles, A.E., 1985, "Techniques to Augment Heat Transfer," Handbook of Heat Transfer Applications, McGraw–Hill, New York, NY, pp. 3–1–80.

Bergles, A.E., 1988, "Heat Transfer Augmentation," Two–Phase Flow Heat Exchangers: Thermal–Hydraulic Fundamentals and Design, Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 343–373.

Bergles, A.E., 1988, "Some Perspectives on Enhanced Heat Transfer – Second Generation Heat Transfer Technology," Journal of Heat Transfer, Vol. 110, pp. 1082–1096.

Bergles, A.E. and Chyu, M.–C., 1981, "Characteristics of Nucleate Pool Boiling From Porous Metallic Coatings," Advances in Enhanced Heat Transfer–1981, ASME, New York, HTD Vol. 18, pp. 61–71.

Bergles, A.E. and Chyu, M.–C., 1982, "Characteristics of Nucleate Pool Boiling From Porous Metallic Coatings," Journal of Heat Transfer, Vol. 104, pp. 279–285.

Bergles, A.E., Jensen, M.K., Somerscales, E.F.C., and Manglik, R.M., 1991, "Literature Review of Heat Transfer Enhancement Technology for Heat Exchangers in Gas–Fired Applications," GRI 91–0146, Gas Research Institute, Chicago, Il.

Bergles, A.E., Junkhan, G.H., and Webb, R.L., 1982, "Energy Conservation Via Heat Transfer Enhancement," HTL–30, Iowa State University, under DOE Contract DE–AC22–78ET13127, COO–4649–16.

Bergles, A.E., Nirmalan, V., Junkan, G.H., and Webb, R.L., 1983, "Bibliography on Augmentation of Convective Heat and Mass Transfer – II," HTL–31, Iowa State University, under DOE Contract DE–FG07–81ID12222.

Bier, K., Gorenflo, D., Salem, M., and Tanes, Y., 1979, "Effect of Pressure and Surface Roughness on Pool Boiling of Refrigents," International Journal of Refrigeration, Vol. 2, No. 4, pp. 211–219.

Biyikli, S. 1985, "Optimum Use of Longitudinal Fins of Rectangular Profiles in Boiling Liquids," Journal of Heat Transfer, Vol. 107, pp. 968–970.

Bokhanovshiy, Y.G., 1980, "Heat Transfer from Freon–12, Freon–22 and Their Mixtures in a Coiled–Tube Condenser," Heat Transfer – Soviet Research, Vol. 12, No. 4, pp. 43–45.

Bondurant, D.L. and Westwater, J.W., 1970, "Heat Transfer with Change of Phase – Part II. Performance of Transverse Fins for Boiling Heat Transfer," American Institute of Chemical Engineers Preprint 49D for 63rd Annual Meeting, Vol. 67, No. 113, pp. 30–37.

Bukin, V.G., Danilova, G.N., and Dyundin, V.A., 1982, "Heat Transfer from Freons in a Film Flowing Over Bundles of Horizontal Tubes That Carry a Porous Coating," Heat Transfer – Soviet Research, Vol. 14, No. 2, pp. 98–103.

Carnavos, T.C., 1980, "An Experimental Study: Condensing R–11 on Augmented Tubes," ASME Paper No. 80–HT–54.

Carnavos, T.C., 1981, "An Experimental Study : Pool Boiling R–11 with Augmented Tubes," Advances in Enhanced Heat Transfer – 1981, Webb, R.L., Carhovos, T.S., Park Jr., E.L., and Hostetler, L.M. (Eds.), ASME, New York, HTD–Vol. 18, pp. 103–108.

Cash, D.R., Klein, G.J., and Westwater, J.W., 1971, "Approximate Optimum Fin Design for Boiling Heat Transfer," Journal of Heat Transfer, Vol. 93, pp. 19–24.

Chaddock, J.B., 1976, "Influence of Oil on Refrigerant Evaporator Performance," ASHRAE Transactions, Vol. 82, Part 1, pp. 474–486.

Chang, K.I. and Spencer, D.L., 1971, "Effects of Regularly Spaced Surface Ridges on Film Condensation Heat Transfer Coefficients for Condensation in the Presence of Noncondensable Gases," International Journal of Heat and Mass Transfer, Vol. 14, pp. 502–505.

Chen, J.–G., Dong, L., and Zhang, H.–J, 1988, "Boiling Heat Transfer on Low Finned Tube," Advances in Phase Change Heat Transfer, International Academic Publishers, Chongqing, China, and Pergamon Press, New York, pp. 129–134.

Cho, C.S.K. and Wu, K., 1988, "Comparison of Burnout Characteristics in Jet Impingement Cooling and Spray Cooling," ASME Proceedings of the 1988 National Heat Transfer Conference, ASME, New York, HTD–96, Vol. 1, pp. 561–567.

Choi, H.Y., 1967, "Electrohydrodynamic Condensation Heat Transfer," Journal of Heat Transfer, Vol. 90, pp. 98–102.

Chukhman, G.I., 1972, "The Internal Heat Transfer in Evaporative Air Coolers with Flow Turbulization," Heat Transfer–Soviet Research, Vol. 4, No. 4, pp. 67–70.

Chyu, M.–C. and Mghamis, A.M., 1989, "Effects of Cylindrical Wall Attachment on Nucleate Boiling," Heat Transfer with Phase Change, edited by I. S. Habib and R. J. Dallman, ASME, NY, HTD–Vol. 114, pp. 10–15.

Chyu, M.–C. and Mghamis, A.M., 1992, "Enhanced Pool Boiling Heat Transfer with Surface Attachment," Experimental Heat Transfer, Vol. 5, pp. 51–63.

Combs, S. K., Mailen, G. S., and Murphy, R. W., 1978, "Condensation of Refrigerants on Vertical Fluted Tubes," Oak Ridge National Laboratory Report No. ORNL/TM–5848.

Conklin, J.C. and Vineyard, E.A., 1990, "Tubeside Evaporation of Nonazeotropic Refrigerant Mixtures from Two Enhanced Surfaces," ASME Paper No. 90–WA/HT–8.

Conklin, J.C. and Vineyard, E.A., 1991, "Tubeside Condensation of Nonazeotropic Refrigerant Mixtures for Two Enhanced Surfaces," Proceedings of the ASME/JSME Thermal Engineering Joint Conference, ASME, Vol. 3, pp. 251–256.

Conklin, J. C. and Vineyard, E. A., 1992, "Flow Boiling Enhancement of R–22 and a non–azeotropic Mixture of R–143A and R–124 using Perforated Foils," ASHRAE Transactions, Vol. 98, Part 2, pp. 402–410.

Cooper, P., 1990, "EHD Enhancement of Nucleate Boiling," Journal of Heat Transfer, Vol. 112, pp. 458–464.

Cornwell, K. and Scoones, D.J., 1988, "Analysis of Low Quality Boiling on Plain and Low–Finned Tube Bundles," Second UK National Conference on Heat Transfer, Glasgow, September 1988, Mechanical Engineering Publications, London, Vol. 1, pp. 21–32.

Cumo, M., Farello, G.E., and Ferrari, G., 1972, "The Influence of Curvature in Post Dry–Out Heat Transfer," International Journal of Heat and Mass Transfer, Vol. 15, pp. 2045–2062.

Curcio, L.A. and Somerscales, E.F.C., 1991, "Pool Boiling of Enhanced Heat Transfer Surfaces in Refrigerant–Oil Mixtures and Aqueous Calcium Sulfate Solutions," Rensselaer Polytechnic Institute Heat Transfer Laboratory Report No. 5 (under DOE Contract No. DE–FC07–88ID12772).

Czikk, A.M., Gottzman, C.F., Ragi, E.G., Withers, J.G., and Habdas, E.P., 1970, "Performance of Advanced Heat Transfer Tubes in Refrigerant–Flooded Liquid Coolers," ASHRAE Transactions, Vol. 76, Part 1, pp. 96–109.

Czikk, A.M. and O'Neill, P.S., 1979, "Correlation of Nucleate Boiling from Porous Metal Films," Advances in Enhanced Heat Transfer, ASME, New York, pp. 53–60.

Czikk, A.M., O'Neill, P.S., and Gottzmann, C.F., 1981, "Nucleate Boiling from Porous Metal Films: Effect of Primary Variables," Advances in Enhanced Heat Transfer – 1981, ASME, New York, HTD Vol. 18, pp. 109–122.

Daniels, T.C. and Williams, R.J., 1979, "The Effects of External Boundary Conditions on Condensation Heat Transfer in Rotating Pipes," International Journal of Heat and Mass Transfer, Vol. 22, pp. 1237–1241.

Danilova, G.N., Dyundin, V.A., Borishanskaya, A.V., Soloviyov, A.G., Vol'nykh, Yu.A., and Kozyrev, A.A., 1990, "Effect of Surface Conditions on Boiling Heat Transfer of Refrigerants in Shell–and–Tube Evaporators," Heat Transfer–Soviet Research, Vol. 22, No. 1, pp. 56–65.

Danilova, G.N., Dyundin, V.A., Soloveyov, A.G., and Tikhonov, A.V., 1991, "Experimental Study on Refrigeration Boiling Heat Transfer Outside Tubes in the Bundles," Experimental Heat Transfer, Fluid Mechanics, and Thermodynamics 1991, J.F. Keffer, R.K. Shah, and E.N. Ganic (eds.), Elsevier Science Publishing, NY, pp. 1401–1406.

Danilova, G.N., Guygo, E.I., Borishanskaya, A.V., Bukin, V.G., Dyundin, V.A., Kozyrev, A.A., Malkov, L.S., and Malyugin, G.I., 1976, "Enhancement of Heat Transfer During Boiling of Liquid Refrigerants at Low Heat Fluxes," Heat Transfer–Soviet Research, Vol. 8, No. 4, pp. 1–8.

Danilova, G.N. and Reznikov, V.I., 1987, "Investigation of Boiling Heat Transfer at a Surface with a System of Cylindrical Cavities Under Conditions of Free Motion," Journal of Engineering Physics, Vol. 53, pp. 741–745.

Danilova, G.N. and Tikhonov, A.V., 1984, "Enhancement of Heat Transfer in the Boiling of the R–113 Refrigerant on Various Kinds of Surfaces," Heat Transfer–Soviet Research, Vol. 16, No. 1, pp. 59–66.

Dhir, V.K. and Scott, J.H., 1985, "On the Superposition of Injection Induced Swirl During Enhancement of Subcooled Critical Heat Flux," Augmentation of Heat Transfer in Energy Systems, ASME, New York, HTD–Vol. 52, pp. 37–45.

Dougherty, R.L., Sauer, H.J., 1974, "Nucleate Pool Boiling of Refrigerant–Oil Mixtures from Tubes," ASHRAE Transactions, Vol. 80, Part 2, pp. 175–193.

Dyundin, V.A., Danilova, G.N., and Borishanskaya, A.V., 1981, "Heat Transfer to Refrigerants Boiling on Tubes Covered with Porous Coatings," Heat Transfer–Soviet Research, Vol. 16, No. 1, pp. 61–74.

Dyundin, V. A., Danilova, G. N., Vol'nykh, Y. A., and Tovara, N. V., 1990, "Surfaces of Intensive Heat Transfer for Tube–In–Shell Evaporators," Thermal Engineering, Vol. 37, No. 12, pp. 632–636.

Eckels, S.J. and Pate, M.B., 1990, "An Experimental Comparison of Evaporation and Condensation Heat Transfer Coefficients for HFC–134a and CFC–12," Proceedings of the 1990 USNC/IIR–Purdue Refrigeration Conference, July 1990, West Lafayette, IN., pp. 215–224.

Eckels, S.J. and Pate, M.B., 1991a, "In–Tube Evaporation and Condensation of Refrigerant–Lubricant Mixtures of HFC–134a and CFC–12," ASHRAE Transactions, Vol. 97, Part 2, pp. 62–70.

Eckels, S.J. and Pate, M.B., 1991b, "Evaporation and Condensation of HFC–134a and CFC–12 in a Smooth and a Micro–Fin Tube," ASHRAE Transactions, Vol. 97, Part 2, pp. 71–81

Eckels, S.J., Pate, M.B., and Bemisderfer, C.H., 1992, "Evaporation Heat Transfer Coefficients for R–22 in Micro–Fin Tubes of Different Configurations," Enhanced Heat Transfer, Pate, M.B. and Jensen, M.K. (Eds.), HTD–Vol. 202, ASME, New York, pp. 117–125.

Faghri, A. and Chow, L.C., 1987, "Forced Condensation in a Tube with Suction at the Wall for Microgravitational Applications," International Symposium on Thermal Problems in Space–Based Systems, ASME, New York, NY, HTD–Vol. 83, pp. 71–76.

Fan, L.T., Lin, S.T., and Azer, N.Z., 1977, "Augmentation of the Rate of Forced Flow Boiling Heat Transfer by Means of In–Line Static Mixers," Letters in Heat and Mass Transfer, Vol. 4, pp. 425–428.

Faynzilberg, S.N., Koloskova, N.Y., and Semena, M.G., 1979, "Correlation of Experimental Data on the Maximum Heat Fluxes in Two–Phase Thermosyphons," Heat Transfer–Soviet Research, Vol. 11, No. 2, pp. 119–122.

Fenner, G.W. and Ragi, E., 1979, "Enhanced Tube Inner Surface Device and Method," U.S. Patent 4154293, May 15.

Fricke, H.D. and Czikk, A.M., 1979, "Enhanced OTEC Sprayed Bundle Evaporator Performance Studies," Advances in Enhanced Heat Transfer, Chenoweth, J.M., Kaellis, J., Michel, J., and Shenkman, S.M. (Eds.), ASME, New York, pp. 23–29.

Fujie, K., Nakayama, W., Kuwahara, H., Nakayama, Y., and Kakizaki, K., 1975, "High–Flux Heat Transfer Tubes "Thermoexcel's": ——Their Performance and the Results of Feasibility Test in a Refrigerating Machine," Paper B1.97, XIV International Congress of Refrigeration, Moscow.

Futagami, K., Ikeda, J., Ohhira, K., and Mizukami, K., 1989, "Condensation Heat Transfer in a Rotating Horizontal Cylinder with a Scraper," Experimental Thermal and Fluid Science, Vol. 2, pp. 384–391.

Galloway, J.E. and Mudawar, I., 1992, "Critical Heat Flux Enhancement by Means of Liquid Subcooling and Centrifugal Force Induced by Flow Curvature," International Journal of Heat and Mass Transfer, Vol. 35, No. 5, pp. 1247–1260.

Gogonin, I.I. and Silkachev, A.E., 1991, "Heat Transfer and Critical Heat Fluxes in Boiling at Finned Surfaces," High Temperature, Vol. 29, pp. 914–920.

Grant, I., Hewitt, G.F., and Qureshi, J., 1989, "Pool Boiling of R113/Oil Mixtures on a High Flux Tube," Eurotherm No. 8, Advances in Pool Boiling Heat Transfer, Paderborn, FRG (May 1989).

Ha, S., 1992, "Heat Transfer Characteristics of Horizontal In–Tube Evaporation," Ph.D. dissertation, Rensselaer Polytechnic Institute, Troy, NY, August 1992.

Hahne, E. and Müller, 1983, "Boiling on a Finned Tube and a Finned Tube Bundle," "International Journal of Heat and Mass Transfer, Vol. 26, pp. 849–859

Hahne, E., Qiu–Rong, C., and Windisch, R., 1991, "Pool Boiling Heat Transfer on Finned Tubes – an Experimental and Theoretical Study," International Journal of Heat and Mass Transfer, Vol. 34, No. 8, pp. 2071–2079.

Haley, K.W. and Westwater, J.W., 1966, "Boiling Heat Transfer from Single Fins," Proceedings of the Third International Heat Transfer Conference, American Institute of Chemical Engineers, New York, Vol. III, pp. 245–253.

Heimbach, P., 1972, "Boiling Coefficients of Refrigerant–Oil–Mixtures Outside a Finned–Tube Bundle," Heat and Mass Transfer in Refrigeration Systems and in Air Conditioning, International Institute of Refrigeration, Paris, France, pp. 117–125.

Hesse, G., 1973, "Heat Transfer in Nucleate Boiling, Maximum Heat Flux and Transition Boiling," International Journal of Heat and Mass Transfer, Vol. 16, pp. 1611–1627.

Hijikata, K. and Himeno, N., 1987, "Systematic Research on Optimized Condition for Condensation of Binary Mixture of Vapors," Research on Efficient Use of Thermal Energy, Reports of Special Project Research on Energy under Grant in Aid of Scientific Research of the Ministry of Education, Science, and Culture, Japan, SPEY 23, pp. 21–26 (Oct. 1987).

Hijikata, K., Simoda, K., and Mori, Y., 1987, "Condensation Heat Transfer Enhancement on a Downward Facing Surface by the Gravity," Proceedings of the 1987 ASME–JSME Thermal Engineering Joint Conference, JSME, Tokyo, and ASME, New York, NY, Vol. 4, pp. 393–400.

Hinton, D.L., Conklin, J.C., and Vineyard, E.A., 1992, "Evaporating Characteristics of R22 Flowing Inside a Corrugated Tube," Enhanced Heat Transfer, HTD–Vol. 202, Pate, M.B. and Jensen, M.K. (Eds.), ASME, New York, pp. 127–132.

Hinton, D.L., Conklin, J.C., and Vineyard, E.A., 1992, "Evaporation of an R143a and R124 NARM Inside Smooth and Corrugated Tubes," ASME Paper No. 92–WA/HT–5.

Honda, H., Nozu, S., and Mitsumori, K., 1983, "Augmentation of Condensation on Horizontal Finned Tubes by Attaching a Porous Drainage Plate," ASME–JSME Thermal Engineering Joint Conference Proceedings, Honolulu, Hawaii, Vol. 3, pp. 289–296.

Honda, H., Nozu, S., and Uchima, B., 1987, "A Generalized Prediction Method for Heat Transfer during Film Condensation on a Horizontal Low Finned Tube," Proceedings of the 1987 ASME–JSME Thermal Engineering Joint Conference, JSME, Tokyo, ASME, New York, NY, Vol. 4, pp. 385–392.

Hughes, D.W., McMullan, J.T., Mawhinney, K.A., and Morgan, R., 1982, "Pressure–Enthalpy Charts for Mixtures of Oil and Refrigerant 12," International Journal of Refrigeration, Vol. 5, pp. 199–202.

Hughes, T.G. and Olson, D.R., 1975, "Critical Heat Fluxes for Curved Surfaces During Subcooled Flow Boiling," Transactions of the Canadian Society of Mechanical Engineers, Vol. 3, No. 3, pp. 122–130.

Ikeuchi, M., Yumikura, T., Fujii, M., and Yamanaka, G., 1984, "Heat–Transfer Characteristics of an Internal Microporous Tube with Refrigerant 22 under Evaporating Conditions," ASHRAE Transactions, Vol. 90, Part 1A, pp. 196–211.

Iltscheff, S., 1971, "Concerning Tests for Achieving Drop Condensation with Fluorinated Refrigerants," Kaeltetechnik–Klimatisierung, Vol. 23, pp. 237–241.

Ito, M., Kimura, H., and Senshu, T., 1977, "Development of High Efficiency Air–Cooled Heat Exchangers," Hitachi Review, Vol. 26, No. 10, pp. 323–326.

Ito, M. and Kimura, H., 1979, "Boiling Heat Transfer and Pressure Drop in Internal Spiral–Grooved Tubes," Bulletin of the JSME, Vol. 22, No. 171, pp. 1251–1257.

Ito, T., Tanaka, K., Tamari, T., 1990, "Prediction of Boiling Heat Transfer from Porous Surfaces," Heat Transfer–Japanese Research, Vol. 19, No. 6, pp. 507–520.

Jensen, M.K., 1984a, "A Correlation for Predicting the Critical Heat Flux Condition with Twisted–Tape Swirl Generators," International Journal of Heat and Mass Transfer, Vol. 27, pp. 2171–2173.

Jensen, M.K., 1984b, "Enhancement of the Critical Heat Flux in Pool Boiling of Refrigerant–Oil Mixtures," Journal of Heat Transfer, Vol. 106, pp. 477–479.

Jensen, M.K., 1985, "An Evaluation of the Effect of Twisted–Tape Swirl Generators in Two–Phase Flow Heat Exchangers," Heat Transfer Engineering, Vol. 6, No.4, pp. 19–30.

Jensen, M.K., 1988, "Enhanced Forced Convective Vaporization and Condensation Inside Tubes," Heat Transfer Equipment Design, Hemisphere Publishing Corporation, Washington, DC, pp. 681–695.

Jensen, M.K. and Bensler, H.P., 1986, "Saturated Forced–Convective Boiling Heat Transfer with Twisted–Tape Inserts," Journal of Heat Transfer, Vol. 108, pp. 93–99.

Jensen, M.K. and Bergles, A.E., 1981, "Critical Heat Flux in Helically Coiled Tubes," Journal of Heat Transfer, Vol. 103, pp. 660–666.

Jensen, M.K. and Bergles, A.E., 1982, "Critical Heat Flux in Helical Coils with a Circumferential Heat Flux Tilt Toward the Outside Surface," International Journal of Heat and Mass Transfer, Vol. 25, pp. 1383–1395.

Jensen, M.K. and Jackman, D.L., 1984, "Prediction of Nucleate Pool Boiling Heat Transfer Coefficients of Refrigerant–Oil Mixtures," Journal of Heat Transfer, Vol. 106, pp. 184–190.

Jensen, M.K., Trewin, R.R., and Bergles, A.E., 1992, "Crossflow Boiling in Enhanced Tube Bundles," Two–Phase Flow in Energy Exchange Systems, ASME, New York, HTD–Vol. 220, pp. 11–17.

Jones, T.B. and Hallock, K.R., 1978, "Surface Wave Model of Electrohydrodynamically Coupled Minimum Film Boiling," Journal of Electrostatics, Vol. 5, pp. 273–284.

Jung, C. and Bergles, A.E., 1989, "Evaluation of Commercial Enhanced Tubes in Pool Boiling," Heat Transfer Laboratory Report No. HTl–2, Rensselaer Polytechnic Institute, Troy, NY, March 1989.

Jung, D.S., Venart, J.E.S., and Sousa, A.C.M., 1987, "Effects of Enhanced Surfaces and Surface Orientation on Nucleate and Film Boiling Heat Transfer in R–11," International Journal of Heat and Mass Transfer, Vol. 30, No. 12, pp. 2627–2639.

Jung, D.S. and Venart, J.E.S., 1986, "Effects of Enhanced Surfaces and Surface Orientation on Pool Boiling Heat Transfer," Heat and Technology, Vol. 4, No. 3–4, pp. 62–79.

Karkhu, V.A. and Borovkov, V.P., 1971, "Film Condensation of Vapor at Finely–Finned Horizontal Tubes," Heat Transfer–Soviet Research, Vol. 3, No. 2, pp. 183–191.

Kabov, O. A. and Padyukov, I. V., 1991, "Condensation Heat Transfer on Horizontal Tubes with Ribs of Constant Curvature," Heat Transfer–Soviet Research, Vol. 23, No. 2, pp. 275–283.

Kajikawa, T., Takazawa, H., and Mizuki, M., 1983, "Heat Transfer Performance of Metal Fiber Sintered Surfaces," Heat Transfer Engineering, Vol. 4, No. 1, pp. 57–66.

Kajikawa, T., Takazawa, H., Nishiyama, K., Agawa, T., Iidaka, H., and Amano, M., 1980, "Development of Enhancement of the Working Fluid Side Heat Transfer for OTEC," Proceedings of the Seventh Ocean Energy Conference, Vol. 2, pp. 12.2–1 – 12.2–9.

Kandlikar, S.G., 1991, "A Model for Correlating Flow Boiling Heat Transfer in Augmented Tubes and Compact Evaporators," Journal of Heat Transfer, Vol. 113, pp. 966–972.

Kandula, M., 1990, "Mechanisms and Predictions of Burnout in Flow Boiling Over Heated Surfaces with an Impinging Jet," International Journal of Heat and Mass Transfer, Vol. 33, No. 9, pp. 1795–1803.

Katz, D.L., Young, E.H., and Balekjian, G., 1954, "Condensing Vapors on Finned Tubes," Petroleum Refiner, Vol. 33, No. 11, pp. 175–178.

Karayiannis, T.G., Collins, M.W., and Allen P.H.G., 1989, "Electrohydrodynamic Enhancement of Nucleate Boiling Heat Transfer in Heat Exchangers," Chemical Engineering Communication, Vol. 81, pp. 15–24.

Katto, Y. and Ishii, K., 1978, "Burnout in a High Heat Flux Boiling System With a Forced Supply of Liquid Through a Plane Jet," Proceedings of the 6th International Heat Transfer Conference, Vol. 1, pp. 435–440.

Katto, Y. and Yokoya, S., 1988, "Critical Heat Flux on a Disk Heater Cooled by a Circular Jet of Saturated Liquid Impinging at the Center," International Journal of Heat and Mass Transfer, Vol. 31, No. 2, pp. 219–227.

Kaushik, N. and Azer, N.Z., 1988, "A General Heat Transfer Correlation for Condensation Inside Internally Finned Tubes," ASHRAE Transactions, Vol. 94, Part 2, pp. 261–279.

Kaushik, N. and Azer, N.Z., 1988, "Condensation Heat Transfer Enhancement by Doubly Augmented Tubes," ASHRAE Transactions, Vol. 94, Part 2, pp. 1159–1175.

Kawano, S., 1990, "Condensation of Binary Mixture in Vertical Condensers," Proceedings of the Second International Symposium on Condensers and Condensation, University of Bath, UK, Heat Transfer and Fluid Flow Service, UK, pp. 49–58.

Kedzierski, M.A. and Webb, R.L., 1990, "Practical Fin Shapes for Surface–Tension–Drained Condensation," Journal of Heat Transfer, Vol. 112, pp. 479–485.

Khanpara, J.C., Bergles, A.E., and Pate, M.B., 1986a, "Augmentation of R–113 In–Tube Condensation with Micro–Fin Tubes," Heat Transfer in Air Conditioning and Refrigeration Equipment, HTD–Vol. 65, ASME, New York, pp. 21–32.

Khanpara, J.C., Bergles, A.E., and Pate, M.B., 1986b, "Augmentation of R–113 In–Tube Evaporation with Micro–Fin Tubes," ASHRAE Transactions, Vol. 92, Part 2B, pp. 506–524.

Khanpara, J.C., Pate, M.B., and Bergles, A.E., 1987a, "Local Evaporation Heat Transfer in a Smooth and a Micro–Fin Tube Using Refrigerants 22 and 113," Boiling and Condensation in Heat Transfer Equipment, Ragi, E.G., Rudy, T.M., Rabas, T.J., and Robertson, J.M. (Eds.), HTD–Vol. 85, ASME, New York, pp. 31–39.

Khanpara, J.C., Bergles, A.E., and Pate, M.B., 1987b, "A Comparison of In–Tube Evaporation of Refrigerant 113 in Electrically Heated and Fluid Heated Smooth and Inner–Finned Tubes," Advances in Enhanced Heat Transfer, ASME HTD–Vol. 68, pp. 35–46.

Kimura, H. and Ito, M., 1981, "Evaporating Heat Transfer in Horizontal Internal Spiral–grooved Tubes in the Region of Low Flow Rates," Bulletin of the JSME, Vol. 24, pp. 1602–1607.

Knoebel, D.H. and Yeh, Y.C., 1977, "The Effect of Artificial Surface Projections on Film–Boiling Heat Transfer," ASME, Paper No. 77–HT–81.

Kohler, J.A. and Stine, R.L., 1987, "Test Loop for Measuring In–Tube Enhancement of Evaporating or Condensing Flow," Boiling and Condensation in Heat Transfer Equipment, Ragi, E.G., Rudy, T.M., Rabas, T.J., and Robertson, J.M. (Eds.), ASME HTD–Vol. 85, pp. 65–70.

Koyama, S., Miyara, A., Takamatsu, H., and Fujii, T., 1990, "Condensation Heat Transfer of Binary Refrigerant Mixtures of R22 and R114 Inside a Horizontal Tube with Internal Spiral Grooves," International Journal of Refrigeration, Vol. 13, pp. 256–263.

Kozawa, Y., Inoue, T., and Okuyama, K., 1986, "Enhancement of Bubble Formation and Heat Removal in Transient Boiling," Heat Transfer – 1986, Hemisphere Publishing Corporation, Washington, DC, Vol. 4, pp. 2007–2012.

Kröger, D.G., 1976, "Laminar Condensation Heat Transfer Inside Inclined Tubes," AIChE Symposium Series No. 164, Vol. 73, pp. 256–260.

Kubanek, G.R. and Miletti, D.L., 1979, "Evaporative Heat Transfer and Pressure Drop Performance of Internally–Finned Tubes with Refrigerant 22," Journal of Heat Transfer, Vol. 101, pp. 447–452.

Kuwahara, H., Yasukawa, A., Nakayama, W., and Yanagida, T., 1990, "Evaporative Heat Transfer from Horizontal Enhanced Tubes in Thin Film Flow," 1990, Heat Transfer – Japanese Research, Vol. 19, No. 3, pp. 83–97.

Lal, S., Varma, H.K., and Agrawal, K.N., 1973, "Heat Transfer and Pressure Drop with Swirl Flow," Proceedings of The Second National Symposium on Refrigeration and Air Conditioning, Department of Mechanical Engineering, University of Roorkee, Roorkee, India, pp. 119–127.

Lazarek, G.M., 1980, "Augmentation of Two–Phase Heat Transfer and Pressure Drop of Refrigerants in Horizontal Tubes," International Journal of Refrigeration, Vol. 3, No. 5, pp. 261–272.

Leiner, W. and Lösing, K.–H., 1986, "Heat Transfer Improvement in Nucleate Boiling Through Application of Poorly Wettable Nucleation Activators," Heat Transfer– 986, Hemisphere Publishing Corporation, Washington, DC, 1986, Vol. 6, pp. 2945–2950.

Lienhard, J. and Dhir, V., 1972, "A Simple Analysis of Laminar Film Condensation with Suction," Journal of Heat Transfer, Vol. 94, pp. 334–336.

Liu, Z. Q., Tan, Y. K., and Cui, N. Y., 1988, "The Enhancement of R–113 Condensation Inside Horizontal Tubes with Novel Tube Inserts," Advances in Phase Change Heat Transfer, International Academic Publishers, Chongqing, China, and Pergamon Press, New York, pp. 448–453.

Lovenguth, R.F. and Hanesian, D., 1971, "Boiling Heat Transfer in the Presence of Nonuniform, Direct Current Electric Fields," Industrial and Engineering Chemistry Fundamentals, Vol. 10, No. 4, pp. 570–576.

Luu, M. and Bergles, A. E., 1979, "Experimental Study of the Augmentation of In–Tube Condensation of R–113," ASHRAE Transactions, Vol. 85, Part 2, pp. 132–145.

Luu, M. and Bergles, A.E., 1980, "Enhancement of Horizontal In–Tube Condensation of R–113," ASHRAE Transactions, Vol. 86, Part 1, pp. 293–312.

Luu, M. and Bergles, A. E., 1981, "Augmentation of In–Tube Condensation of R–113 by Means of Surface Roughness," ASHRAE Transactions, Vol. 87, Part 2, pp. 33–50.

Ma, C.–F. and Bergles, A.E., 1983, "Boiling Jet Impingement Cooling of Simulated Microelectronic Chips," Heat Transfer in Electronic Equipment–1983, Oktay, S. and Bar–Cohen, A. (Eds.), ASME, New York, HTD–Vol. 28, pp. 5–12.

Ma, C.–F. and Bergles, A.E., 1986, "Jet Impingement Nucleate Boiling," International Journal of Heat and Mass Transfer, Vol. 29, No. 8, pp. 1095–1101.

Maeda, H., Izumi, R., Yamashita, H., and Kaga, S., 1985, "Study on a Rotating Condenser with a Scraper (3rd Report, Experiment of Condensation on Outer Surface of Vertical and Horizontal Cylinders), " Bulletin of JSME, Vol. 28, No. 235, pp. 94–100.

Malyshenko, S.P., 1991, "Features of Heat Transfer with Boiling on Surfaces with Porous Coatings," Thermal Engineering, Vol. 38, No. 2, pp. 81–88.

Manwell, S.P. and Bergles, A.E., 1990, "Gas–Liquid Flow Patterns in Refrigerant–Oil Mixtures," ASHRAE Transactions, Vol. 96, Part 2, pp. 456–464.

Marto, P.J. and Hernandez, B., 1983, "Nucleate Pool Boiling Characteristics of a Gewa–T Surface in Freon–113," AIChE No. 225, Vol. 79, pp. 1–10.

Marto, P.J. and Lepere, V.J., 1982, "Pool Boiling Heat Transfer From Enhanced Surfaces to Dielectric fluids," Journal of Heat Transfer, Vol. 104, pp. 292–299.

Marto, P.J., Wanniarachchi, A.S., and Pulido, R.J., 1985, "Augmenting the Nucleate Pool–Boiling Characteristics of Gewa–T Finned Tubes in R–113," Augmentation of Heat Transfer in Energy Systems, P.J. Bishop (ed.), ASME, NY, HTD–Vol. 52, pp. 67–73.

Marto, P. J., Zebrowski, D., Wanniarachchi, A. S., and Rose, J. W., 1988, "Film Condensation of R–113 on Horizontal Finned Tubes," ASME Proceedings of the 1988 National Heat Transfer Conference, ASME, New York, NY, HTD–96, Vol. 2, pp. 583–592.

Marvillet, C., 1989, "Influence of Oil on Nucleate Pool Boiling on Refrigerants R12 and R22 from Porous Layer Tube," Eurotherm No. 8, Advances in Pool Boiling Heat Transfer, Paderborn, FRG (May 1989).

McMullan, J.T., Hughes, D.W., and Morgan, R., 1985, "A Suite of Computer Programs for Calculating the Thermodynamic Properties of Refrigerant–Oil Mixtures," Journal of Heat Recovery Systems, Vol. 5, pp. 181–184.

McManus, S.M., Marto, P.J., and Wanniarachchi, A.S., 1986, "An Evaluation of Enhanced Heat Transfer Tubing for Use in R–114 Water Chillers," Heat Transfer in Air Conditioning and Refrigeration Equipment, Kohler, J.A. and Lu, J.W.B. (Eds.), ASME, HTD–Vol. 65, pp. 11–19.

Medwell, J.O., and Nicol, A.A., 1965, "Surface Roughness Effects on Condensate Films," ASME Paper No. 65–HT–43.

Memory, S.B., Chilman, S.V., and Marto, P.J., 1992, "Nucleate Boiling Characteristics of a Small Enhanced Tube Bundle in a Pool of R–113," Two–Phase Flow and Heat Transfer – 1992, J. H. Kim, R. A. Nelson and A. Hashemi (eds.) ASME, NY, HTD–Vol. 197, pp. 129–138.

Memory, S.B. and Marto, P.J., 1992, "The Influence of Oil on Boiling Hysteresis of R–114 from Enhanced Surfaces," Pool and External Flow Boiling, V.K. Dhir and A.E. Bergles (eds.), ASME, NY, pp. 63–71.

Messina, A.D., and Park, Jr., E.L., 1980, "A New Tool for Nucleate Boiling Research," Chemical Engineering Communications, Vol. 4, No. 1, pp. 69–76.

Messina, A.D., and Park, Jr., E.L., 1981, "Effects of Precise Arrays of Pits on Nucleate Boiling," International Journal of Heat and Mass Transfer, Vol. 24, pp. 141–145.

Michel, J.W. and Murphy, R.W., 1980, "Enhanced Condensation Heat Transfer," AICHE Symposium Series No. 199, Vol. 76, pp. 183–191.

Miller, W.J., Gebhart, B., and Wright, N.T., 1990, "Effects of Boiling History on a Microconfigured Surface in a Dielectric Liquid," International Communications in Heat and Mass Transfer, Vol. 17, pp. 389–398.

Mitsuda, M., Kanzaki, N., Yamamoto, M., and Sonoi, H., 1990, "Performance of a Compact Heat Exchanger as the Condenser of Binary Refrigerants Working in a Heat

Pump," Proceedings of the Second International Symposium on Condensers and Condensation, University of Bath, UK, Heat Transfer and Fluid Flow Service, UK, pp. 357–366.

Monde, M., 1987, "Critical Heat Flux in Saturated Forced Convection Boiling on a Heated Disk With an Impinging Jet," Journal of Heat Transfer, Vol. 109, pp. 991–996.

Monde, M. and Furukawa, Y., 1988, "Critical Heat Flux in Saturated Forced Convective Boiling with an Impinging Jet Coexistence of Pool and Forced Convective Boilings," Heat Transfer – Japanese Research, Vol. 17, No. 5, pp. 81–91.

Monde, M. and Inoue, T., 1991, "Critical Heat Flux in Saturated Forced Convective Boiling on a Heated Disk with Multiple Impinging Jets," Journal of Heat Transfer, Vol. 113, pp. 722–727.

Monde, M. and Katto, Y., 1978, "Burnout in a High Heat Flux Boiling System with an Impinging Jet," International Journal of Heat and Mass Transfer, Vol. 21, pp. 295–305.

Monde, M. and Okuma, Y., 1985, "Critical Heat Flux in Saturated Forced Convective Boiling on a Heated Disk with an Impinging Jet – CHF in L–Regime," International Journal of Heat and Mass Transfer, Vol. 28, No. 3, pp. 547–552.

Mori, S., Sakitani, K., and Isaji, A., 1975, "Experimental Research on Heat Transfer of a Flooded Type Evaporator," (In Japanese) Refrigeration, Vol. 50, No. 573, pp. 1–6.

Mori, Y., Hijikata, K., and Hirasawa, S., 1981, "Optimized Performance of Condensers With Outside Condensing Surfaces," Journal of Heat Transfer, Vol. 103, pp. 96–102.

Mudawar, K. and Wadsworth, D.C., 1991, "Critical Heat Flux from a Simulated Chip to a Confined Rectangular Impinging Jet of Dielectric Liquid," International Journal of Heat and Mass Transfer, Vol. 34, No. 6, pp. 1465–1479.

Müller, J., 1986, "Boiling Heat Transfer on Finned Tube Bundles – The Effect of Tube Position and Intertube Spacing," Heat Transfer – 1986, Hemisphere Publishing Corporation, Washington, DC, Vol. 4, pp. 2111–2116.

Müller, J. and Hahne, E., 1981, "Boiling Heat Transfer in Finned Tube Bundles," Heat Transfer – Soviet Research, Vol. 13, No. 6, pp. 19–25.

Murata, K. and Hashizume, K., 1992, "Prediction of Condensation Heat Transfer Coefficient in Horizontal Integral–Fin Tube Bundles," Experimental Heat Transfer, Vol. 5, pp. 115–130.

Murphy, T.J., 1987, "Pool Boiling Of R–114/Oil Mixtures from Single Tubes and Tube Bundles," M.S. Thesis, Naval Postgraduate School, Monterey, CA., September.

Murphy, R.W. and Bergles, A.E., 1972, "Subcooled Flow Boiling of Fluorocarbons – Hysteresis and Dissolved Gas Effects on Heat Transfer," Proceedings of the 1972 Heat Transfer and Fluid Mechanics Institute, Stanford University, pp. 400–416.

Murphy, R.W., Chen, F.C., and Hwang, B.C., 1988, "Condensing Heat Transfer for R114/R12 Mixtures on Horizontal Finned Tubes," International Journal of Refrigeration, Vol. 11, pp. 361–366.

Nakayama, W., Daikoku, T., Kuwahara, H., and Kakizaki, K., 1975, "High–Flux Heat Transfer Surface 'THERMOEXCEL'," Hitachi Review, Vol. 24, No. 8, pp. 329–334.

Nakayama, W., Daikoku, T., Kuwahara, H., and Nakajima, T., 1979, "Dynamic Model of Enhanced Boiling Heat Transfer on Porous Surfaces," Journal of Heat Transfer, Vol. 102, pp. 445–456.

Nakayama, W., Daikoku, T., and Nakajima, T., 1982, "Effects of Pore Diameters and System Pressure on Saturated Pool Nucleate boiling Heat Transfer From Porous Surfaces," Journal of Heat Transfer, Vol. 104, pp. 286–291.

Nakayama, W., Daikoku, T., and Nakajima, T., 1980, "Modeling of Liquid Suction Mechanism in Porous Surface Boiling," ASME Paper No. 80–HT–122.

Nakayama, W., Kuwahara, H., and Daikoku, T., 1978, "Boiling Heat Transfer on the Surface Having a Porous Structure Composed of Small Tunnels and Pores," Hitachi Limited, Mechanical Engineering Research Laboratory Technical Paper MTR No. 1.

Nandapurkar, S.S., and Beatty Jr., K.O., 1960, "Condensation on a Horizontal Rotating Disk," Chemical Engineering Progress Symposium Series No. 30, Vol. 56, pp. 129–137.

Navruzov, Yu.V., 1986, "Heat Transfer to Liquids Boiling in Porous Structures," Heat Transfer–Soviet Research, Vol. 18, No. 2, pp. 123–128.

Nishikawa, K., 1983, "Boiling Heat Transfer and Its Augmentation," ASME–JSME Thermal Engineering Joint Conference Proceedings, Vol. 3, pp. 11–20.

Nishikawa, K., Fujita, Y., Ohta, H., and Hidaka, S., 1982, "Effect of the Surface Roughness on the Nucleate Boiling Heat Transfer Over the Wide Range of Pressure," Heat Transfer – 1982, Hemisphere Publishing Company, Washington, D.C., Vol. 4, pp. 61–66.

Nishikawa, K., Ito, T., Yoshida, S., Fujita, Y., 1985, "Development of the Highest Performance Boiling Surface and its Application to Heat Exchangers," Research on Effective Use of Thermal Energy, Report of Special Projects, SPEY 14, Ministry of Education, Science, and Culture, Japan, pp. 21–28.

Nishikawa, K. and Ito, T., 1982, "Augmentation of Nucleate Boiling by Prepared Surfaces," Heat Transfer in Energy Problems, (Proceedings of the Japan–U.S. Joint Seminar 1980, Tokyo), Hemisphere Publishing Corporation, Washington, DC, pp. 119–126.

Nishikawa, K., Ito, T. and Tanaka, K., 1978, "Enhanced Heat Transfer by Nucleate Boiling on a Sintered Metal Layer," Heat Transfer – Japanese Research, Vol. 8, No. 2, pp. 65–81.

Nishiyama, K., Murata, A., and Kajikawa, T., 1986, "The Study of Condensation Due to Periodic Motion of a Vertical Tube," Heat Transfer–Japanese Research, Vol. 15, No. 6, pp. 32–43.

Nozu, Sh., Ozaki, K., Inaba, H., and Honda, H., 1991, "Condensation of Non–Azeotropic Refrigerant Mixture of R114/R113 in the Annuli With an Enhanced Inner Tube," Proceedings of the ASME/JSME Thermal Engineering Joint Conference, ASME, Vol. 2, pp. 471–478.

Nozu, Sh., Ozaki, K., Inaba, H., and Honda, H., 1992, "Condensation of a Nonazeotropic Refrigerant Mixture R114/R113 in Horizontal Annuli With an Enhanced Inner Tube," Journal of Heat Transfer, Vol. 114, pp. 201–210.

Ohadi, M.M., Papar, R.A., Kumar, A., and Ansari, A.I., 1992, "Some Observations on EHD–Enhanced Boiling of R–123 in the Presence of Oil Contamination," Pool and External Flow Boiling, V.K. Dhir and A.E. Bergles (Eds.), ASME, NY, pp. 387–396.

Ohara, T., Yamamoto, T., and Fujita, H., 1990, "Heat Transfer and Pressure Drop of Boiling Flow in a Cross–Ribbed Flat Channel," International Communications in Heat and Mass Transfer, Vol. 17, pp. 555–556.

O'Neill, P.S., Gottzmann, C.F., and Terbot, J.W., 1971, "Heat Exchanger for NGL," Chemical Engineering Progress, Vol. 67, No. 7, pp. 80–82.

O'Neill, P.S., Gottzmann, C.F., and Terbot, J.W., 1972, "Novel Heat Exchanger Increases Cascade Cycle Efficiency for Natural Gas Liquefaction," Advanced in Cryogenic Engineering, Vol. 17, pp. 420–437.

Pais, C. and Webb, R.L., 1991, "Literature Survey of Pool Boiling on Enhanced Surfaces," ASHRAE Transactions, Vol. 97, Part 1, pp. 79–89.

Palm, B., 1990, "Heat Transfer Augmentation in Flow boiling by Aid of Perforated Metal Foils," ASME Paper No. 90–WA/HT–10.

Palm, B., 1991a, "Enhancement of Boiling Heat Transfer by Aid of Perforated Metal Foils," Ph.D. dissertation, Department of Applied Thermodynamics and Refrigeration, The Royal Institute of Technology, Stockholm, Sweden.

Palm, B., 1991b, "Heat Transfer Augmentation in Pool Boiling by Aid of Perforated Metal Foils," Paper No. 89, 18th International Congress of Refrigeration, Montreal, Canada.

Panchal, C.B., France, D.M., and Bell, K.J., 1992, "Experimental Investigation of Single–Phase, Condensation, and Flow Boiling Heat Transfer for a Spirally Fluted Tube," Heat Transfer Engineering, Vol. 13, pp. 42–52.

Park, K.–A, Bergles, A.E., 1988, "Ultrasonic Enhancement of Saturated and Subcooled Pool Boiling," International Journal of Heat and Mass Transfer, Vol. 31, No. 3, pp. 664–667.

Pearson, J. F. and Withers, J. G., 1969, "New Finned Tube Configuration Improves Refrigerant Condensing," ASHRAE Journal, June 1969, pp. 77–82.

Pinto, A.D., Caplanis, S., Sokol, P., and Gorenflo, D., 1992, "Variation of Hysteresis Phenomena with Saturation Pressure and Surface Roughness, Pool and External Flow Boiling, V.K. Dhir and A.E. Bergles, (Eds.), ASME, NY, pp. 37–42.

Plumb, O.A., Burnett, D.B., and Shekarriz, A., 1990, "Film Condensation on a Vertical Flat Plate in a Packed Bed," Journal of Heat Transfer, Vol. 112, pp. 235–239.

Polezhaev, Yu.V. and Kovalev, S.A., 1990, "Modelling Heat Transfer with Boiling on Porous Structures," Thermal Engineering, Vol. 37, No. 12, pp. 617–620.

Poulter, R., and Allen, P.H.G., 1986, "Electrohydrodynamically Augmented Heat and Mass Transfer in the Shell/Tube Heat Exchanger," Heat Transfer – 1986, Hemisphere Publishing Corporation, Washington, DC, Vol. 6, pp. 2963–2968.

Qi, M., Cai, Y., and Freeston, D.H., 1990, "Bubble Departure Frequency During Boiling from Porous Surfaces," Heat Transfer Enhancement and Energy Conservation, Hemisphere Publishing Corporation, New York, pp. 449–456.

Ramilison, J.M., Sadasivan, P., and Lienhard, J.H., 1992, "Surface Factors Influencing Burnout on Flat Heaters," Journal of Heat Transfer, Vol. 114, pp. 287–290.

Rannenberg, M. and Beer, H., 1980, "Heat Transfer by Evaporation in Capillary Porous Wire Mesh Structures," Letters in Heat and Mass Transfer, Vol. 7, No. 6, pp. 425–436.

Reid, R.S., Pate, M.B., and Bergles, A.E., 1987, "A Comparison of Augmentation Techniques During In–Tube Evaporation of R–113," Boiling and Condensation in Heat Transfer Equipment, Ragi, E.G., Rudy, T.M., Rabas, T.J., and Robertson, J.M. (Eds.), ASME, NY, HTD–Vol. 85, pp. 21–30.

Reisbig, R.L., 1974, "Condensing Heat Transfer Augmentation Inside Splined Tubes," ASME Paper 74–HT–7.

Renz, U., 1986, "Measures to Improve Heat Transfer in Condensation," German Chemical Engineering, Vol. 1, pp. 30–41.

Riffert, V.G., Leont'yev, G.G., Chaplinskiy, S.I., and Yefremov, A.A., 1976, "Augmentation of Heat Transfer from Refrigerants Condensing on Vertical Tubes," Heat Transfer–Soviet Research, Vol. 8, No. 6, pp. 120–126.

Rosenfeld, J.H., 1989, "Nucleate Boiling Heat Transfer in Porous Wick Structures," Heat Transfer Equipment Fundamentals, Design, Applications and Operating Problems, Shah, R.K. (Ed.), ASME, New York, HTD–Vol. 108, pp. 47–55.

Rubin, I.R., Roizen, L.I., Dul'kin, I.N., and Yudina, L.A., 1979, "Heat Transfer in the Boiling of a Liquid on Horizontal Pipes with Annular Fins," High Temperature, Vol. 17, No. 3, pp. 475–480.

Ruch, M.A. and Holman, J.P., 1975, "Boiling Heat Transfer to a Freon–113 Jet Impinging Upward Onto a Flat Heat Surface," International Journal of Heat and Mass Transfer, Vol. 18, pp. 51–60

Saaski, E.W. and Franklin, J.L., 1977, "Performance of an Evaporative Heat Transfer Wick," Chemical Engineering Progress, July 1977, pp. 74–77.

Said, S.A. and Azer, N.Z., 1983, "Heat Transfer and Pressure Drop During Condensation Inside Horizontal Tubes with Twisted–Tape Inserts," ASHRAE Transactions, Vol. 89, Part 1, pp. 96–113.

Said, S. A. and Azer, N. Z., 1983, "Heat Transfer and Pressure Drop During Condensation Inside Horizontal Finned Tubes," ASHRAE Transactions, Vol. 89, Part 1, pp. 114–135.

Sami, S.M. and Duong, T.N., 1991, "Experimental Study of the Heat Transfer Characteristics of Refrigerant Mixture R–22/R–114 in the Annulus of Enhanced Surface Tubing," International Communications in Heat and Mass Transfer, Vol. 18, pp. 547–558.

Sami, S.M. and Duong, T.N., 1992a, "Flow Boiling Characteristics of Refrigerant Mixture R22/R114 in the Annulus of Enhanced Surface Tubing," International Journal of Energy Research, Vol. 16, pp. 241–252.

Sami, S.M. and Duong, T.N., 1992b, "Flow Boiling Characteristics of Refrigerant Mixture R22/R114 in the Annulus of Enhanced Surface Tubing," Heat Recovery Systems & CHP, Vol. 12, pp. 39–48.

Sami, S.M., Duong, T.N., and Snelson, W.K., 1992, "Two Phase Boiling Characteristics of R–134a and R–12 in Annuli of Enhanced Surface Tubing," International Communications in Heat and Mass Transfer, Vol. 19, pp. 203–214.

Sami, S.M. and Schnotale, J., 1992a, "Comparative Study of Two Phase Flow Boiling of Refrigerant Mixtures and Pure Refrigerants Inside Enhanced Surface Tubing," International Communications in Heat and Mass Transfer, Vol. 19, pp. 137–148.

Sami, S.M. and Schnotale, J., 1992b, "Forced Convective Boiling of Nonazeotropic Refrigerant Mixtures Inside Enhanced Surface Tubing," International Journal of Energy Research, Vol. 16, pp. 637–651.

Sami, S.M. and Schnotale, J., 1992c, "Prediction of Two Phase Flow Condensation of Pure and Refrigerant Mixtures on Enhanced Surface Tubing," International Communications in Heat and Mass Transfer, Vol. 19, pp. 191–202.

Sauer, H.J. and Chongrungreong, S., 1980, "Nucleate Boiling Performance of Refrigerants and Refrigerant–Oil Mixtures," Journal of Heat Transfer, Vol. 102, pp. 701–705.

Sauer, H.J., Davidson, G.W., and Chongrungreong, S. 1980, "Nucleate Pool Boiling of Refrigerant–Oil Mixtures From Finned Tubing," ASME Paper No. 80–HT–111.

Sauer, H.J. and Medrow, R.A., 1975, "Effects of Surface Condition on Nucleate Boiling of Refrigerant–11," ASHRAE Transactions, Vol. 81, Part 2, pp. 274–281.

Sauer, H.J. and Williams, P.E., 1982, "Condensation of Refrigerant–Oil Mixtures on Low–Profile Finned Tubing," Heat Transfer – 1982, Proceedings of Seventh International Heat Transfer Conference, Munich, Vol. 5, pp. 147–152.

Schlager, L.M., Bergles, A.E., and Pate, M.B., 1987, "A Survey of Refrigerant Heat Transfer and Pressure Drop Emphasizing Oil Effects and In–Tube Augmentation," ASHRAE Transactions, Vol. 93, Part 1, pp. 392–416.

Schlager, L.M., Pate, M.B., and Bergles, A.E., 1988a, "Evaporation and Condensation of Refrigerant–Oil Mixtures in a Smooth Tube and a Micro–fin Tube," ASHRAE Transactions, Vol. 94, Part 1, pp. 149–166.

Schlager, L.M., Pate, M.B., and Bergles, A.E., 1988b, "Evaporation and Condensation of Refrigerant–Oil Mixtures in a Low–Fin Tube," ASHRAE Transactions, Vol. 94, Part 2, pp. 1176–1194.

Schlager, L.M., Pate, M.B., and Bergles, A.E., 1989a, "Evaporation and Condensation Heat Transfer and Pressure Drop in Horizontal, 12.7–mm Micro–Fin Tubes with Refrigerant–22," Heat Transfer Equipment Fundamentals, Design Applications, and Operating Problems, Shah, R.K. (Ed.), HTD–Vol. 108, ASME, New York, pp. 205–213.

Schlager, L.M., Pate, M.B., and Bergles, A.E., 1989b, " A Comparison of 150 SUS and 300 SUS Oil Effects on Refrigerant Evaporation and Condensation in a Smooth and a Micro–fin Tube," ASHRAE Transactions, Vol. 95, Part 2, pp. 387–397.

Schlager, L.M., Pate, M.B., and Bergles, A.E., 1989c, "Heat Transfer and Pressure Drop Performance of Smooth and Internally Finned Tubes with Oil and Refrigerant 22 Mixtures," ASHRAE Transactions, Vol. 95, Part 2, pp. 375–385.

Schlager, L.M., Pate, M.B., and Bergles, A.E., 1989d, "Performance of Micro–Fin Tubes with Refrigerant–22 and Oil Mixture," ASHRAE Journal, pp. 17–28 (November 1989).

Schlager, L.M., Pate, M.B., and Bergles, A.E., 1990a, "Evaporation and Condensation Heat Transfer and Pressure Drop in Horizontal, 12.7–mm Microfin Tubes with Refrigerant 22,," Journal of Heat Transfer, Vol. 112, pp. 1041–1047.

Schlager, L.M., Pate, M.B., and Bergles, A.E., 1990b, "Performance Predictions of Refrigerant–Oil Mixtures in Smooth and Internally Finned Tubes – Part I: Literature Review," ASHRAE Transactions, Vol. 96, Part 1, pp. 160–169.

Schlager, L.M., Pate, M.B., and Bergles, A.E., 1990c, "Performance Predictions of Refrigerant–Oil Mixtures in Smooth and Internally Finned Tubes – Part II: Design Equations," ASHRAE Transactions, Vol. 96, Part 1, pp. 170–182.

Schlager, L.M., Pate, M.B., and Bergles, A.E., 1990d, "Condensation of Refrigerant–Oil Mixtures in Smooth and Augmented Tubes," Proceedings of the Second International Symposium on Condensers and Condensation, University of Bath, UK, Heat Transfer and Fluid Flow Service, UK, pp. 451–460.

Shekarriz, A. and Plumb, O.A., 1989, "Enhancement of Film Condensation Using Porous Fins," Journal of Thermophysics and Heat Transfer, Vol. 3, No. 3, pp. 309–314.

Shih, C.–C. and Westwater, J.W., 1972, "Use of Coatings of Low Thermal Conductivity to Improve Fins Used in Boiling Liquids," International Journal of Heat and Mass Transfer, Vol. 15, pp. 1965–1968.

Shih, C.–C. and Westwater, J.W., 1974, "Spheres, Hemispheres and Discs as High–Performance Fins for Boiling Heat Transfer," International Journal of Heat and Mass Transfer, Vol. 17, pp. 125–133.

Shohtani, H., 1990, "The Experimental Research on Condensation of the Plate–Fin Heat Exchangers, Using Non–Azeotropic Refrigerant Mixtures," Proceedings of the Second International Symposium on Condensers and Condensation, University of Bath, UK, Heat Transfer and Fluid Flow Service, UK, pp. 367–376.

Shoji, M. and Witte, L.C., 1988, "The Effect of Liquid Subcooling and Surface Roughness on Film/Transition Boiling," ASME Proceedings of the 1988 National Heat Transfer Conference, HTD–96, ASME, New York, Vol. 2, pp. 667–673.

Shoji, M., Witt, L.C., and Sankaran, S., 1990, "The Influence of Surface Conditions and Subcooling on Film–Transition Boiling," Experimental Thermal and Fluid Science, Vol. 3, pp. 280–290

Shollenberger, K., Carey, V.P., and Tervo, P., 1992, "Onset of Dryout and Post–Dryout Heat Transfer in Enhanced Passage Geometries for Compact Evaporators," Two–Phase Flow and Heat Transfer, HTD–Vol. 197, ASME, New York, pp. 83–91.

Smirnov, G.F., 1976, "Heat Transfer in Condensation of Binary Mixtures on Finned Surfaces," Heat Transfer – Soviet Research, Vol. 8, No. 1, pp. 45–50.

Sozen, M. and Vafai, K., 1990, "Analysis of the Non–Thermal Equilibrium Condensing Flow of a Gas Through a Packed Bed," International Journal of Heat and Mass Transfer, Vol. 33, pp. 1247–1261.

Stephan, K., 1982, "Heat Transfer in Boiling of Mixtures," Heat Transfer – 1982, Hemisphere Publishing Corporation, Washington, DC, Vol. 1, pp. 59–81.

Stephan, K. and Körner, M., 1969, "Berechnung des Warmeubergangs verdampfender binarer Flussigkeitsgemische," Chemie–Ing.–Techn., Vol. 41, pp. 409–417.

Stephan, K. and Mitrovic, J., 1981, "Heat Transfer in Natural Convective Boiling of Refrigerants and Refrigerant–Oil Mixtures in Bundles of T–Shaped Finned Tubes," Advances in Enhanced Heat Transfer, Webb, R.L., Carnavos, T.C., Park, Jr., E.L., and Hostetler (Eds.), ASME, HTD–Vol. 18, pp. 131–146.

Stephan, K. and Mitrovic, J., 1982, "Heat Transfer in Natural Convective Boiling of Refrigerant–Oil Mixtures," Proceedings of the Seventh International Heat Transfer Conference, Munich, Germany, Vol. 5, pp. 73–87.

Styrikovich, M.A., Leont'yev, A.I., Mostinskiy, I.L., Polonskiy, V.S., and Chernina, I.M., 1982, "Experimental Study of Flow and Boiling Crisis in Horizontal Steam Generating Pipes with Wire Gauze–Covered Inner Walls," Heat Transfer–Soviet Research, Vol. 14, No. 2, pp. 86–91.

Sur, B. and Azer, N.Z., 1991, "Condensation Heat Transfer and Pressure Drop of Oil–Refrigerant Mixtures Inside Smooth and Internally Finned Tubes," Heat Transfer – 1990, Hemisphere Publishing, NY, Vol. 5, pp. 33–38.

Sur, B. and Azer, N.Z., 1991, "Effect of Oil on Heat Transfer and Pressure Drop During Condensation of Refrigerant–113 Inside Smooth and Internally Finned Tubes," ASHRAE Transactions, Vol. 97, Part 1, pp. 365–373.

Takamatsu, H., Miyara, A., Koyama, S., Fujii, T., and Yonemoto,K., 1990, "Forced Convective Boiling of Nonazeotropic Refrigerant Mixtures of R22 and R114 Inside a Horizontal Tube," Heat Transfer – Japanese Research, Vol. 19, pp. 68–82.

Takeyama, T., 1985, "Optimization of Fin Array in Boiling Heat Transfer," Research on Effective Use of Thermal Energy, Report of Special Projects, Ministry of Education, Science and Culture, pp. 113–120.

Tang, S.–I. and McDonald, T.W., 1971, "A Study of Boiling Heat Transfer from a Rotating Horizontal Cylinder," International Journal of Heat and Mass Transfer, Vol. 17, pp. 1643–1658.

Tatara, R.A. and Payvar, P., 1986, "Pressure Drop and Heat Transfer Measurements of Boiling Refrigerant in Normal Flow through a Porous Coated Tube Bundle," Heat Transfer in Air Conditioning and Refrigeration Equipment, eds. by J.A. Kohler and J.W.B. Lu, ASME, New York, NY, HTD–Vol. 65, pp. 1–9.

Tatsumi, A., Oizumi, K., Hayashi, M., and Ito, M., 1982, "Application of Inner Groove Tubes to Air Conditioners," Hitachi Cable Review, No. 1, pp. 55–60.

Tekhver, Ya.Kh., 1990, "Hysteresis Phenomena with Boiling on Porous Coatings," Thermal Engineering, Vol. 37, No. 12, pp. 625–627.

Thome, J.R., 1992, "Mechanisms of Enhanced Nucleate Pool Boiling," Pool and External Flow Boiling, eds. V.K. Dhir and A.E. Bergles, ASME, NY pp. 337–343.

Thomas, A., Hillis, D., Panchal, C., Yung, D.J., and Sather, N., 1980, "Experimental Tests of 1 MWT OTEC Heat Exchangers at Argonne National Laboratory," Proceedings of the 7th Ocean Energy Conference, CONF–800633, Vol. 2, pp. 12.2–1 – 12.2–9.

Thome, J.R. and Shock, R.A.W., 1984, "Boiling of Multicomponent Liquid Mixtures," Advances in Heat Transfer, Vol. 16, pp. 59–156.

Tojo, S., Hosokawa, K., Arimoto, T., Yamada, H., and Ohta, Y., 1984, "Performance Characteristics of Multi–Grooved Tubes for Air Conditioners," Australian Refrigeration, Air Conditioning and Heating, August 1984, pp. 45–61.

Torii, T., Hirasawa, S., Kuwahara, H., Yanagida, T., and Fujie, K., 1978, "The Use of Heat Exchangers with THERMOEXCEL's Tubing in Ocean Thermal Energy Power Plants," ASME, Paper No. 78–WA/HT–65.

Trewin, R.R., 1992, "Enhanced Boiling Heat Transfer in Horizontal Tube Bundles," Ph.D. dissertation, Rensselaer Polytechnic Institute, Troy, NY, August 1992.

Trewin, R.R., Jensen, M.K., and Bergles, A.E., 1993, "Experimental Results of Enhanced Bundle Boiling in Binary Mixtures," Journal of Energy, Heat and Mass Transfer. (in press.)

Trommelmans, J. and Berghmans, J., 1986, "Influence of Electric Fields on Condensation Heat Transfer of Nonconducting Fluids on Horizontal Tubes," Heat Transfer – 1986, Hemisphere Publishing Corporation, Washington, DC, pp. 2969–2976.

Uemura, M., Nishio, S., and Tanasawa, I., 1990, "Enhancement of Pool Boiling Heat Transfer by Static Electric Field," Heat Transfer – 1990, Hemisphere Publishing Corporation, Washington, DC, Vol. 4, pp. 75–80.

Vasil'ev, L.L., Abramenko, A.N., and Kanonchik, L.E., 1978, "Boiling Liquid Heat Transfer on Porous and Developed Heater Surfaces," Journal of Engineering Physics, Vol. 34, pp. 508–524.

Vasil'ev, L.L., Kalita, V., and Khrolenok, V.V., 1984, "Intensification of Heat Exchange in the Condensation Zone of Centrifugal Heat Pipes," Journal of Engineering Physics, Vol. 46, pp. 382–387.

Venart, J.E.S., Sousa, A.C.M., and Jung, D.S., 1986, "Nucleate and Film Boiling Heat Transfer in R11: The Effects of Enhanced Surfaces and Inclination," Heat Transfer – 1986, Hemisphere Publishing Corporation, Washington, DC, Vol. 4, pp. 2019–2024.

Vrable, D.L., Yang, W.J., and Clark, A., 1974, "Condensation of Refrigerant–12 Inside Horizontal Tubes with Internal Axial Fins," Heat Transfer – 1974, JSME, Tokyo, Vol. 3, pp. 250–274.

Wang, J.C.Y., Lin, S., Fazio, P., and Jiang, Z., 1989, "Experimental Study on Condensation of Refrigerant–Oil Mixtures, Part III: R–12 and R–22 on the External Surface of Single and Multiple Horizontal Finned Tubes," ASHRAE Transactions, Vol. 95, Part 2, pp. 386–392.

Wanniarachchi, A.S., Marto, P.J., and Reilly, J.T., 1986, "The Effect of Oil Contamination on the Nucleate Pool Boiling Performance of R–114 from a Porous–Coated Surface," ASHRAE Transactions, Vol.92, Part 2, pp. 525–538.

Wanniarachchi, A.S., Sawyer, L.M., and Marto, P.J., 1987, "Effect of Oil on Pool Boiling Performance of R–114 from Enhanced Surfaces," Proceedings of the 1987 ASME–JSME Thermal Engineering Joint Conference, JSME, Tokyo, and ASME, New York, Vol.1, pp. 531–537.

Webb, R.L., 1981, "The Evolution of Enhanced Surface Geometries for Nucleate Boiling," Heat Transfer Engineering, Vol. 2, No. 3–4, pp. 46–69.

Webb, R.L., 1983, "Nucleate Boiling on Porous Coated Surfaces," ASME Paper No. 83–HT–37.

Webb, R.L., 1984, "Nucleate Boiling on Porous Coated Surfaces," Heat Transfer Engineering, Vol. 4, No. 3–4, pp. 71–82.

Webb, R. L., 1988, "Enhancement of Film Condensation," International Communications in Heat and Mass Transfer, Vol. 15, pp. 475–507.

Webb, R.L. and Apparao, T.V.R., 1990, "Performance of Flooded Refrigerant Evaporators with Enhanced Tubes," Heat Transfer Engineering, Vol. 11, No. 2, pp. 29–43.

Webb, R.L., Bergles, A.E., and Junkan, G.H., 1983, "Bibliography of U.S. Patents on Augmentation of Convective Heat and Mass Transfer," HTL–32, Iowa State University, under DOE Contract DE–FG07–81ID12222.

Webb, R.L. , and Gee, D.L., 1979, "Analytical Prediction for a New Concept Spine–Fin Surface Geometries," ASHRAE Transactions, Vol. 85, Part 2, pp. 274–283.

Webb, R.L. and Haider, I., 1992, "An Analytical Model for Nucleate Boiling on Enhanced Surfaces," Pool and External Flow Boiling, V.K. Dhir and A.E. Bergles (eds.) ASME, NY, pp. 345–360.

Webb, R.L. and Murawski, C.G., 1990, "Row Effect for R–11 Condensation on Enhanced Tubes," Journal of Heat Transfer, Vol. 112, pp. 768–776.

Webb, R.L. and Pais, C., 1991, "Pool Boiling Data for Five Refrigerants on Three Tube Geometries," ASHRAE Transactions, Vol. 97, Part 1, pp. 72–78.

Webb, R.L., Rudy, T.M., and Kedzierski, M.A., 1985, "Prediction of the Condensation Coefficient on Horizontal Integral–Fin Tubes," Journal of Heat Transfer, Vol. 107, pp. 369–376.

Westwater, J.W., 1973, "Development of Extended Surfaces for Use in Boiling Liquids," AIChE Symposium Series No. 131, Vol. 69, pp. 1–9.

Windisch, R., Hahne, E., and Kiss, V., 1985, "Heat Transfer for Boiling on Finned tube Bundles," International Communications in Heat and Mass Transfer, Vol. 12, pp. 355–368.

Wright, N.T. and Gebhart, B., 1992, "A Two Bubble Model of Boiling Enhancement From Microconfigured Surfaces," Pool and External Flow Boiling, Eds. V.K. Dhir and A.E. Bergles, ASME, NY, pp. 367–372.

Xin, M.D., Xie, H.D., and Chen, Y.G., 1984, "Boiling Heat Transfer on Heating Surfaces Covered by Metal Screens," Proceedings of Fifth International Heat Pipe Conference, Part 1, Japan Technology and Economics Center Incorporated, Tokoyo, Japan 1984, pp. 151–155.

Yabe, A. and Maki, H., 1988, "Augmentation of Convective and Boiling Heat Transfer by Applying an Electro–Hydrodynamical Liquid Jet," International Journal of Heat and Mass Transfer, Vol. 31, pp. 407–417.

Yabe, A., 1991, "Active Heat Transfer Enhancement by Applying Electric Fields," Proceedings of the 1991 ASME–JSME Thermal Engineering Joint Conference, JSME, Tokyo, and ASME, New York, Vol. 3, pp. xv–xxiii.

Yabe, A., Iguchi, M., Taketani, T., and Kikuchi, K., 1987, "Augmentation Mechanism of Burnout Heat Flux by Applying Electric Fields (1st Report : Latent Heat Flux and its Enhancement by Electric Fields)," Proceedings of the 1987 ASME–JSME Thermal Engineering Joint Conference, Vol. 4, pp. 417–424.

Yabe, A., Taketani, T., Kikuchi, K., and Maki, H., 1986, "Augmentation of Condensation Heat Transfer by Applying Electro–Hydro–Dynamical Pseudo–Dropwise Condensation," Heat Transfer – 1986, Hemisphere Publishing Corporation, Washington, DC, Vol. 6, pp. 2957–2962.

Yamaguchi, H. and James, D.D., 1988, "Effect of Wire Meshes on Boiling Heat Transfer From a Plane Heating Surface," Experimental Heat Transfer, Fluid Mechanics, and Thermodynamics – 1988, Elsevier Science Publishing Co., Inc., New York, pp. 587–594.

Yamashita, T., 1972, "Heat Transfer of Shell–and–Coil Condenser," Heat Transfer – Japanese Research, Vol. 1, No. 3, pp. 8–18.

Yamashita, K., Kumagai, M., Sekita, S., Yabe, A., Taketani, T., and Kikuchi, K., 1991, "Heat Transfer Characteristics of an EHD Condenser," Proceedings of the 1991 ASME–JSME Thermal Engineering Joint Conference, JSME, Tokyo, and ASME, New York, Vol. 3, pp. 61–67.

Yang, G.W., Yang, W.–J., and Zhang, N., 1992, "Mechanisms of Nucleate Pooling on Composite Surfaces," International Communications in Heat and Mass Transfer, Vol. 19, pp. 781–790.

Yang, W.–J., Takizawa, H., and Vrable, D.L., 1991, "Augmented Boiling on Copper–Graphite Composite Surface," International Journal of Heat and Mass Transfer, Vol. 34, No. 11, pp. 2751–2758.

Yokoyama, T., Yamazaki, T., Kubo, Y., Ogata, J., Kawada, A., and Ooki, Y., 1987, "The Effect of an Electric Field on Boiling Heat Transfer of Fluorocarbon R–11," Heat and Mass Transfer in Refrigeration and Cryogenics, Eds. J. Bongard and N. Afgan, Hemisphere Publishing Corporation, pp. 140–151.

Yoshida, S. and Matsunaga, T., 1991, "Influence of Oil on Heat Transfer to Refrigerant Flowing in a Horizontal, Spirally Grooved Evaporator Tube," Proceedings of the ASME/JSME Thermal Engineering Joint Conference, ASME, Vol.2, pp. 327–332.

Yoshida, S., Matsunaga, T., Hong, H.–P., and Nishikawa, K., 1988, "Heat Transfer Enhancement in Horizontally Spirally Grooved Evaporator Tubes," JSME International Journal, Series II, Vol. 31, No. 3, pp. 505–512.

Zhang, H.J. and Zhao, X.B., 1992, "Critical Heat Flux for a Thin Powder Porous Layer," Experimental Heat Transfer, Fluid Mechanics, and Thermodynamics–1991, J.F. Keefer, R.K. Shah, and E.N. Ganic (eds.) Elsevier Science Publishing Co., Inc., New York pp. 627–632.

APPENDIX 1

LITERATURE SURVEYS - POOL BOILING

ALLEN;P.H.G.
"HEAT TRANSFER ENHANCEMENT BY DIELECTROPHORESIS"
SECOND UK NATIONAL CONFERENCE ON HEAT TRANSFER, GLASGOW, VOL.1, 1988, PP.861-870
000194 1988 IIUKNHTC LITSURVEY
ELECTROFIELD CONDENSATION POOLBOIL

BERGLES;A.E.
"AUGMENTATION OF BOILING HEAT TRANSFER"
NOTES FOR MASSACHUSETTS INSTITUTE OF TECHNOLOGY SPECIAL SUMMER PROGRAM, TWO-PHASE GAS-LIQUID FLOW AND HEAT TRANSFER, 1967
000032 1967 MIT LITSURVEY
POOLBOIL FLOBOIL

BERGLES;A.E.
"SURVEY OF AUGMENTATION OF TWO-PHASE HEAT TRANSFER"
PREPRINTED AND PRESENTED AT ASHRAE SEMIANNUAL MEETING, DALLAS,1976,ASHRAE TRANSACTIONS,VOL.82,PT.1,1976,PP.891-905.
000053 1976 ASHRAET LITSURVEY
POOLBOIL FLOBOIL CONDENSATION

BERGLES;A.E.
"THE EVOLUTION OF COOLING TECHNOLOGY FOR ELECTRICAL, ELECTRONIC, AND MICROELECTRONIC EQUIPMENT"
HEAT TRANSFER IN ELECTRONIC EQUIPMENT-1986, HTD-VOL.57, ASME, NEW YORK, 1986, PP.1-9
000168 1986 ASME LITSURVEY
EXTENDEDSURF 1NATCONV 1FORCECONV POOLBOIL

BERGLES;A.E.
"HEAT TRANSFER AUGMENTATION"
TWO-PHASE FLOW HEAT EXCHANGERS: THERMAL-HYDRAULIC FUNDAMENTALS AND DESIGN, KLUWER ACADEMIC PUBLISHERS, DORDRECHT, THE NETHERLANDS, 1988, PP.343-373
000161 1988 ** LITSURVEY
1FORCECONV POOLBOIL FLOBOIL CONDENSATION

BERGLES;A.E.
"HIGH FLUX BOILING APPLIED TO MICROELECTRONICS THERMAL CONTROL"
INTERNATIONAL COMMUNICATIONS IN HEAT AND MASS TRANSFER, VOL.15, 1988, PP.509-531
000172 1988 ICHMT LITSURVEY
POOLBOIL TREATSURF ADDFORLIQUIDS

JENSEN;M.K.
"BOILING ON THE SHELLSIDE OF HORIZONTAL TUBE BUNDLES"
TWO-PHASE FLOW HEAT EXCHANGERS: THERMAL-HYDRAULIC FUNDAMENTALS AND DESIGN, KLUWER ACADEMIC PUBLISHERS, DORDRECHT, THE NETHERLANDS, 1988, PP.707-746
000162 1988 ** LITSURVEY
POOLBOIL EXTENDEDSURF TREATSURF

NAKAYAMA;W.
"ENHANCEMENT OF HEAT TRANSFER"
HEAT TRANSFER 1982, VOL.1, HEMISPHERE PUBLISHING COMPANY, WASHINGTON, D.C., 1982, PP.223-240
000110 1982 VIIIHTC LITSURVEY
1FORCECONV POOLBOIL FLOBOIL CONDENSATION

PAIS;C. WEBB;R.L.
"LITERATURE SURVEY OF POOL BOILING ON ENHANCED SURFACES"
ASHRAE TRANSACTIONS, VOL.97, PART 1, 1991, PP.79-89
000200 1991 ASHRAE LITSURVEY
POOLBOIL

THOME;J.R.
"MECHANISMS OF ENHANCED NUCLEATE POOL BOILING"
PROCEEDINGS OF THE ENGINEERING FOUNDATION CONFERENCE ON POOL AND EXTERNAL FLOW BOILING, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1992, PP.337-343
000197 1992 ASME LITSURVEY
POOLBOIL

WEBB;R.L.
"THE EVOLUTION OF ENHANCED SURFACE GEOMETRIES FOR NUCLEATE BOILING"
HEAT TRANSFER ENGINEERING, VOL.2, NOS.3-4, 1981, PP.46-69
000118 1981 HTE LITSURVEY
TREATSURFF ROUGHSURF POOLBOIL

WEBB;R.L.
"HIGH PERFORMANCE HEAT TRANSFER SURFACES FOR BOILING AND CONDENSATION"
HEAT TRANSFER IN ENERGY PROBLEMS, PROCEEDINGS OF THE JAPAN-UNITED STATES JOINT SEMINAR, TOKYO, JAPAN, SEPTEMBER 1980, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, 1982, PP. 127-132
000100 1982 ** LITSURVEY
POOLBOIL CONDENSATION

TREATED SURFACES - POOL BOILING

AFGAN;N.H. JOVIC;L.A. KOVALEV;S.A.
LENYKOV;V.A.
"BOILING HEAT TRANSFER FROM SURFACES WITH POROUS LAYERS"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.28, NO.2, 1985, PP.415-422
013151 1985 IJHMT TREATSURF POOLBOIL

ANDERSON;T.M. MUDAWWAR;I.
"MICROELECTRONIC COOLING BY ENHANCED POOL BOILING OF A DIELECTRIC FLUOROCARBON LIQUID"
ASME PROCEEDINGS OF THE 1988 NATIONAL HEAT TRANSFER CONFERENCE, HTD-96, VOL.1, ASME, NEW YORK, 1988, PP.551-560
033079 1988 ASME EXTENDEDSURF POOLBOIL TREATSURF

ANDERSON;T.M. MUDAWAR;I.
"MICROELECTRONIC COOLING BY ENHANCED POOL BOILING OF A DIELECTRIC FLUOROCARBON LIQUID"
JOURNAL OF HEAT TRANSFER, VOL.111, 1989, PP.752-759
013156 1989 JHT TREATSURF POOLBOIL EXTENDEDSURF ROUGHSURF

ANONYMOUS
"NEW HEAT EXCHANGER TUBES MAKE THEIR COMMERCIAL DEBUT"
CHEMICAL ENGINEERING, MARCH, 1970, PP.60-62
013070 1970 ** TREATSURF POOLBOIL

ANTONELLI;R. O'NEILL;P.S.
"DESIGN AND APPLICATION CONSIDERATIONS FOR HEAT EXCHANGERS WITH ENHANCED BOILING SURFACES"
HEAT EXCHANGERS: THEORY AND PRACTICE, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, AND MC GRAW-HILL BOOK COMPANY, NEW YORK, 1983, PP.175-192
013144 1983 ** TREATSURF POOLBOIL

ANTONENKO;V.A.
"CAUSES OF ENHANCED BOILING HEAT TRANSFER ON SURFACES COVERED WITH PERFORATED POLYMER FILM"
JOURNAL OF ENGINEERING PHYSICS, VOL.54, 1988, PP.391-393
013233 1988 JEP TREATSURF POOLBOIL

ARAI;A. ARAI;N. FUSHIMA;T.
NAKAYAMA;W. FUJIE;K.
"HEAT TRANSFER CHARACTERISTICS OF "THERMOEXCEL" TUBES IN HEAT EXCHANGERS OF TURBO-REFRIGERATING MACHINES"
IIF-IIR COMMISSIONS B1, B2, AND B3, BELGRADE, YUGOSLAVIA, 1977, PP.15-20
013068 1977 ** TREATSURF POOLBOIL CONDENSATION

AYUB;Z.H. BERGLES;A.E.
"POOL BOILING FROM GEWA SURFACES IN WATER AND R-113"
AUGMENTATION OF HEAT TRANSFER IN ENERGY SYSTEMS, HTD-VOL.52, ASME, NEW YORK, 1985, PP.57-66
013191 1985 ASME TREATSURF POOLBOIL

AYUB;Z.H.
"POOL BOILING FROM GEWA SURFACES IN WATER AND R-113"
WAERME- UND STOFFUEBERTRAGUNG, VOL.21, 1987, PP.209-219
013158 1987 ** TREATSURF POOLBOIL

AYUB;Z.H. BERGLES;A.E.
"NUCLEATE POOL BOILING CURVE HYSTERESIS FOR GEWA-T SURFACES IN SATURATED R-113"
ASME PROCEEDINGS OF THE 1988 NATIONAL HEAT TRANSFER CONFERENCE, HTD-96, VOL.2, ASME, NEW YORK, 1988, PP.515-521
013223 1988 ASME TREATSURF POOLBOIL

AYUB;Z.H. BERGLES;A.R.
"NUCLEATE POOL BOILING CURVE HYSTERESIS FOR GEWA-T SURFACES IN SATURATED R-113"
EXPERIMENTAL THERMAL AND FLUID SCIENCE, VOL.3, 1990, PP.249-255
013172 1990 ETFS TREATSURF POOLBOIL

BAHHUTH;A. GENETTI;W.E.
"NUCLEATE BOILING HEAT TRANSFER ENHANCEMENT WITH HEAT TRANSFER SURFACE CAVITIES"
AMERICAN INSTITUTE OF CHEMICAL ENGINEERS SYMPOSIUM SERIES, NO.225, VOL.79, 1983, PP.28-33
013138 1983 AICHESS TREATSURF POOLBOIL

BAR-COHEN;A. SIMON;T.W.
"WALL SUPERHEAT EXCURSIONS IN THE BOILING INCIPIENCE OF DIELECTRIC FLUIDS"
HEAT TRANSFER IN ELECTRONIC EQUIPMENT-1986, HTD-VOL.57, ASME, NEW YORK, 1986, PP.83-94
013193 1986 ASME TREATSURF POOLBOIL

BAR-COHEN;A. SIMON;T.W.
"WALL SUPERHEAT EXCURSIONS IN THE BOILING INCIPIENCE OF DIELECTRIC FLUIDS"
HEAT TRANSFER ENGINEERING, VOL.9, NO.3, 1988, PP.19-
013215 1988 HTE TREATSURF POOLBOIL

BERGLES;A.E. BAKHRU;N. SHIRES JR.;J.W.
"COOLING OF HIGH-POWER-DENSITY COMPUTER COMPONENTS"
MASSACHUSETTS INSTITUTE OF TECHNOLOGY ENGINEERING PROJECTS LABORATORY REPORT 70712-60, 1968
013025 1968 MIT TREATSURF POOLBOIL FLOBOIL

BERGLES;A.E. THOMPSON JR.;W.G.
"THE RELATIONSHIP OF QUENCH DATA TO STEADY-STATE POOL BOILING DATA"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.13, 1970, PP.55-68
013031 1970 IJHMT TREATSURF ROUGHSURF POOLBOIL

BERGLES;A.E. CHYU;M.-C.
"CHARACTERISTICS OF NUCLEATE POOL BOILING FROM POROUS METALLIC COATINGS"
ADVANCES IN ENHANCED HEAT TRANSFER-1981, HTD VOL. 18, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1981, PP. 61-71.
013086 1981 ** TREATSURF POOLBOIL

BERGLES;A.E. CHYU;M.C.
"CHARACTERISTICS OF NUCLEATE POOL BOILING FROM POROUS METALLIC COATINGS"
JOURNAL OF HEAT TRANSFER, VOL.104, 1982, PP.279-285
013111 1982 JHT TREATSURF POOLBOIL

BERGLES;A.E.
"HIGH FLUX BOILING APPLIED TO MICROELECTRONICS THERMAL CONTROL"
INTERNATIONAL COMMUNICATIONS IN HEAT AND MASS TRANSFER, VOL.15, 1988, PP.509-531
000172 1988 ICHMT LITSURVEY POOLBOIL TREATSURF ADDFORLIQUIDS

BORISHANSKAYA;A.V.
"ON HEAT TRANSFER DURING BOILING OF FREONS ON SURFACES WITH POROUS METALLIC COATINGS"
KHOLODELNAYA TEKHNIKA, NO.12, 1979, PP.17-20
013117 1979 ** TREATSURF POOLBOIL

BUKIN;V.G. DANILOVA;G.N. DYUNDIN;V.A.
"HEAT TRANSFER FROM FREONS IN A FILM FLOWING OVER BUNDLES OF HORIZONTAL TUBES THAT CARRY A POROUS COATING"
HEAT TRANSFER - SOVIET RESEARCH, VOL.14, NO.2, 1982, PP.98-103
013080 1982 HTSR TREATSURF POOLBOIL

CAI;B. ZHUANG;L. TAN;Y.
DENG;S.

"INVESTIGATION OF BOILING HEAT TRANSFER MECHANISM AND PERFORMANCE OF MECHANICALLY FABRICATED POROUS SURFACE"
PROCEEDINGS OF JOINT MEETING OF CHEMICAL ENGINEERING, CHEMICAL INDUSTRY, AND ENGINEERING SOCIETY OF CHINA/ AICHE, BEIJING, CHINA, SEPTEMBER 1982, VOL.II, PP. 664-672
013127 1982 ** TREATSURF POOLBOIL

CAO;Y.-D. XIN;M.-D.
"MECHANISM OF BOILING HYSTERESIS OF ENHANCED SURFACES"
HEAT TRANSFER IN ELECTRONIC AND MICROELECTRONIC EQUIPMENT, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, 1990, PP.469-478
013160 1990 ** TREATSURF POOLBOIL

CARNAVOS;T.C.
"AN EXPERIMENTAL STUDY: POOL BOILING R-11 WITH AUGMENTED TUBES"
ADVANCES IN ENHANCED HEAT TRANSFER-1981, HTD VOL. 18 AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1981, PP. 103-108.
033040 1981 ** EXTENDEDSURF POOLBOIL TREATSURF

CORTY;C. FOUST;A.S.
"SURFACE VARIABLES IN NUCLEATE BOILING"
CHEMICAL ENGINEERING PROGRESS SYMPOSIUM SERIES, VOL.51, NO.17, 1955, PP.1-12
013002 1955 CEPSS TREATSURF POOLBOIL

CZIKK;A.M. FRICKE;H.D. GANIC;E.N.
"ENHANCED PERFORMANCE HEAT EXCHANGERS"
PROCEEDINGS FOURTH ANNUAL CONFERENCE ON OCEAN THERMAL ENERGY CONVERSION, NEW ORLEANS, LOUISIANA, MARCH 1977, PP. VI-71 - VI-92.
013091 1977 ** TREATSURF POOLBOIL

CZIKK;A.M. FRICKE;H.D. GANIC;E.N. SHARMA;B.I.
"FLUID DYNAMIC AND HEAT TRANSFER STUDIES OF OTEC HEAT EXCHANGERS"
PROCEEDINGS OF THE FIFTH OCEAN THERMAL ENERGY CONVERSION CONFERENCE, MIAMI BEACH, FLORIDA, 1978, PP.VI181-VI236.
013078 1978 OTEC TREATSURF POOLBOIL EXTENDEDSURF CONDENSATION

CZIKK;A.M. O'NEILL;P.S.
"CORRELATIONS OF NUCLEATE BOILING FROM POROUS METAL FILMS"
ADVANCES IN ENHANCED HEAT TRANSFER, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1979, PP.53-60.
013061 1979 ASME TREATSURF POOLBOIL

CZIKK;A.M. O'NEILL;P.S. GOTTZMANN;C.F.
"NUCLEATE BOILING FROM POROUS METAL FILMS: EFFECT OF PRIMARY VARIABLES"
ADVANCES IN ENHANCED HEAT TRANSFER-1981, HTD VOL. 18, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1981, PP. 109-122.
013087 1981 ASME TREATSURF POOLBOIL

DANILOVA;G.N. GUYGO;E.I. BORISHANSKAYA;A.V.
BUKIN;V.G. DYUNDIN;V.A. KOZYREV;A.A.
MALKOV;L.S. MALYUGIN;G.I.
"ENHANCEMENT OF HEAT TRANSFER DURING BOILING OF LIQUID REFRIGERANTS AT LOW HEAT FLUXES"
HEAT TRANSFER - SOVIET RESEARCH, VOL.8, NO.4, 1976, PP.1-8
013060 1976 HTSR TREATSURF ROUGHSURF POOLBOIL FLOBOIL

DANILOVA;G.N. GUIGO;E.I. BORISHANSKAYA;A.V.
BUKIN;V.G. DYUNDIN;V.A. KOZYREV;A.A.
MALKOV;L.S. MALYUGIN;G.I.
"ENHANCEMENT OF HEAT TRANSFER WITH LOW-TEMPERATURE LIQUID BOILING AT SMALL HEAT FLUX RATES"
ABSTRACT FROM THE FIFTH ALL-UNION HEAT AND MASS TRANSFER CONFERENCE, MINSK, USSR, 1976. P.69
013104 1976 ** TREATSURF POOLBOIL

DANILOVA,G.N. TIKHONOV;A.V.
"ENHANCEMENT OF HEAT TRANSFER IN THE BOILING OF THE R-113 REFRIGERANT ON VARIOUS KINDS OF SURFACES"
HEAT TRANSFER-SOVIET RESEARCH, VOL. 16, NO.1, 1984, PP.59-66
013198 1984 HTSR TREATSURF POOLBOIL

DANILOVA;G.N. REZNIKOV;V.I.
"INVESTIGATION OF BOILING HEAT TRANSFER AT A SURFACE WITH A SYSTEM OF CYLINDRICAL CAVITIES UNDER CONDITIONS OF FREE MOTION"
JOURNAL OF ENGINEERING PHYSICS, VOL.53, 1987, PP.741-745
013232 1987 JEP TREATSURF POOLBOIL

DYUNDIN;V.A. DANILOVA;G.N. BORISHANSKAYA;A.V.
KROTKOV;V.N. GOGOLIN;V.A. VAKHALIN;V.A.
PROTASOV;G.A.
"INTENSIFICATION OF HEAT EXCHANGE ON THE BOILING OF COOLING AGENTS ON SURFACES HAVING GAS-THERMAL COATINGS"
CHEMICAL AND PETROLEUM ENGINEERING, VOL.11, 1975, PP.816-818
013040 1975 ** TREATSURF POOLBOIL

DYUNDIN;V.A. DANILOVA;G.N. BORISHANSKAYA;A.V.
"HEAT TRANSFER TO REFRIGERANTS BOILING ON TUBES COVERED WITH POROUS COATINGS"
HEAT TRANSFER - SOVIET RESEARCH, VOL.13, NO.1, 1981, PP. 61-74
013106 1981 HTSR TREATSURF POOLBOIL

DYUNDIN;V.A. SOLOV'YEV;A.G. BORISHANSKAYA;A.V.
VOL'NYKH;YU.A.
"EFFECT OF THE KIND OF SURFACE ROUGHNESS ON THE HEAT TRANSFER CORFFICIENT IN BOILING OF REFRIGERANTS"
HEAT TRANSFER-SOVIET RESEARCH, VOL.16, N0.1, 1984, PP. 53-58
013197 1984 HTSR TREATSURF POOLBOIL ROUGHSURF FLOBOIL

FAGERHOLM;N.E. KIVIOJA;K. GHAZANFARI;A.R.
JARVINEN;E.
"USING STRUCTURED SURFACES TO ENHANCE HEAT TRANSFER IN FALLING FILM FLOW"
INSTITUTE OF ENERGY ENGINEERING, HELSINKI UNIVERSITY OF TECHNOLOGY, HELSINKI, FINLAND, 1986, PP.1-35
013241 1986 ** TREATSURF POOLBOIL

FRICKE;H.D. CZIKK;A.H.
"ENHANCED OTEC SPRAYED BUNDLE EVAPORATOR PERFORMANCE STUDIES
ADVANCES IN ENHANCED HEAT TRANSFER, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1979, PP.23-29.
013039 1979 ASME TREATSURF POOLBOIL

FUJIE;K. NAKAYAMA;W. KUWAHARA;H.
NAKAYAMA;Y. KAKIZAKI;K.
"HIGH-FLUX HEAT TRANSFER TUBES "THERMOEXCEL'S": THEIR PERFORMANCE AND THE RESULTS OF FEASIBILITY TEST IN A REFRIGERATING MACHINE"
PAPER B1,97, XIV INTERNATIONAL CONGRESS OF REFRIGERATION, MOSCOW, 1975
013064 1975 ** TREATSURF POOLBOIL

FUJII;M.
"BOILING HEAT TRANSFER OF A TWO-PHASE CLOSED THERMOSYPHON WITH A POROUS SURFACE"
PROCEEDINGS OF FIFTH INTERNATIONAL HEAT PIPE CONFERENCE, PART 2, JAPAN TECHNOLOGY AND ECONOMICS CENTER INCORPORATED, TOKYO, JAPAN, 1984, PP.105-112
013249 1984 ** TREATSURF POOLBOIL

FUJII;M.

"NUCLEATE POOL BOILING HEAT TRANSFER FROM POROUS HEATING SURFACE (OPTIMUM PARTICLE DIAMETER)"
ABSTRACTED IN BULLETIN OF JSME, VOL.27, 1984, PP.2594
013260 1984 BJSME TREATSURF POOLBOIL

GLIELMINI;G. MISALE;M. SCHENONE;C.
PASQUALI;C. ZAPPATERRA;M.
"ON PERFORMANCES OF NUCLEATE BOILING ENHANCED SURFACES FOR COOLING OF HIGH POWER ELECTRONIC DEVICES"
HEAT TRANSFER IN ELECTRONIC AND MICROELECTRONIC EQUIPMENT, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, 1990, PP.589-600
013163 1990 ** TREATSURF POOLBOIL

GOTTZMANN;C.F. O'NEILL;P.S. MINTON;P.E.
"HIGH EFFICIENCY HEAT EXCHANGERS"
CHEMICAL ENGINEERING PROGRESS, VOL.69, NO.7, 1973, PP.69-75
013044 1973 CEP TREATSURF EXTENDEDSURF POOLBOIL FLOBOIL

HAMANO;Y. CHUJO;Y.
"NUCLEATE BOILING HEAT TRANSFER ON HORIZONTAL CYLINDERS WITH RE-ENTRANT GROOVED SURFACES"
HEAT TRANSFER IN ELECTRONIC AND MICROELECTRONIC EQUIPMENT, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, 1990, PP.561-572
013161 1990 ** TREATSURF POOLBOIL

HILLIS;D.L. LORENZ;J.J. YUNG;D.T.
SATHER;N.F.
"OTEC PERFORMANCE TESTS OF THE UNION CARBIDE SPRAYED-BUNDLE EVAPORATOR"
ARGONNE NATIONAL LABORATORY, REPORT ANL/OTEC-PS-3, MAY 1979.
013083 1979 ANL TREATSURF POOLBOIL

ITO;T. NISHIKAWA;K. TANAKA;K.
"EVALUATION OF POTENTIAL HIGH PERFORMANCE POROUS BOILING SURFACES (1ST REPORT)"
REFRIGERATION, VOL.57, NO.651, 1982, PP.25-29
013136 1982 ** TREATSURF POOLBOIL

ITO;T. TANAKA;K. TAMARI;T.
"PREDICTION OF BOILING HEAT TRANSFER FROM POROUS SURFACES"
HEAT TRANSFER - JAPANESE RESEARCH, VOL.19, NO.6, 1990, PP.507-520
013251 1990 HTJR TREATSURF POOLBOIL

JENSEN;M.K.
"BOILING ON THE SHELLSIDE OF HORIZONTAL TUBE BUNDLES"
TWO-PHASE FLOW HEAT EXCHANGERS: THERMAL-HYDRAULIC FUNDAMENTALS AND DESIGN, KLUWER ACADEMIC PUBLISHERS, DORDRECHT, THE NETHERLANDS, 1988, PP.707-746
000162 1988 ** LITSURVEY POOLBOIL EXTENDEDSURF TREATSURF

JONES;B.G. SUN;J.Y. PAN;C.
"ELECTRONIC COOLING THROUGH POROUS LAYERS WITH WICK BOILING"
ASME PROCEEDINGS OF THE 1988 NATIONAL HEAT TRANSFER CONFERENCE, HTD-96, VOL.1, ASME, NEW YORK, 1988, PP.523-532
013224 1988 ASME TREATSURF POOLBOIL

JUNG;C. BERGLES;A.E.
"EVALUATION OF COMMERCIAL ENHANCED TUBES IN POOL BOILING"
HEAT TRANSFER LABORATORY REPORT NO. HTL-2, RENSSELAER POLYTECHNIC INSTITUTE, TROY, NY, MARCH 1989
013228 1989 RPI TREATSURF POOLBOIL

JUNG;D.S. VENART;J.E.S.
"EFFECTS OF ENHANCED SURFACES AND SURFACE ORIENTATION ON POOL BOILING HEAT TRANSFER"
HEAT AND TECHNOLOGY, VOL.4, NO.3-4, 1986, PP.62-79
013259 1986 ** TREATSURF POOLBOIL

JUNG;D.S. VENART;J.E.S. SOUSA;A.C.M.
"EFFECTS OF ENHANCED SURFACES AND SURFACE ORIENTATION ON NUCLEATE AND FILM BOILING HEAT TRANSFER IN R-11"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.30, NO.12, 1987, PP.2627-2639
013152 1987 IJHMT TREATSURF POOLBOIL

KAJIKAWA;T. TAKAZAWA;H. NISHIYAMA;K.
AGAWA;T. IIDAKA;H. AMANO;M.
"DEVELOPMENT OF ENHANCEMENT OF THE WORKING FLUID SIDE HEAT TRANSFER FOR OTEC"
PROCEEDINGS OF THE SEVENTH OCEAN ENERGY CONFERENCE, CONF-800633, VOL.2, 1980, PP.12.2-1 - 12.2-9
013113 1980 ** TREATSURF POOLBOIL EXTENDEDSURF CONDENSATION

KAJIKAWA;T. TAKAZAWA;H. MIZUKI;M.
"HEAT TRANSFER PERFORMANCE OF METAL FIBER SINTERED SURFACES"
HEAT TRANSFER ENGINEERING, VOL.4, NO.1, 1983, PP.57-66
013135 1983 HTE TREATSURF POOLBOIL

KARTSOUNES;G.T.
"A STUDY OF SURFACE TREATMENT ON POOL BOILING HEAT TRANSFER IN REFRIGERANT-12"
ASHRAE TRANSACTIONS, VOL.81, PT.1, 1975, PP.320-326.
013036 1975 ASHRAE TREATSURF POOLBOIL

KIM;C.-J. BERGLES;A.E.
"STRUCTURED SURFACES FOR ENHANCED NUCLEATE BOILING"
HEAT TRANSFER LABORATORY REPORT NO. HTL-36, ISU-ERI-AMES-86220, IOWA STATE UNIVERSITY, AMES, IA, 1985
013220 1985 ISU TREATSURF POOLBOIL

KO;S.Y. LIU;B. YAO;Y.Q.
"BOILING HYSTERESIS ON POROUS METALLIC COATINGS"
SECOND INTERNATIONAL SYMPOSIUM ON MULTIPHASE FLOW AND HEAT TRANSFER, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, VOL.1, 1989, PP.259-268
013269 1989 ** TREATSURF POOLBOIL

KOZAWA;Y. INOUE;T. OLUYAMA;K.
"ENHANCEMENT OF BUBBLE FORMATION AND HEAT REMOVAL IN TRANSIENT BOILING"
HEAT TRANSFER 1986, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, 1986, VOL.4, PP.2007-2012
013171 1986 VIIIIHTC TREATSURF POOLBOIL

KRAVETS;V.Y. FRIDRIKHSON;Y.V. BOSAYA;O.V.
"HEAT-TRANSFER CRISIS IN THE BOILING OF LIQUIDS ON MICROSURFACES"
JOURNAL OF ENGINEERING PHYSICS, VOL.60, 1991, PP.215-218
013243 1991 JEP TREATSURF POOLBOIL

KULOOR;N.R. RADHAKRISHNAN;V.N.
"EFFECT OF SURFACE ROUGHNESS ON NUCLEATE BOILING"
CHEMICAL AND PROCESS ENGINEERING, VOL.47, NO.6, 1966, PP. 276-280
013017 1966 CPE TREATSURF ROUGHSURF POOLBOIL

KUNZ;H.R. LANGSTON;L.S. HILTON;B.H.
WYDE;S. NASHICK;G.H.
"VAPOR-CHAMBER FIN STUDIES"
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, REPORT NO. NASA-CR-812, JUNE 1967
013121 1967 ** TREATSURF POOLBOIL

LEINER;W. LOSING;K.-H.
"HEAT TRANSFER IMPROVEMENT IN NUCLEATE BOILING THROUGH APPLICATION OF POORLY WETTABLE NUCLEATION ACTIVATORS"

HEAT TRANSFER 1986, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, 1986, VOL.6, PP.2945-2950
013170 1986 VIIIIHTC TREATSURF POOLBOIL

LEONTIEV;A.I. OKHOTIN;A.S. KORNEYEV;A.D. KORNEYEV;S.D.
"CALCULATION OF HEAT TRANSFER CHARACTERISTICS FOR BOILING IN SLOT CHANNELS"
HEAT TRANSFER-SOVIET RESEARCH, VOL.17, NO.2, 1985, PP.101-
013199 1985 HTSR TREATSURF POOLBOIL

LEWIS;L.G. SATHER;N.F.
"OTEC PERFORMANCE TESTS OF THE UNION CARBIDE FLOODED-BUNDLE EVAPORATOR"
OCEAN THERMAL ENERGY CONVERSION PROGRAM, ARGONNE NATIONAL LABORATORY, ANL-OTEC-PS-1, 1978
013021 1978 ** TREATSURF POOLBOIL

LORENZ;J.J. YUNG;D. HOWARD;P.A. PANCHAL;C.B. POUCHER;F.W.
"OTEC-1 POWER SYSTEM TEST PROGRAM: PERFORMANCE OF ONE-MEGAWATT HEAT EXCHANGERS"
ARGONNE NATIONAL LABORATORY, OCEAN THERMAL CONVERSION PROGRAM REPORT NO. ANL/OTEC-PS-10, NOVEMBER 1981
013107 1981 ANL TREATSURF POOLBOIL OTEC

MALYSHENKO;S.P.
"FEATURES OF HEAT TRANSFER WITH BOILING ON SURFACES WITH POROUS COATINGS"
THERMAL ENGINEERING, VOL.38, NO.2, 1991, PP.81-88
013253 1991 TENG TREATSURF POOLBOIL

MARTO;P.J. HERNANDEZ;B.
"NUCLEATE POOL BOILING CHARACTERISTICS OF A GEWA-T SURFACE IN FREON-113"
AMERICAN INSTITUTE OF CHEMICAL ENGINEERS SYMPOSIUM SERIES, NO.225, VOL.79, 1983, PP.1-10
013139 1983 AICHESS TREATSURF POOLBOIL

MARTO;P.J. WANNIARACHCHI;A.S. PULIDO;R.J.
"AUGMENTING THE NUCLEATE POOL-BOILING CHARACTERISTICS OF GEWA-T FINNED TUBES IN R-113"
AUGMENTATION OF HEAT TRANSFER IN ENERGY SYSTEMS, HTD-VOL.52, ASME, NEW YORK, 1985, PP.67-73
013192 1985 ASME TREATSURF POOLBOIL

MCMANUS;S.M. MARTO;P.J. WANNIARACHCHI;A.S.
"AN EVALUATION OF ENHANCED HEAT TRANSFER TUBING FOR USE IN R-114 WATER CHILLERS"
HEAT TRANSFER IN AIR CONDITIONING AND REFRIGERATION EQUIPMENT, HTD-VOL.65, ASME, NEW YORK, 1986, PP.11-19
013195 1986 ASME TREATSURF POOLBOIL COMPOUNDTECH

MEMORY;S.B. MARTO;P.J.
"THE INFLUENCE OF OIL ON BOILING HYSTERESIS OF R-114 FROM ENHANCED SURFACES"
PROCEEDINGS OF THE ENGINEERING FOUNDATION CONFERENCE ON POOL AND EXTERNAL FLOW BOILING, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1992, PP.63-71
013242 1992 ASME TREATSURF POOLBOIL

MESSINA;A.D.
"EFFECTS OF PRECISE ARRAYS OF PITS ON THE NUCLEATE BOILING OF FREON 113 FROM FLAT COPPER SURFACES AT ONE ATMOSPHERE PRESSURE"
PH.D. THESIS, UNIVERSITY OF MISSOURI-ROLLA, 1978
013119 1979 ** TREATSURF POOLBOIL NHC

MESSINA;A.D. PARK;E.L.
"A NEW TOOL FOR NUCLEATE BOILING RESEARCH"
CHEMICAL ENGINEERING COMMUNICATIONS, VOL.4, NO.1, 1980, PP. 69-76
013120 1980 ** TREATSURF POOLBOIL

MESSINA;A.D. PARK,JR.;E.L.
"EFFECTS OF PRECISE ARRAYS OF PITS ON NUCLEATE BOILING"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.24, 1981, PP.141-145
013108 1981 IJHMT TREATSURF POOLBOIL

MILLER;W.J. GEBHART;B. WRIGHT;N.T.
"EFFECTS OF BOILING HISTORY ON A MICROCONFIGURES SURFACE IN A DIELECTRIC LIQUID"
INTERNATIONAL COMMUNICATIONS IN HEAT AND MASS TRANSFER, VOL.17, 1990, PP.389-398
013212 1990 ICHMT TREATSURF POOLBOIL

MOGI;I. KAWAI;S. MACHIYAMA;T.
"EXPERIMENTAL INVESTIGATIONS ON BOILING HEAT TRANSFER CHARACTERISTICS OF THE TUBES WITH SINTERED METAL SURFACE (III)"
BULLETIN OF SCIENCE AND ENGINEERING RESEARCH LABORATORY, WASEDA UNIVERSITY, NO.56, 1972, PP.1-8
013069 1972 ** TREATSURF POOLBOIL

NAKAYAMA;W. KUWAHARA;H. DAIKOKU;T.
"BOILING HEAT TRANSFER ON THE SURFACE HAVING A POROUS STRUCTURE COMPOSED OF SMALL TUNNELS AND PORES"
HITACHI LTD. MECHANICAL ENGINEERING RESEARCH LABORATORY TECHNICAL PAPER MTR NO.1, 1978
013066 1978 ** TREATSURF POOLBOIL

NAKAYAMA;W. DAIKOKU;T. KUWAHARA;H. NAKAJIMA;T.
"DYNAMIC MODEL OF ENHANCED BOILING HEAT TRANSFER ON POROUS SURFACES"
JOURNAL OF HEAT TRANSFER, VOL. 102, 1980, PP. 445-456
013050 1979 JHT TREATSURF POOLBOIL

NAKAYAMA;W. DAIKOKU;T. NAKAJIMA;T.
"MODELING OF LIQUID SUCTION MECHANISM IN POROUS SURFACE BOILING"
AMERICAN SOCIETY OF MECHANICAL ENGINEERS PAPER NO. 80-HT-122,1980.
013071 1980 ASME TREATSURF POOLBOIL

NAKAYAMA;W. DAIKOKO;T. NAKAJIMA;T.
"EFFECTS OF PORE DIAMETERS AND SYSTEM PRESSURE ON SATURATED POOL NUCLEATE BOILING HEAT TRANSFER FROM POROUS SURFACES"
JOURNAL OF HEAT TRANSFER, VOL.104, 1982, PP.286-291
013110 1982 JHT TREATSURF POOLBOIL

NAKAYAMA;W. DAIKOKU;T. NAKAJIMA;T.
"ENHANCEMENT OF BOILING AND EVAPORATION ON STRUCTURED SURFACES WITH GRAVITY DRIVEN FILM FLOW OF R-11"
HEAT TRANSFER 1982, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, D.C., 1982, PP.409-414
013141 1982 VIIIHTC TREATSURF POOLBOIL

NAKAYAMA;W. NAKAJIMA;T. HIRASAWA;S.
"HEAT SINK STUDS HAVING ENHANCED BOILING SURFACES FOR COOLING OF MICROELECTRONIC COMPONENTS"
AMERICAN SOCIETY OF MECHANICAL ENGINEERS PAPER NO. 84-WA/HT-89, 1989
143008 1984 ASME COMPOUNDTECH TREATSURF EXTENDEDSURF POOLBOIL

NAKAYAMA;W. KUWAHARA;H. NAKAJIMA;T. YOSHIDA;H.
"EVAPORATOR TUBES WITH ENHANCED BOILING SURFACES: THE EFFECT OF PARTIAL BLOCKAGE OF PORES WITH PROTUBERANCES"
ADVANCES IN PHASE CHANGE HEAT TRANSFER, INTERNATIONAL ACADEMIC PUBLISHERS, CHONGQING, CHINA, AND PERGAMON PRESS, NEW YORK, 1988, PP.413-418

013185 1988 ** TREATSURF
POOLBOIL

NAVRUZOV;YU.V.
"HEAT TRANSFER TO LIQUIDS BOILING IN POROUS STRUCTURES"
HEAT TRANSFER-SOVIET RESEARCH, VOL.18, NO.2, 1986,
PP.123-128
013202 1986 HTSR TREATSURF
POOLBOIL

NISHIKAWA;K. ITO;T. TANAKA;K.
"ENHANCED HEAT TRANSFER BY NUCLEATE BOILING ON A SINTERED METAL LAYER"
HEAT TRANSFER-JAPANESE RESEARCH, VOL. 8, NO. 2, 1979,
PP. 65-81.
013090 1979 HTJR TREATSURF
POOLBOIL

NISHIKAWA;K. ITO;T.
"AUGMENTATION OF NUCLEATE BOILING HEAT TRANSFER BY PREPARED SURFACES"
HEAT TRANSFER IN ENERGY PROBLEMS, PROCEEDINGS OF THE JAPAN-UNITED STATES JOINT SEMINAR, TOKYO, JAPAN, SEPTEMBER 1980,
HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, 1982, PP.
119-126
013109 1982 ** TREATSURF
POOLBOIL

NISHIKAWA;K.
"BOILING HEAT TRANSFER AND ITS AUGMENTATION"
ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE PROCEEDINGS,
HONOLULU, HAWAII, MARCH 1983, VOL.3, PP.11-20
013129 1983 ** TREATSURF
POOLBOIL

NISHIKAWA;K. ITO;T. TANAKA;K.
"AUGMENTED HEAT TRANSFER BY NUCLEATE BOILING AT PREPARED SURFACES"
ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE PROCEEDINGS,
HONOLULU, HAWAII, MARCH 1983, VOL.1, PP.387-393
013130 1983 ** TREATSURF
POOLBOIL

NISHIKAWA;K. ITO;T. YOSHIDA;S.
FUJITA;Y.
"DEVELOPMENT OF THE HIGHEST PERFORMANCE BOILING SURFACE AND ITS APPLICATION TO HEAT EXCHANGER"
RESEARCH ON EFFECTIVE USE OF THERMAL ENERGY, REPORT OF
SPECIAL PROJECTS, SPEY 14, MINISTRY OF EDUCATION, SCIENCE,
AND CULTURE, JAPAN, 1985, PP.21-28
013239 1985 SPEY TREATSURF
POOLBOIL

O'NEILL;P.S. GOTTZMANN;C.F. TERBOT;C.F.
"HEAT EXCHANGER FOR NGL"
CHEMICAL ENGINEERING PROGRESS, VOL.67, NO.7, 1971, PP.80-82
013034 1971 CEP TREATSURF
POOLBOIL

O'NEILL;P.S. GOTTZMANN;C.F. TERBOT;J.W.
"NOVEL HEAT EXCHANGER INCREASES CASCADE CYCLE EFFICIENCY FOR NATURAL GAS LIQUEFACTION"
ADVANCES IN CRYOGENIC ENGINEERING, VOL.17, 1972, PP.420-437
013062 1972 ** TREATSURF
POOLBOIL

OKTAY;S. SCHMECKENBECHER;A.F.
"PREPARATION AND PERFORMANCE OF DENDRITIC HEAT SINKS"
JOURNAL OF THE ELECTROCHEMICAL SOCIETY, VOL.21, 1974,
PP.912-918
013033 1974 ** TREATSURF
POOLBOIL

OKTAY;S.
"DEPARTURE FROM NATURAL CONVECTION (DNC) IN LOW-TEMPERATURE BOILING HEAT TRANSFER ENCOUNTERED IN COOLING MICRO-ELECTRONIC LSI DEVICES"
HEAT TRANSFER ENGINEERING, VOL.9, NO.3, 1988, PP.93-
013216 1988 HTE TREATSURF
POOLBOIL

OROZCO;J. POULIKAKOS;D. GUTJAHR;M.
"SUBCOOLED POOL FILM BOILING FROM A CYLINDER AND FROM A SPHERE PLACED IN A LIQUID SATURATED BED OF BEADS"
JOURNAL OF THERMOPHYSICS AND HEAT TRANSFER, VOL.4, 1990,
PP.247-250
013244 1990 JTHT TREATSURF
POOLBOIL

PALEN;J.W. TABOREK;J.
"CHARACTERISTICS OF BOILING OUTSIDE LARGE SCALE HORIZONTAL MULTITUBE BUNDLES"
AMERICAN INSTITUTE OF CHEMICAL ENGINEERS 12TH NATIONAL HEAT TRANSFER CONFERENCE, TULSA, OKLAHOMA, 1971, PAPER NO. 9
033033 1971 AICHE TREATSURF
EXTENDEDSURF POOLBOIL

PANCHAL;C.P. LORENZ;J.J. HILLIS;D.L.
"THE EFFECTS OF AMMONIA CONTAMINATION BY WATER ON OTEC POWER SYSTEM PERFORMANCE"
ARGONNE NATIONAL LABORATORY, ANL/OTEC-PS-8, AUGUST 1981.
033038 1981 ANL EXTENDEDSURF
POOLBOIL TREATSURF

PARK;K.-A. BERGLES;A.E.
"HEAT TRANSFER CHARACTERISTICS OF SIMULATED MICROELECTRONIC CHIPS UNDER NORMAL AND ENHANCED CONDITIONS"
HEAT TRANSFER LABORATORY REPORT NO. HTL-35, ISU-ERI-AMES-86211, IOWA STATE UNIVERSITY, AMES, IA, 1985
013221 1985 ISU TREATSURF
POOLBOIL FLUIDVIB

PARK;K.-A. BERGLES;A.E.
"BOILING HEAT TRANSFER CHARACTERISTICS OF SIMULATED MICROELECTRONIC CHIPS WITH FLUORINERT LIQUIDS"
HEAT TRANSFER LABORATORY REPORT NO. HTL-40, ISU-ERI-AMES-87022, IOWA STATE UNIVERSITY, AMES, IA, 1986
013222 1986 ISU TREATSURF
POOLBOIL

PARK;K.-A. BERGLES;A.E. DANIELSON;R.D.
"BOILING HEAT TRANSFER CHARACTERISTICS OF SIMULATED MICROELECTRONIC CHIPS WITH FLUORINERT LIQUIDS"
HEAT TRANSFER IN ELECTRONIC AND MICROELECTRONIC EQUIPMENT,
HEMISPHERE PUBLISHING CORPORATION, NEW YORK, 1990,
PP.573-588
013162 1990 ** TREATSURF
POOLBOIL

POLEZHAEV;Y.V. KOVALEV;S.A.
"MODELLING HEAT TRANSFER WITH BOILING ON POROUS STRUCTURES"
THERMAL ENGINEERING, VOL.37, NO.12, 1990, PP.617-620
013246 1990 TENG TREATSURF
POOLBOIL

QI;M. CAI;Y. FREESTON;D.H.
"BUBBLE DEPARTURE FREQUENCY DURING BOILING FROM POROUS SURFACES"
HEAT TRANSFER ENHANCEMENT AND ENERGY CONSERVATION,
HEMISPHERE PUBLISHING CORPORATION, NEW YORK, 1990,
PP.449-456
013166 1990 ** TREATSURF
POOLBOIL

RANNENBERG;M. BEER;H.
"HEAT TRANSFER BY EVAPORATION IN CAPILLARY POROUS WIRE MESH STRUCTURES"
LETTERS IN HEAT AND MASS TRANSFER, VOL.7, NO.6, 1980, PP.
425-436
013118 1980 LHMT TREATSURF
POOLBOIL

ROSENFELD;J.H.
"NUCLEATE BOILING HEAT TRANSFER IN POROUS WICK STRUCTURES"
HEAT TRANSFER EQUIPMENT FUNDAMENTALS, DESIGN, APPLICATIONS,
AND OPERATING PROBLEMS, HTD-VOL.108, ASME, NEW YORK, 1989,
PP.47-55
013225 1989 ASME TREATSURF
POOLBOIL

SAASKI;E.W. HARTL;J.H.
"HIGH PERFORMANCE HEAT PIPES FOR HEAT RECOVERY APPLICATIONS"

SIGMA RESEARCH, INC. FINAL REPORT FOR CONTRACT NO. NAS5-25357, RICHLAND, WASHINGTON, SEPTEMBER 1979.
013084 1979 ** TREATSURF
POOLBOIL CONDENSATION

SABIN;C.M. POPPENDIEK;H.F.
"HEAT TRANSFER ENHANCEMENT FOR EVAPORATORS"
PROCEEDINGS FOURTH ANNUAL CONFERENCE ON OCEAN THERMAL ENERGY
CONVERSION, NEW ORLEANS, LOUISIANA, MARCH 1977, PP. VI-93 - VI-104
013089 1977 ** TREATSURF
ROUGHSURF DISPENHDEVICE POOLBOIL 1FORCECONV

SABIN;C.M. POPPENDIEK;H.F.
"FILM EVAPORATION OF AMMONIA OVER HORIZONTAL ROUND TUBES"
PROCEEDINGS OF THE FIFTH OCEAN THERMAL ENERGY CONVERSION CONFERENCE, VOL.3, 1978, PP.VI.237-VI-260
013077 1978 OTEC TREATSURF
POOLBOIL

SATHER;N.F. LEWIS;L.G. LORENZ;J.J. YUNG;D.
"PERFORMANCE TESTS OF 1 MWT OTEC HEAT EXCHANGERS"
PROCEEDINGS OF THE FIFTH OCEAN THERMAL ENERGY CONVERSION CONFERENCE, VOL.3, 1978 PP.VI-1-VI-19
013079 1978 ** TREATSURF
POOLBOIL ROUGHSURF CONDENSATION

SAUER JR.;H.J. MEDROW;R.A.
"EFFECTS OF SURFACE CONDITION ON NUCLEATE BOILING OF REFRIGERANT-11"
ASHRAE TRANSACTIONS,VOL.81,PART2,1975,PP.274-281
013041 1975 ASHRAE TREATSURF
POOLBOIL

SHIH;C.C. WESTWATER;J.W.
"USE OF COATINGS OF LOW THERMAL CONDUCTIVITY TO IMPROVE FINS USED IN BOILING LIQUIDS"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.15, 1972, PP.1965-1968
013035 1972 IJHMT TREATSURF
EXTENDEDSURF POOLBOIL

SHOJI;M. WITTE;L.C. SANKARAN;S.
"THE INFLUENCE OF SURFACE CONDITIONS AND SUBCOOLING ON FILM-TRANSITION BOILING"
EXPERIMENTAL THERMAL AND FLUID SCIENCE, VOL.3, 1990, PP.280-290
013174 1990 ETFS TREATSURF
POOLBOIL ROUGHSURF FOULING

SILVESTRI;V.J. SACHAR;K.S.
DEPOSITION TECHNIQUES AND HEAT TRANSFER PROPERTIES OF POROUS ALUMINIUM"
JOURNAL OF THE ELECTROCHEMICAL SOCIETY, VOL.129, 1982 PP. 1029-1036
013134 1982 ** TREATSURF
POOLBOIL

SNYDER;J.E. SPROUSE;A.M.
"DESIGN OF 1 MWE OCEAN THERMAL ENERGY CONVERSION (OTEC) HEAT EXCHANGERS FOR OCEAN TESTING"
HEAT TRANSFER IN OCEAN THERMAL ENERGY (OTEC) SYSTEMS, HTD-VOL. 12, ASME, NEW YORK, 1980, PP. 17-27.
013101 1980 ** TREATSURF
POOLBOIL

STARNER;K.E. CROMIS;R.A.
"ENERGY SAVINGS THROUGH USE OF HIGH-FLUX EVAPORATOR SURFACE IN CENTRIFUGAL CHILLERS"
PROCEEDINGS OF THE CENTRAL CHILLED WATER CONFERENCE, PURDUE UNIVERSITY, NOVEMBER 1976
013055 1976 ** TREATSURF
POOLBOIL

STEPHAN;K. MITROVIC;J.
"HEAT TRANSFER IN NATURAL CONVECTIVE BOILING OF REFRIGERANTS AND REFRIGERANT-OIL-MIXTURES IN BUNDLES OF T-SHAPED FINNED TUBES"
ADVANCES IN ENHANCED HEAT TRANSFER-1981, HTD VOL. 18, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1981, PP. 131-146.
013095 1981 ** TREATSURF
POOLBOIL

TATARA;R.A. PAYVAR;P.
"PRESSURE DROP AND HEAT TRANSFER MEASUREMENTS OF BOILING REFRIGERANT IN NORMAL FLOW THROUGH A POROUS COATED TUBE BUNDLE"
HEAT TRANSFER IN AIR CONDITIONING AND REFRIGERATION EQUIPMENT, HTD-VOL.65, ASME, NEW YORK, 1986, PP.1-9
013194 1986 ASME TREATSURF
POOLBOIL

TEKHVER;Y.K.
"HYSTERESIS PHENOMENA WITH BOILING ON POROUS COATINGS"
THERMAL ENGINEERING, VOL.37, NO.12, 1990, PP.625-627
013245 1990 TENG TREATSURF
POOLBOIL

THOMAS;A. HILLIS;D. PANCHAL;C.
LORENZ;J. YUNG;D. SATHER;N.
"EXPERIMENTAL TESTS OF 1 MWT OTEC HEAT EXCHANGERS AT ARGONNE NATIONAL LABORATORY"
PROCEEDINGS OF THE SEVENTH OCEAN ENERGY CONFERENCE, CONF-800633, VOL.2, 1980, PP.12.1-1 - 12.1-8
013112 1980 ** TREATSURF
POOLBOIL EXTENDEDSURF CONDENSATION

TONGZE;M. ZHENGFANG;Z. HUIQUN;L.
"VAPORIZATION HEAT TRANSFER IN CAPILLARY WICK STRUCTURES FORMED BY SINTERED SCREENS"
PROCEEDINGS OF FIFTH INTERNATIONAL HEAT PIPE CONFERENCE, PART 1, JAPAN TECHNOLOGY AND ECONOMICS CENTER INCORPORATED, TOKYO, JAPAN, 1984, PP.156-163
013256 1984 ** TREATSURF
SURFTENSION POOLBOIL

TUNG;V.X. DHIR;V.K.
"EXPERIMENTAL STUDY OF BOILING HEAT TRANSFER FROM A SPHERE EMBEDDED IN A LIQUID-SATURATED POROUS MEDIUM"
JOURNAL OF HEAT TRANSFER, VOL.112, 1990, PP.736-743
013236 1990 JHT TREATSURF
POOLBOIL

VENART;J.E.S. SOUSA;A.C.M. JUNG;D.S.
"NUCLEATE AND FILM BOILING HEAT TRANSFER IN R11: THE EFFECTS OF ENHANCED SURFACES AND INCLINATION"
HEAT TRANSFER 1986, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, 1986, VOL.4, PP.2019-2024
013168 1986 VIIIIHTC TREATSURF
POOLBOIL

WANNIARACHCHI;A.S. MARTO;P.J. REILLY;J.T.
"THE EFFECT OF OIL CONTAMINATION ON THE NUCLEATE POOL-BOILING PERFORMANCE OF R-114 FROM A POROUS-COATED SURFACE"
ASHRAE TRANSACTIONS, VOL.92, PART 2B, 1986, PP.525-538
013159 1986 ASHRAE TREATSURF
POOLBOIL

WANNIARACHCHI;A.S. SAWYER;L.M. MARTO;P.J.
"EFFECT OF OIL ON POOL-BOILING PERFORMANCE OF R-114 FROM ENHANCED SURFACES"
PROCEEDINGS OF THE 1987 ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE, VOL.1, JSME, TOKYO, AND ASME, NEW YORK, 1987, PP.531-538
013234 1987 ASME-JSME TREATSURF
POOLBOIL

WEBB;R.L.
"THE EVOLUTION OF ENHANCED SURFACE GEOMETRIES FOR NUCLEATE BOILING"
HEAT TRANSFER ENGINEERING, VOL.2, NOS.3-4, 1981, PP.46-69
000118 1981 HTE LITSURVEY
TREATSURFF ROUGHSURF POOLBOIL

WEBB;R.L.
"PERFORMANCE, COST EFFECTIVENESS, AND WATER-SIDE FOULING CONSIDERATIONS OF ENHANCED TUBE HEAT EXCHANGERS FOR BOILING SERVICE WITH TUBE-SIDE WATER FLOW"
HEAT TRANSFER ENGINEERING, VOL.3, NOS.3-4, 1982, PP.84-98
150070 1982 HTE PERFORMANCE

TREATEDSURF POOLBOIL ROUGHSURF 1FORCECONV

WEBB;R.L.
"NUCLEATE BOILING ON POROUS COATED SURFACES"
AMERICAN SOCIETY OF MECHANICAL ENGINEERS PAPER NO. 83-HT-37, 1983
013142 1983 ASME TREATSURF POOLBOIL

WEBB;R.L. HAIDER;I.
"AN ANALYTICAL MODEL FOR NUCLEATE BOILING ON ENHANCED SURFACES"
PROCEEDINGS OF THE ENGINEERING FOUNDATION CONFERENCE ON POOL AND EXTERNAL FLOW BOILING, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1992, PP.345-350
013240 1992 ASME TREATSURF POOLBOIL

XIN;M.D. XIE;H.D. CHEN;Y.G.
"BOILING HEAT TRANSFER ON HEATING SURFACES COVERED BY METAL SCREENS"
PROCEEDINGS OF FIFTH INTERNATIONAL HEAT PIPE CONFERENCE, PART 1, JAPAN TECHNOLOGY AND ECONOMICS CENTER INCORPORATED, TOKYO, JAPAN, 1984, PP.151-155
013248 1984 ** TREATSURF POOLBOIL

XU;X. CAREY;V.P.
"FILM EVAPORATION FROM MICRO-GROOVED SURFACE - AN APPROXIMATE HEAT TRANSFER MODEL AND ITS COMPARISON WITH EXPERIMENTAL DATA"
JOURNAL OF THERMOPHYSICS AND HEAT TRANSFER, VOL.4, 1990, PP.512-520
013258 1990 JTHT TREATSURF POOLBOIL

YABE;A. SHIRAISHI;M. TAKETANI;T.
KASHIZAWA;H. KIKUCHI;K.
"STUDIES OF ENHANCED BOILING SURFACES FOR TWO-PHASE CLOSED THERMOSYPHONS"
PROCEEDINGS OF FIFTH INTERNATIONAL HEAT PIPE CONFERENCE, PART 1, JAPAN TECHNOLOGY AND ECONOMICS CENTER INCORPORATED, 1984, PP.121-126
013254 1984 ** TREATSURF POOLBOIL

YAGOV;V.V. LABUNTSOV;D.A.
"INTENSIFICATION OF HEAT TRANSFER AND STABILIZATION OF BOILING IN A REGION OF VERY LOW PRESSURES"
JOURNAL OF ENGINEERING PHYSICS, VOL.20, 1971, PP.693-698
013047 1971 JEP TREATSURF POOLBOIL

YOKOYAMA;T. YAMAZAKI;T. KUBO;Y.
OGATA;J. KAWADA;A. OOKI;Y.
"THE EFFECT OF AN ELECTRIC FIELD ON BOILING HEAT TRANSFER OF FLUOROCARBON R-11"
HEAT AND MASS TRANSFER IN REFRIGERATION AND CRYOGENICS, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, 1987, PP.140-151
143010 1987 ** COMPOUNDTECH ELECTROFIELD TREATSURF POOLBOIL

YANG;G.W. YANG;W.J. ZHANG;N.
"MECHANISMS OF NUCLEATE POOL BOILING ON COMPOSITE SURFACES"
INTERNATIONAL COMMUNICATIONS IN HEAT AND MASS TRANSFER, VOL.19, 1992, PP.781-790
013235 1992 ICHMT TREATSURF POOLBOIL

YANG;W.J. TAKIZAWA;H. VRABLE;D.L.
"AUGMENTED BOILING ON COPPER-GRAPHITE COMPOSITE SURFACE"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.34, 1991, PP.2751-2758
013237 1991 IJHMT TREATSURF POOLBOIL

ZHANG;H.J. ZHAO;X.B.
"CRITICAL HEAT FLUX FOR A THIN POWDER POROUS LAYER"
EXPERIMENTAL HEAT TRANSFER, FLUID MECHANICS, AND THERMODYNAMICS 1991, ELSEVIER SCIENCE PUBLISHING, NEW YORK, 1991, PP.627-632
013250 1992 IIWCEHTFMT TREATSURF POOLBOIL

ZHANG;Y. ZHANG;H.
"BOILING HEAT TRANSFER FROM A THIN POWDER POROUS LAYER AT LOW AND MODERATE HEAT FLUX"
SECOND INTERNATIONAL SYMPOSIUM ON MULTIPHASE FLOW AND HEAT TRANSFER, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, VOL.1, 1989, PP.358-366
013270 1989 ** TREATSURF POOLBOIL

ZHONG;L. TAN;Y. WANG;S.
"INVESTIGATION OF THE HEAT TRANSFER PERFORMANCE OF MECHANICALLY MADE POROUS SURFACE TUBES WITH RIBBED TUNNELS"
SECOND INTERNATIONAL SYMPOSIUM ON MULTIPHASE FLOW AND HEAT TRANSFER, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, VOL.1, 1989, PP.700-707
013268 1989 ** TREATSURF POOLBOIL

ROUGH SURFACES - POOL BOILING

ANDERSON;T.M. MUDAWAR;I.
"MICROELECTRONIC COOLING BY ENHANCED POOL BOILING OF A DIELECTRIC FLUOROCARBON LIQUID"
JOURNAL OF HEAT TRANSFER, VOL.111, 1989, PP.752-759
013156 1989 JHT TREATSURF
POOLBOIL EXTENDEDSURF ROUGHSURF

ANTONENKO;V.A. OSTROVSKII;Y.N. SPIVAKOV;Y.A.
"CRITICAL HEAT TRANSFER WITH BOILING ON AN IMMERSED SURFACE WITH A MESH COVERING UNDER CONDITIONS OF SHARPLY ENHANCED HEAT FLUX"
HIGH TEMPERATURE, VOL.26, NO.6, 1988, PP.901-904
023042 1988 ** ROUGHSURF
POOLBOIL

ARAI;N. FUKUSHIMA;T. ARAI;A.
NAKAJIMA;T. FUJIE;K. NAKAYAMA;Y.
"HEAT TRANSFER TUBES ENHANCING BOILING AND CONDENSATION IN HEAT EXCHANGER OF A REFRIGERATING MACHINE"
ASHRAE TRANSACTIONS, VOL.83, PT.2, 1977, PP.58-70
023008 1977 ASHRAE ROUGHSURF
POOLBOIL CONDENSATION 1FORCECONV

ASAKAVICIUS;J.P. ZUKAUSKAS;A.A. GAIGALIS;V.A.
EVA;V.K.
"HEAT TRANSFER FROM FREON-113, ETHYL ALCOHOL AND WATER WITH SCREEN WICKS"
HEAT TRANSFER - SOVIET RESEARCH, VOL.11, NO.1, 1979, PP. 92-100
023006 1979 HTSR ROUGHSURF
POOLBOIL

BIER;K. GORENFLO;D. SALEM;M.
TANES;Y.
"EFFECT OF PRESSURE AND SURFACE ROUGHNESS ON POOL BOILING OF REFRIGERANTS"
INTERNATIONAL JOURNAL OF REFRIGERATION, VOL.2, NO.4, 1979, PP.211-219
023013 1979 ** ROUGHSURF
POOLBOIL

DANILOVA;G.N. GUYGO;E.I. BORISHANSKAYA;A.V.
BUKIN;V.G. DYUNDIN;V.A. KOZYREV;A.A.
MALKOV;L.S. MALYUGIN;G.I.
"ENHANCEMENT OF HEAT TRANSFER DURING BOILING OF LIQUID REFRIGERANTS AT LOW HEAT FLUXES"
HEAT TRANSFER - SOVIET RESEARCH, VOL.8, NO.4, 1976, PP.1-8
013060 1976 HTSR TREATSURF
ROUGHSURF POOLBOIL FLOBOIL

DYUNDIN;V.A. SOLOV'YEV;A.G. BORISHANSKAYA;A.V.
VOL'NYKH;YU.A.
"EFFECT OF THE KIND OF SURFACE ROUGHNESS ON THE HEAT TRANSFER CORFFICIENT IN BOILING OF REFRIGERANTS"
HEAT TRANSFER-SOVIET RESEARCH, VOL.16, NO.1, 1984, PP. 53-58
013197 1984 HTSR TREATSURF
POOLBOIL ROUGHSURF FLOBOIL

FUJITA;Y. NISHIKAWA;K. OHTA;H.
HIDAKA;S.
"EFFECT OF THE SURFACE ROUGHNESS ON THE NUCLEATE BOILING HEAT TRANSFER"
ABSTRACTED IN BULLETIN OF JSME, VOL.26, 1983, PP.678-679
023044 1983 BJSME ROUGHSURF
POOLBOIL

KNOEBEL;D.H. YEH;Y.C.
"THE EFFECT OF ARTIFICIAL SURFACE PROJECTIONS ON FILM BOILING HEAT TRANSFER"
AMERICAN SOCIETY OF MECHANICAL ENGINEERS PAPER NO. 77-HT-81, 1977
023009 1977 ASME ROUGHSURF
POOLBOIL

KULOOR;N.R. RADHAKRISHNAN;V.N.
"EFFECT OF SURFACE ROUGHNESS ON NUCLEATE BOILING"
CHEMICAL AND PROCESS ENGINEERING, VOL.47, NO.6, 1966, PP. 276-280
013017 1966 CPE TREATSURF
ROUGHSURF POOLBOIL

MARTO;P.J. LEPERE;V.J.
"POOL BOILING HEAT TRANSFER FROM ENHANCED SURFACES TO DIELECTRIC FLUIDS"
JOURNAL OF HEAT TRANSFER, VOL.104, 1982, PP.292-299
023014 1982 JHT ROUGHSURF
POOLBOIL

NAKAJIMA;K. MOLIMOTO;S,
"EXPERIMENTS ON THE BOILING HEAT TRANSFER OF MIXTURES OF TWO COMPONENTS - THE EFFECT OF COMPOSITION OF MIXTURES AND SURFACE ROUGHNESS ON BOILING CURVES"
MITSUI TECHNICAL REVIEW, VOL.55, 1966, PP.27-41
023025 1966 ** ROUGHSURF
POOLBOIL ADDFORLIQUIDS

NAKAYAMA;W. DAIKOKU;T. KUWAHARA;H.
KAKIZAKI;K.
"HIGH-FLUX HEAT TRANSFER SURFACE "THERMOEXCEL""
HITACHI REVIEW, VOL. 24, 1975, PP. 329-333
023011 1975 ** ROUGHSURF
POOLBOIL CONDENSATION

NISHIKAWA;K. FUJITA;Y. OHTA;H.
HIDAKA;S.
"EFFECT OF THE SURFACE ROUGHNESS ON THE NUCLEATE BOILING HEAT TRANSFER OVER THE WIDE RANGE OF PRESSURE"
HEAT TRANSFER 1982, VOL.4, HEMISPHERE PUBLISHING COMPANY, WASHINGTON, D.C., 1982, PP.61-66
023022 1982 VIIIHTC ROUGHSURF
POOLBOIL

PINTO;A.D. CAPLANIS;S. SOKOL;P.
GORENFLO;D.
"VARIATION OF HYSTERESIS PHENOMENA WITH SATURATION PRESSURE AND SURFACE ROUGHNESS"
PROCEEDINGS OF THE ENGINEERING FOUNDATION CONFERENCE ON POOL AND EXTERNAL FLOW BOILING, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1992, PP.37-42
023043 1992 ASME ROUGHSURF
POOLBOIL

RAMILISON;J.M. SADASIVAN;P. LIENHARD;J.H.
"SURFACE FACTORS INFLUENCING BURNOUT ON FLAT HEATERS"
JOURNAL OF HEAT TRANSFER, VOL.114, 1992, PP.287-290
023040 1992 JHT ROUGHSURF
POOLBOIL

SABIN;C.M. POPPENDIEK;H.F.
"HEAT TRANSFER ENHANCEMENT FOR EVAPORATORS"
PROCEEDINGS FOURTH ANNUAL CONFERENCE ON OCEAN THERMAL ENERGY
CONVERSION, NEW ORLEANS, LOUISIANA, MARCH 1977, PP. VI-93 - VI-104
013089 1977 ** TREATSURF
ROUGHSURF DISPENHDEVICE POOLBOIL 1FORCECONV

SATHER;N.F. LEWIS;L.G. LORENZ;J.J.
YUNG;D.
"PERFORMANCE TESTS OF 1 MWT OTEC HEAT EXCHANGERS"
PROCEEDINGS OF THE FIFTH OCEAN THERMAL ENERGY CONVERSION CONFERENCE, VOL.3, 1978 PP.VI-1-VI-19
013079 1978 ** TREATSURF
POOLBOIL ROUGHSURF CONDENSATION

SHOJI;M. WITTE,L.C.
"THE EFFECT OF LIQUID SUBCOOLING AND SURFACE ROUGHNESS ON FILM/TRANSITION BOILING"
ASME PROCEEDINGS OF THE 1988 NATIONAL HEAT TRANSFER CONFERENCE, HTD-96, VOL.2, ASME, NEW YORK, 1988, PP.667-673
023036 1988 ASME ROUGHSURF
POOLBOIL

SHOJI;M. WITTE;L.C. SANKARAN;S.
"THE INFLUENCE OF SURFACE CONDITIONS AND SUBCOOLING ON FILM-TRANSITION BOILING"
EXPERIMENTAL THERMAL AND FLUID SCIENCE, VOL.3, 1990, PP.280-290
013174 1990 ETFS TREATSURF

POOLBOIL ROUGHSURF FOULING

STEPHAN;K. MITROVIC;J.
"HEAT TRANSFER IN NATURAL CONVECTIVE BOILING OF REFRIGERANT-OIL MIXTURES"
HEAT TRANSFER 1982, VOL.4, HEMISPHERE PUBLISHING COMPANY, WASHINGTON, D.C., 1982, PP.73-87
023023 1982 VIIIHTC ROUGHSURF
POOLBOIL

TEVAPAUGH;J.A. KESHOCK;E.G.
"INFLUENCE OF ARTIFICIAL SURFACE PROJECTIONS ON FILM BOILING HEAT TRANSFER"
ADVANCES IN ENHANCED HEAT TRANSFER, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1979, PP.133-146.
023050 1979 ASME ROUGHSURF
POOLBOIL

TORII;T. HIRASAWA;S. KUWAHARA;H.
YANAGIDA;T. FUJIE;K.
"THE USE OF HEAT EXCHANGERS WITH THERMOEXCEL'S TUBING IN OCEAN THERMAL ENERGY POWER PLANTS"
AMERICAN SOCIETY OF MECHANICAL ENGINEERS PAPER NO.78-WA/HT-65, 1978
023004 1978 ASME ROUGHSURF
POOLBOIL CONDENSATION 1FORCECONV

VASILIEV;L.L. ABRAMENKO;A.N. KANONCHIK;L.E.
"BOILING LIQUID HEAT TRANSFER ON POROUS AND DEVELOPED SURFACES"
JOURNAL OF ENGINEERING PHYSICS, VOL.34, 1978, PP.508-524
023024 1978 JEP ROUGHSURF
POOLBOIL EXTENDEDSURF

WEBB;R.L.
"THE EVOLUTION OF ENHANCED SURFACE GEOMETRIES FOR NUCLEATE BOILING"
HEAT TRANSFER ENGINEERING, VOL.2, NOS.3-4, 1981, PP.46-69
000118 1981 HTE LITSURVEY
TREATSURFF ROUGHSURF POOLBOIL

WEBB;R.L.
"PERFORMANCE, COST EFFECTIVENESS, AND WATER-SIDE FOULING CONSIDERATIONS OF ENHANCED TUBE HEAT EXCHANGERS FOR BOILING SERVICE WITH TUBE-SIDE WATER FLOW"
HEAT TRANSFER ENGINEERING, VOL.3, NOS.3-4, 1982, PP.84-98
150070 1982 HTE PERFORMANCE
TREATEDSURF POOLBOIL ROUGHSURF 1FORCECONV

WRIGHT;N.T. GEBHART;B.
"A TWO BUBBLE MODEL OF BOILING ENHANCEMENT FROM MICROCONFIGURED SURFACES"
PROCEEDINGS OF THE ENGINEERING FOUNDATION CONFERENCE ON POOL AND EXTERNAL FLOW BOILING, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, 1992, PP.367-372
023041 1992 ASME ROUGHSURF
POOLBOIL

YAMAGUCHI;H. JAMES;D.D.
"EFFECT OF WIRE MESHES ON BOILING HEAT TRANSFER FROM A PLANE HEATING SURFACE"
EXPERIMENTAL HEAT TRANSFER, FLUID MECHANICS, AND THERMODYNAMICS 1988, ELSEVIER SCIENCE PUBLISHING, NEW YORK, 1988, PP.587-594
023032 1988 IWCEHTFMT ROUGHSURF
POOLBOIL

EXTENDED SURFACES - POOL BOILING

ABUAF;N. BLACK;S.H. STAUB;F.W.
"POOL BOILING PERFORMANCE OF FINNED SURFACES IN R-113"
INTERNATIONAL JOURNAL OF HEAT AND FLUID FLOW, VOL.6, 1985, PP. 23-30
033064 1985 IJHFF EXTENDEDSURF POOLBOIL

ALLEN;P.H.G. COOPER;P.
"THE POTENTIAL OF ELECTRICALLY ENHANCED EVAPORATORS"
THIRD INTERNATIONAL SYMPOSIUM ON THE LARGE SCALE APPLICATIONS OF HEAT PUMPS, OXFORD, ENGLAND, 1987, PP.221-229
143009 1987 ** COMPOUNDTECH ELECTROFIELD EXTENDEDSURF POOLBOIL

ANDERSON;T.M. MUDAWWAR;I.
"MICROELECTRONIC COOLING BY ENHANCED POOL BOILING OF A DIELECTRIC FLUOROCARBON LIQUID"
ASME PROCEEDINGS OF THE 1988 NATIONAL HEAT TRANSFER CONFERENCE, HTD-96, VOL.1, ASME, NEW YORK, 1988, PP.551-560
033079 1988 ASME EXTENDEDSURF POOLBOIL TREATSURF

ANDERSON;T.M. MUDAWAR;I.
"MICROELECTRONIC COOLING BY ENHANCED POOL BOILING OF A DIELECTRIC FLUOROCARBON LIQUID"
JOURNAL OF HEAT TRANSFER, VOL.111, 1989, PP.752-759
013156 1989 JHT TREATSURF POOLBOIL EXTENDEDSURF ROUGHSURF

BERNDT;T. CONNELL;J.W.
"PLATE HEAT EXCHANGERS FOR OTEC"
PROCEEDINGS OF THE FIFTH OCEAN THERMAL ENERGY CONVERSION CONF., MIAMI BEACH, FLORIDA, FEBRUARY 1978, PP.VI/288-VI/320
033032 1978 ** EXTENDEDSURF POOLBOIL CONDENSATION

BERGLES;A.E.
"THE EVOLUTION OF COOLING TECHNOLOGY FOR ELECTRICAL, ELECTRONIC, AND MICROELECTRONIC EQUIPMENT"
HEAT TRANSFER IN ELECTRONIC EQUIPMENT-1986, HTD-VOL.57, ASME, NEW YORK, 1986, PP.1-9
000168 1986 ASME LITSURVEY EXTENDEDSURF 1NATCONV 1FORCECONV POOLBOIL

BIYIKLI;S.
"OPTIMUM USE OF LONGITUDINAL FINS OF RECTANGULAR PROFILES IN BOILING LIQUIDS"
JOURNAL OF HEAT TRANSFER, VOL.107, 1985, PP.968-970
033067 1985 JHT EXTENDEDSURF POOLBOIL

BONDURANT;D.L. WESTWATER;J.W.
"HEAT TRANSFER WITH CHANGE OF PHASE - PART II. PERFORMANCE OF TRANSVERSE FINS FOR BOILING HEAT TRANSFER"
AMERICAN INSTITUTE OF CHEMICAL ENGINEERS PREPRINT 49D FOR 63RD ANNUAL MEETING, 1970
033010 1970 AICHE EXTENDEDSURF POOLBOIL

CARNAVOS;T.C.
"AN EXPERIMENTAL STUDY: POOL BOILING R-11 WITH AUGMENTED TUBES"
ADVANCES IN ENHANCED HEAT TRANSFER-1981, HTD VOL. 18 AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1981, PP. 103-108.
033040 1981 ** EXTENDEDSURF POOLBOIL TREATSURF

CASH;D.R. KLEIN;G.J. WESTWATER;J.W.
"APPROXIMATE OPTIMUM FIN DESIGN FOR BOILING HEAT TRANSFER"
JOURNAL OF HEAT TRANSFER, VOL.93, 1971, PP.19-24
033014 1971 JHT EXTENDEDSURF POOLBOIL

CHEN;J.-G. DONG;L. ZHANG;H.-J.
"BOILING HEAT TRANSFER ON LOW FINNED TUBE"
ADVANCES IN PHASE CHANGE HEAT TRANSFER, INTERNATIONAL ACADEMIC PUBLISHERS, CHONGQING, CHINA, AND PERGAMON PRESS, NEW YORK, 1988, PP.129-134
033075 1988 ** EXTENDEDSURF POOLBOIL

CHYU;M.C. MGHAMIS;A.M.
"EFFECTS OF CYLINDRICAL WALL ATTACHMENT ON NUCLEATE BOILING"
HEAT TRANSFER WITH PHASE CHANGE, HTD VOL.114, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1989, PP.69-74
033081 1989 ASME EXTENDEDSURF POOLBOIL

CONTI;R.J.
"EXPERIMENTAL INVESTIGATION OF HORIZONTAL-TUBE AMMONIA FILM EVAPORATORS WITH SMALL TEMPERATURE DIFFERENTIALS"
PROCEEDINGS OF THE FIFTH OCEAN THERMAL ENERGY CONVERSION CONFERENCE, MIAMI BEACH, FLORIDA, FEBRUARY, 1978
PP. VI 161 - VI 180.
033030 1978 OTEC EXTENDEDSURF POOLBOIL

CORMAN;J.C. MC LAUGHLIN;M.H.
"BOILING AUGMENTATION WITH STRUCTURED SURFACES"
PREPRINTED AND PRESENTED AT ASHRAE SEMIANNUAL MEETING, DALLAS, 1976, ASHRAE TRANSACTIONS, VOL. 82, PART 1, 1976, PP.906-918
063007 1976 ASHRAE SURFTENSION EXTENDEDSURF POOLBOIL

CZIKK;A.M. FRICKE;H.D. GANIC;E.N. SHARMA;B.I.
"FLUID DYNAMIC AND HEAT TRANSFER STUDIES OF OTEC HEAT EXCHANGERS"
PROCEEDINGS OF THE FIFTH OCEAN THERMAL ENERGY CONVERSION CONFERENCE, MIAMI BEACH, FLORIDA, 1978, PP.VI181-VI236.
013078 1978 OTEC TREATSURF POOLBOIL EXTENDEDSURF CONDENSATION

DANILOVA;G.N. DYUNDIN;V.A.
"HEAT TRANSFER DURING BOILING OF FREON 12 AND 22 IN BUNDLES OF FINNED TUBES"
KHOLODIL'NAYA TEKHNIKA, VOL.48, 1971, PP.40-43.
033029 1971 ** EXTENDEDSURF POOLBOIL

DULNEV;G.N. KORABLYOV;V.A. SHARKOV;A.V.
"CONVECTIVE HEAT TRANSFER IN ELECTRONIC FACILITIES"
HEAT TRANSFER IN ELECTRONIC AND MICROELECTRONIC EQUIPMENT, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, 1990, PP.339-363
033068 1990 ** EXTENDEDSURF POOLBOIL

GALEZHA;V.B. USYUKIN;I.P. KAN;K.D.
"BOILING HEAT TRANSFER WITH FREONS IN FINNED-PLATE HEAT EXCHANGERS"
HEAT TRANSFER - SOVIET RESEARCH, VOL.8, NO.3, 1976, PP.103-110
033026 1976 HTSR EXTENDEDSURF POOLBOIL

GANIC;E.N. WU;J.
"ON THE SELECTION OF WORKING FLUIDS FOR OTEC POWER PLANTS"
ENERGY CONVERSION AND MANAGEMENT, VOL.20, NO.1, 1980, PP.9-22
033061 1980 ** EXTENDEDSURF POOLBOIL CONDENSATION

GOGONIN;I.I. SILKACHEV;A.E.
"HEAT TRANSFER AND CRITICAL HEAT FLUXES IN BOILING AT FINNED SURFACES"
HIGH TEMPERATURE, VOL.29, 1991, PP.914-920
033080 1991 ** EXTENDEDSURF POOLBOIL

GOLOVINSKII;G.P.
"HEAT TRANSFER FROM FINNED AND CORRUGATED TUBES TO BOILING LIQUIDS"
INTERNATIONAL CHEMICAL ENGINEERING, VOL.15, 1975, PP.258-260
033017 1975 ICE EXTENDEDSURF POOLBOIL

GOTTZMANN;C.F. O'NEILL;P.S. MINTON;P.E.
"HIGH EFFICIENCY HEAT EXCHANGERS"

CHEMICAL ENGINEERING PROGRESS, VOL.69, NO.7, 1973, PP.69-75
013044 1973 CEP TREATSURF
EXTENDEDSURF POOLBOIL FLOBOIL

HAHNE;E. MUELLER;J.
"BOILING ON A FINNED TUBE AND A FINNED TUBE BUNDLE"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.26, 1983, PP.849-859
033058 1983 IJHMT EXTENDEDSURF
POOLBOIL

HAHNE;E. QIU-RONG;C. WINDISCH;R.
"POOL BOILING HEAT TRANSFER ON FINNED TUBES-AN EXPERIMENTAL AND THEORETICAL STUDY"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.34, 1991, PP.2071-2079
033082 1991 IJHMT EXTENDEDSURF
POOLBOIL

HALEY;K.W. WESTWATER;J.W.
"BOILING HEAT TRANSFER FROM SINGLE FINS"
PROCEEDINGS OF THE THIRD INTERNATIONAL HEAT TRANSFER CONFERENCE, AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, NEW YORK, VOL.III, 1966, PP.245-253
033009 1966 IIIIHTC EXTENDEDSURF
POOLBOIL

HESSE;G.
"HEAT TRANSFER IN NUCLEATE BOILING, MAXIMUM HEAT FLUX AND TRANSITION BOILING"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.16, 1973, PP.1611-1627
033008 1973 IJHMT EXTENDEDSURF
POOLBOIL

HOMMAN;G.H.
"BOILING HEAT TRANSFER FROM FREONS ON HORIZONTAL SMOOTH AND FINNED TUBES"
HEAT TRANSFER-SOVIET RESEARCH, VOL.4, NO.3, 1972, PP.57-63
033013 1972 HTSR EXTENDEDSURF
POOLBOIL

JENSEN;M.K.
"BOILING ON THE SHELLSIDE OF HORIZONTAL TUBE BUNDLES"
TWO-PHASE FLOW HEAT EXCHANGERS: THERMAL-HYDRAULIC FUNDAMENTALS AND DESIGN, KLUWER ACADEMIC PUBLISHERS, DORDRECHT, THE NETHERLANDS, 1988, PP.707-746
000162 1988 ** LITSURVEY
POOLBOIL EXTENDEDSURF TREATSURF

KAJIKAWA;T. TAKAZAWA;H. NISHIYAMA;K.
AGAWA;T. IIDAKA;H. AMANO;M.
"DEVELOPMENT OF ENHANCEMENT OF THE WORKING FLUID SIDE HEAT TRANSFER FOR OTEC"
PROCEEDINGS OF THE SEVENTH OCEAN ENERGY CONFERENCE, CONF-800633, VOL.2, 1980, PP.12.2-1 - 12.2-9
013113 1980 ** TREATSURF
POOLBOIL EXTENDEDSURF CONDENSATION

KATZ;D.L. MEYERS;J.E. YOUNG;E.H.
BALEKJIAN;G.
"BOILING OUTSIDE FINNED TUBES"
PETROLEUM REFINER, VOL.34, NO.2, 1955, PP.113-116.
033001 1955 ** EXTENDEDSURF
POOLBOIL

KLEIN;G.J. WESTWATER;J.W.
"HEAT TRANSFER FROM MULTIPLE SPINES TO BOILING LIQUIDS"
AMERICAN INSTITUTE OF CHEMICAL ENGINEERS JOURNAL, VOL.17, 1971, PP.1050-1056
033011 1971 AICHEJ EXTENDEDSURF
POOLBOIL

KUMAGAI;S. JHO;S.G. HIRONO;Y.
SHIMADA;R. TAKEYAMA;T.
"ON THE INTERFERENCE OF LIQUID AND VAPOR FLOW IN BOILING HEAT TRANSFER ON AN ANNULAR FIN ARRAY (2ND REPORT, THE EFFECT OF FIN HEIGHT)"
ABSTRACTED IN BULLETIN OF JSME, VOL.28, 1985, PP.1569
033089 1985 BJSME EXTENDEDSURF
POOLBOIL

KUMAGAI;S. JHO;S.G. HIRONO;Y.
SHIMADA;R. TAKEYAMA;T.
"BOILING HEAT TRANSFER FROM CIRCULAR SURFACES WITH RECTANGULAR FIN ARRAY"
ABSTRACTED IN BULLETIN OF JSME, VOL.29, 1986, PP.3242
033090 1986 BJSME EXTENDEDSURF
POOLBOIL

KUMAGAI;S. MATSUI;S. SHIMADA;R.
HARAGUCHI;T. OUCHI;M. TAKEYAMA;T.
"ON THE CHARACTERISTICS OF TRANSITIONAL PHENOMENA IN HEAT TRANSFER FROM EXTENDED SURFACES TO BOILING LIQUID"
HEAT TRANSFER 1990, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, VOL.4, 1990, PP.87-92
033072 1990 IXIHTC EXTENDEDSURF
POOLBOIL

LALLEMAND;M. DUYME;V. ECKES;U.
MEREL;P.
"CLOSED TWO-PHASE THERMOSYPHON FOR COOLING OF HIGH-POWER SEMICONDUCTORS"
HEAT TRANSFER IN ELECTRONIC AND MICROELECTRONIC EQUIPMENT, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, 1990, PP.551-559
033069 1990 ** EXTENDEDSURF
POOLBOIL

LIAW;S.P. YEH;R.H.
"BOILING HEAT TRANSFER FROM AN EXCAVATED FIN"
INTERNATIONAL COMMUNICATIONS IN HEAT AND MASS TRANSFER, VOL.19, 1992, PP.215-228
033085 1992 ICHMT EXTENDEDSURF
POOLBOIL

LORENZ;J.J. YUNG;D.T. HILLIS;D.L.
SATHER;N.F.
"OTEC PERFORMANCE TESTS OF THE CARNEGIE-MELLON UNIVERSITY VERTICAL FLUTED-TUBE EVAPORATOR"
ARGONNE NATIONAL LABORATORY, OCEAN THERMAL ENERGY CONVERSION
PROGRAM, REPORT NO. ANL/OTEC-PS-5, JULY 1979.
033036 1979 ANL EXTENDEDSURF
POOLBOIL 1FORCECONV

MAILEN;G.S.
"THE ENHANCEMENT OF HEAT TRANSFER FOR AMMONIA EVAPORATING OUTSIDE VERTICAL TUBES"
OAK RIDGE NATIONAL LABORATORY REPORT NO. ORNL-5639, 1980.
033035 1980 ORNL EXTENDEDSURF
POOLBOIL

MAILEN;G.S.
"EXPERIMENTAL STUDIES OF OTEC HEAT TRANSFER EVAPORATION OF AMMONIA ON VERTICAL SMOOTH AND FLUTED TUBES"
PROCEEDINGS OF THE SEVENTH OCEAN ENERGY CONFERENCE, CONF-800633, VOL.2, 1980, PP.12.5-1 - 12.5-10
033050 1980 ** EXTENDEDSURF
POOLBOIL

MANWELL;S.P. BERGLES;A.E.
"GAS-LIQUID FLOW PATTERNS IN REFRIGERANT-OIL MIXTURES"
ASHRAE TRANSACTIONS, VOL. 96, PART 2, 1990, PP.456-464
033086 1990 ASHRAE EXTENDEDSURF
POOLBOIL

MEMORY;S.B. CHILMAN;S.V. MARTO;P.J.
"NUCLEATE BOILING CHARACTERISTICS OF A SMALL ENHANCED TUBE BUNDLE IN A POOL OF R-113"
TWO-PHASE FLOW AND HEAT TRANSFER, HTD VOL.197, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1992, PP.129-138
033087 1992 ASME EXTENDEDSURF
POOLBOIL

MORI;S. SAKITANI;K. ISAJI;A.
"EXPERIMENTAL RESEARCH ON HEAT TRANSFER OF A FLOODED TYPE EVAPORATOR"
REFRIGERATION, VOL.50, 1975, PP.499-504
033019 1975 ** EXTENDEDSURF
POOLBOIL

MUELLER;J. HAHNE;E.

"BOILING HEAT TRANSFER IN FINNED TUBE BUNDLES"
ABSTRACT FROM THE SIXTH ALL-UNION HEAT AND MASS TRANSFER CONFERENCE, MINSK, USSR, 1980, P. 70.
033037 1980 ** EXTENDEDSURF POOLBOIL

MUELLER;J. HAHNE;E.
"BOILING HEAT TRANSFER IN FINNED TUBE BUNDLES"
HEAT TRANSFER - SOVIET RESEARCH, VOL.13, NO.6, 1981, PP.19-25
033057 1981 HTSR EXTENDEDSURF POOLBOIL

MULLER;J.
"BOILING HEAT TRANSFER ON FINNED TUBE BUNDLES - THE EFFECT OF TUBE POSITION AND INTERTUBE SPACING"
HEAT TRANSFER 1986, HEMISPHERE PUBLISHING CORPORAITON, WASHINGTON, DC, 1986, VOL.4, PP.2111-2116
033070 1986 VIIIIHTC EXTENDEDSURF POOLBOIL

NAKAYAMA;W. NAKAJIMA;T. HIRASAWA;S.
"HEAT SINK STUDS HAVING ENHANCED BOILING SURFACES FOR COOLING OF MICROELECTRONIC COMPONENTS"
AMERICAN SOCIETY OF MECHANICAL ENGINEERS PAPER NO. 84-WA/HT-89, 1989
143008 1984 ASME COMPOUNDTECH TREATSURF EXTENDEDSURF POOLBOIL

NAKAJIMA;K. SHIOZAWA;A.
"AN EXPERIMENTAL STUDY ON THE PERFORMANCE OF A FLOODED TYPE EVAPORATOR"
HEAT TRANSFER-JAPANESE RESEARCH,VOL.4,NO.4,1975,PP.49-66
033020 1975 HTJR EXTENDEDSURF POOLBOIL

OKTAY;S.
"DEPARTURE FROM NATURAL CONVECTION (DNC) IN LOW-TEMPERATURE BOILING HEAT TRANSFER ENCOUNTERED IN COOLING MICRO-ELECTRONIC LSI DEVICES"
HEAT TRANSFER 1982, VOL.4, HEMISPHERE PUBLISHING COMPANY, WASHINGTON, D.C., 1982, PP.113-118
033053 1982 VIIIHTC EXTENDEDSURF POOLBOIL

PALEN;J.W. TABOREK;J.
"CHARACTERISTICS OF BOILING OUTSIDE LARGE SCALE HORIZONTAL MULTITUBE BUNDLES"
AMERICAN INSTITUTE OF CHEMICAL ENGINEERS 12TH NATIONAL HEAT TRANSFER CONFERENCE, TULSA, OKLAHOMA, 1971, PAPER NO. 9
033033 1971 AICHE TREATSURF EXTENDEDSURF POOLBOIL

PANCHAL;C.P. LORENZ;J.J. HILLIS;D.L.
"THE EFFECTS OF AMMONIA CONTAMINATION BY WATER ON OTEC POWER SYSTEM PERFORMANCE"
ARGONNE NATIONAL LABORATORY, ANL/OTEC-PS-8, AUGUST 1981.
033038 1981 ANL EXTENDEDSURF POOLBOIL TREATSURF

PANCHAL;C.B. HILLIS;D.L. LORENZ;J.J. YUNG;D.T.
"OTEC PERFORMANCE TESTS OF THE TRANE PLATE-FIN HEAT EXCHANGER"
ARGONNE NATIONAL LABORATORY, REPORT NO. ANL/OTEC-PS-7, APRIL 1981.
150053 1981 ANL PERFORMANCE EXTENDEDSURF POOLBOIL CONDENSATION

PETUKHOV;B.S. KOVALEV;S.A. GESHELE;V.D.
"HEAT TRANSFER IN BOILING ON FINNED SURFACES"
HEAT TRANSFER - SOVIET RESEARCH, VOL.13, NO.1, 1981, PP.51-60
033049 1981 HTSR EXTENDEDSURF POOLBOIL

RANGARAJAN;J. RAI;M.M. SEETHARAMU;K.N.
"APPLICATION OF FINITE ELEMENT METHOD TO THE ANALYSIS OF FINS IN BOILING LIQUIDS"
NUMERICAL METHODS IN THERMAL PROBLEMS, PINERIDGE PRESS UNITED KINGDOM, 1979, PP.1149-1155
033056 1979 ** EXTENDEDSURF POOLBOIL

ROTHFUS;R.R. NEUMAN;C.P.
"THE OTEC PROGRAM AT CARNEGIE-MELLON UNIVERSITY HEAT TRANSFER RESEARCH AND POWER CYCLE TRANSIENT MODELING"
PROCEEDINGS OF THE FOURTH ANNUAL CONFERENCE ON OCEAN THERMAL ENERGY CONVERSION, NEW ORLEANS, LOUISIANA, MARCH 1977, PP.VI-55 - VI-70
033039 1977 ** EXTENDEDSURF CONDENSATION POOLBOIL

RUBIN;G.R. ROYZEN;L.I. DULKIN;I.N.
"HEAT TRANSFER IN LIQUID BOILING ON INSULATION-COATED FINS"
HEAT TRANSFER-SOVIET RESEARCH, VOL.3, NO.5, 1971, PP.130-134
033006 1971 HTSR EXTENDEDSURF POOLBOIL

RUBIN;I.R. ROIZEN;L.I. DUL'KIN;I.N. YUDINA;L.A.
"HEAT TRANSFER IN THE BOILING OF A LIQUID ON HORIZONTAL PIPES WITH ANNULAR FINS"
HIGH TEMPERATURE, VOL.17, NO.3, 1979, PP.475-480
033046 1979 ** EXTENDEDSURF POOLBOIL

SAASKI;E.W. FRANKLIN;J.
"HEAT TRANSFER: PERFORMANCE OF AN EVAPORATIVE HEAT TRANSFER WICK"
CHEMICAL ENGINEERING PROGRESS, JULY 1977, PP. 74-77.
033034 1977 CEP EXTENDEDSURF POOLBOIL

SAUER;H.J. DAVIDSON;G.W. CHONGRUNGREONG;S.
"NUCLEATE BOILING OF REFRIGERANT-OIL MIXTURES FROM FINNED TUBING"
AMERICAN SOCIETY OF MECHANICAL ENGINEERS PAPER NO.80-HT-111, 1980.
033024 1980 ASME EXTENDEDSURF POOLBOIL

SCHNABEL;G.
"ANALYSIS OF LOCAL AND OVERALL HEAT TRANSFER ENHANCEMENT BY DOUBLE FLUTED CONDENSER/EVAPORATOR TUBES"
HEAT EXCHANGERS: THEORY AND PRACTICE, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, AND MC GRAW-HILL BOOK COMPANY, NEW YORK, 1983, PP.205-220
033062 1983 ** EXTENDEDSURF POOLBOIL CONDENSATION

SHIH;C.C. WESTWATER;J.W.
"SPHERES, HEMISPHERES AND DISCS AS HIGH-PERFORMANCE FINS FOR BOILING HEAT TRANSFER"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.17, 1974, PP.125-134
033015 1974 IJHMT EXTENDEDSURF POOLBOIL

THOMAS;A. HILLIS;D. PANCHAL;C. LORENZ;J. YUNG;D. SATHER;N.
"EXPERIMENTAL TESTS OF 1 MWT OTEC HEAT EXCHANGERS AT ARGONNE NATIONAL LABORATORY"
PROCEEDINGS OF THE SEVENTH OCEAN ENERGY CONFERENCE, CONF-800633, VOL.2, 1980, PP.12.1-1 - 12.1-8
013112 1980 ** TREATSURF POOLBOIL EXTENDEDSURF CONDENSATION

UEHARA;H. KUSUDA;H. MIYOSHI;M. SUMITOMO;H.
"PLATE TYPE EVAPORATOR AND CONDENSER FOR OCEAN THERMAL ENERGY CONVERSION PLANT"
PROCEEDINGS OF THE FIFTH OCEAN THERMAL ENERGY CONVERSION CONFERENCE, MIAMI BEACH, FLORIDA, FEBRUARY, 1978, PP.VI/261-VI287
033031 1978 OTEC EXTENDEDSURF POOLBOIL CONDENSATION

UNAL;H.C.
"AN ANALYTIC STUDY OF BOILING HEAT TRANSFER FROM A FIN"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER
033066 1987 IJHMT EXTENDEDSURF

POOLBOIL

VASILIEV;L.L. ABRAMENKO;A.N. KANONCHIK;L.E.
"BOILING LIQUID HEAT TRANSFER ON POROUS AND DEVELOPED SURFACES"
JOURNAL OF ENGINEERING PHYSICS, VOL.34, 1978, PP.508-524
023024 1978 JEP ROUGHSURF
POOLBOIL EXTENDEDSURF

WEBB;R.L. PAIS;C.
"POOL BOILING DATA FOR FIVE REFRIGERANTS ON THREE TUBE GEOMETRIES"
ASHRAE TRANSACTIONS, VOL.97, PART 1, 1991, PP.72-78
033088 1991 ASHRAE EXTENDEDSURF
POOLBOIL

WINDISCH;R. HAHNE;E. KISS;V.
"HEAT TRANSFER FOR BOILING ON FINNED TUBE BUNDLES"
INTERNATIONAL COMMUNICATIONS IN HEAT AND MASS TRANSFER, VOL.12, 1985, PP.355-368
033078 1985 ICHMT EXTENDEDSURF
POOLBOIL

ZHANG;H. DONG;L.
"ANALYSIS AND EXPERIMENTS OF POOL BOILING HEAT TRANSFER FROM CIT-SHAPED FINNED TUBE ABOVE ATMOSPHERIC PRESSURE"
SECOND INTERNATIONAL SYMPOSIUM ON MULTIPHASE FLOW AND HEAT TRANSFER, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, VOL.1, 1989, PP.384-392
033095 1989 ** EXTENDEDSURF
POOLBOIL

DISPLACED ENHANCEMENT DEVICES - POOL BOILING

CHYU;M.C. MGHAMIS;A.M.
"ENHANCED POOL BOILING HEAT TRANSFER WITH SURFACE ATTACHMENT"
EXPERIMENTAL HEAT TRANSFER, VOL.5, 1992. PP.51-63
043005 1992 EHT DISPENHDEVICE POOLBOIL

SABIN;C.M. POPPENDIEK;H.F.
"HEAT TRANSFER ENHANCEMENT FOR EVAPORATORS"
PROCEEDINGS FOURTH ANNUAL CONFERENCE ON OCEAN THERMAL ENERGY
CONVERSION, NEW ORLEANS, LOUISIANA, MARCH 1977, PP. VI-93 - VI-104
013089 1977 ** TREATSURF ROUGHSURF DISPENHDEVICE POOLBOIL 1FORCECONV

PALM;B.
"HEAT TRANSFER AUGMENTATION IN POOL BOILING BY AID OF PERFORATED METAL FOILS"
PROCEEDINGS OF EIGHTEENTH INTERNATIONAL CONGRESS OF REFRIGERATION, PAPER NO.89, MONTREAL, CANADA, 1991
043008 1991 ** DISPENHDEVICE POOLBOIL

VARMA;H.K. AGRAWAL;K.N. BANSAL;M.L.
"HEAT TRANSFER AUGMENTATION BY COILED WIRE TURBULENCE PROMOTERS IN A HORIZONTAL REFRIGERANT-22 EVAPORATOR"
ASHRAE TRANSACTIONS, VOL.97, PART 1, 1991, PP.359-364
043004 1991 ASHRAE DISPENHDEVICE POOLBOIL

SURFACE TENSION DEVICES - POOL BOILING

ASAKAVICIUS;J. GAIGALIS;V. EVA;V.
"TRANSPORT CHARACTERISTICS AND SOME OPERATING FEATURES OF A HEAT PIPE WITH WATER, METHANOL, AND FREON-113"
FIFTH NATIONAL CONFERENCE ON HEAT AND MASS TRANSFER, MINSK, USSR, 1976, ABSTRACTED IN HEAT AND MASS TRANSFER SOURCEBOOK, SCRIPTA PUBLISHING COMPANY, 1977, P. 364
063013 1976 ** SURFTENSION
POOLBOIL

CORMAN;J.C. MC LAUGHLIN;M.H.
"BOILING AUGMENTATION WITH STRUCTURED SURFACES"
PREPRINTED AND PRESENTED AT ASHRAE SEMIANNUAL MEETING, DALLAS, 1976, ASHRAE TRANSACTIONS, VOL. 82, PART 1, 1976, PP.906-918
063007 1976 ASHRAE SURFTENSION
EXTENDEDSURF POOLBOIL

FUKUSAKO;S. YAMADA;M. KINOSHITA;K.
KAWABE;H.
"BOILING HEAT TRANSFER IN A LIQUID-SATURATED POROUS BED"
PROCEEDINGS OF THE 1991 ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE, VOL.2, JSME, TOKYO, AND ASME, NEW YORK, 1991, PP.281-288
063018 1991 ASME-JSME SURFTENSION
POOLBOIL

KATSUTA;M. NAGATA;K.
"BOILING INDUCED HEAT-TRANSFER ENHANCEMENT USING A NARROW SPACE"
PROCEEDINGS OF THE ENGINEERING FOUNDATION CONFERENCE ON POOL AND EXTERNAL FLOW BOILING, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1992, PP.381-386
063017 1992 ASME SURFTENSION
POOLBOIL

TONGZE;M. ZHENGFANG;Z. HUIQUN;L.
"VAPORIZATION HEAT TRANSFER IN CAPILLARY WICK STRUCTURES FORMED BY SINTERED SCREENS"
PROCEEDINGS OF FIFTH INTERNATIONAL HEAT PIPE CONFERENCE, PART 1, JAPAN TECHNOLOGY AND ECONOMICS CENTER INCORPORATED, TOKYO, JAPAN, 1984, PP.156-163
013256 1984 ** TREATSURF
SURFTENSION POOLBOIL

ADDITIVES FOR LIQUIDS - POOL BOILING

BERGLES;A.E.
"HIGH FLUX BOILING APPLIED TO MICROELECTRONICS THERMAL CONTROL"
INTERNATIONAL COMMUNICATIONS IN HEAT AND MASS TRANSFER, VOL.15, 1988, PP.509-531
000172 1988 ICHMT LITSURVEY
POOLBOIL TREATSURF ADDFORLIQUIDS

BURKHARDT;J. HAHNE;E.
"INFLUENCE OF OIL ON THE NUCLEATE BOILING OF REFRIGERANT 11"
PROCEEDINGS OF THE XV INTERNATIONAL CONGRESS OF REFRIGERATION, INTERNATIONAL INSTITUTE OF REFRIGERATION, 1979, PP.537-544
073071 1979 ** ADDFORLIQUIDS
POOLBOIL

DOUGHERTY;R.L. SAUER;H.J.
"NUCLEATE POOL BOILING OF REFRIGERANT-OIL MIXTURES FROM TUBES"
ASHRAE TRANSACTIONS, VOL.80, PART 2, 1974, PP.175-193.
073045 1974 ASHRAET ADDFORLIQUIDS
POOLBOIL

JENSEN;M.K.
"ENHANCEMENT OF THE CRITICAL HEAT FLUX IN POOL BOILING OF REFRIGERANT-OIL MIXTURES"
JOURNAL OF HEAT TRANSFER, VOL.106, 1984, PP.477-479
073062 1984 JHT ADDFORLIQUIDS
POOLBOIL

KAUTZKY;D.E. WESTWATER;J.W.
"FILM BOILING OF A MIXTURE ON A HORIZONTAL PLATE"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.10, 1967, PP.253-256
073028 1967 IJHMT ADDFORLIQUIDS
POOLBOIL

LIU;T. CAI;Z. JIFANG;L.
"A MECHANISM STUDY ON ENHANCEMENT OF NUCLEATE BOILING HEAT TRANSFER WITH ADDITIVES"
SECOND INTERNATIONAL SYMPOSIUM ON MULTIPHASE FLOW AND HEAT TRANSFER, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, VOL.1, 1989, PP.640-648
073073 1989 ** ADDFORLIQUIDS
POOLBOIL

MONDE;M. KUSUDA;H.
"ENHANCEMENT OF HEAT TRANSFER DUE TO BUBBLES PASSING THROUGH A NARROW VERTICAL RECTANGULAR CHANNEL"
EXPERIMENTAL HEAT TRANSFER, FLUID MECHANICS, AND THERMODYNAMICS 1988, ELSEVIER SCIENCE PUBLISHING, NEW YORK, 1988, PP.1459-1465
073065 1988 IWCEHTFMT ADDFORLIQUIDS
POOLBOIL

NAKAJIMA;K. MOLIMOTO;S,
"EXPERIMENTS ON THE BOILING HEAT TRANSFER OF MIXTURES OF TWO COMPONENTS - THE EFFECT OF COMPOSITION OF MIXTURES AND SURFACE ROUGHNESS ON BOILING CURVES"
MITSUI TECHNICAL REVIEW, VOL.55, 1966, PP.27-41
023025 1966 ** ROUGHSURF
POOLBOIL ADDFORLIQUIDS

STEPHAN;K.
"INFLUENCE OF OIL ON HEAT TRANSFER OF BOILING REFRIGERANT 12 AND REFRIGERANT 22"
XI INTERNATIONAL CONGRESS OF REFRIGERATION, 1963.
(SUMMARIZED, I.I.R. BULLETIN NO.3, 1963)
073044 1963 ** ADDFORLIQUIDS
POOLBOIL NHC

VAN STRALEN;S.J.D.
"HEAT TRANSFER TO BOILING BINARY LIQUID MIXTURES PART I, PART II"
BRITISH CHEMICAL ENGINEERING, VOL.4, 1959, PP.8-17, 78-82
073010 1959 BCE ADDFORLIQUIDS
POOLBOIL

WU;W.T. YANG;Y.M.
"ENHANCED BOILING HEAT TRANSFER BY SURFACTANT ADDITIVES"
PROCEEDINGS OF THE ENGINEERING FOUNDATION CONFERENCE ON POOL AND EXTERNAL FLOW BOILING, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1992, PP.361-366
073068 1992 ASME ADDFORLIQUIDS
POOLBOIL

MECHANICAL AIDS - POOL BOILING

GALLOWAY;J.E. MUDAWAR;I.
"CRITICAL HEAT FLUX ENHANCEMENT BY MEANS OF LIQUID SUBCOOLING AND CENTRIFUGAL FORCE INDUCED BY FLOW CURVATURE"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.35, 1992, PP.1247-1260
093028 1992 IJHMT MECHAID
POOLBOIL

MURATA;Y. YAMAGUCHI;K. TANAKA;S.
TAMURA;K.
"DIRECT CONTACT HEAT TRANSFER IN A RECIPROCATING PLATE COLUMN"
HEAT TRANSFER - JAPANESE RESEARCH, VOL.9, 1980, NO.4, PP.11-18
093024 1980 HTJR MECHAID
POOLBOIL

PLEVYAK;T.J.
"IMPROVED BOILING HEAT TRANSFER WITH INDUCED BUBBLE MIXING"
AMERICAN SOCIETY OF MECHANICAL ENGINEERS PAPER NO. 68-WA/HT-29, 1968
093001 1968 ASME MECHAID
POOLBOIL

TANG;S.I. MC DONALD;T.W.
"A STUDY OF BOILING HEAT TRANSFER FROM A ROTATING HORIZONTAL CYLINDER"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL. 14, 1971, PP.1643-1658
093003 1971 IJHMT MECHAID
POOLBOIL 1FORCECONV

FLUID VIBRATIONS - POOL BOILING

DI CICCO;D.A. SCHOENHALS;R.J.
"HEAT TRANSFER IN FILM BOILING WITH PULSATING PRESSURES"
JOURNAL OF HEAT TRANSFER, VOL.86, 1964, PP.457-461
113005 1964 JHT FLUIDVIB
POOLBOIL

INOUE;A. BANKOFF;S.G.
"DESTABILIZATION OF FILM BOILING DUE TO ARRIVAL OF A PRESSURE"
JOURNAL OF HEAT TRANSFER, VOL.103, 1981, PP.459-464
113016 1981 JHT FLUIDVIB
POOLBOIL

PARK;K.-A. BERGLES;A.E.
"HEAT TRANSFER CHARACTERISTICS OF SIMULATED MICROELECTRONIC CHIPS UNDER NORMAL AND ENHANCED CONDITIONS"
HEAT TRANSFER LABORATORY REPORT NO. HTL-35, ISU-ERI-AMES-86211, IOWA STATE UNIVERSITY, AMES, IA, 1985
013221 1985 ISU TREATSURF
POOLBOIL FLUIDVIB

ELECTRIC OR MAGNETIC FIELDS - POOL BOILING

ALLEN;P.H.G. COOPER;P.
"THE POTENTIAL OF ELECTRICALLY ENHANCED EVAPORATORS"
THIRD INTERNATIONAL SYMPOSIUM ON THE LARGE SCALE APPLICATIONS OF HEAT PUMPS, OXFORD, ENGLAND, 1987, PP.221-229
143009 1987 ** COMPOUNDTECH ELECTROFIELD EXTENDEDSURF POOLBOIL

ALLEN;P.H.G.
"HEAT TRANSFER ENHANCEMENT BY DIELECTROPHORESIS"
SECOND UK NATIONAL CONFERENCE ON HEAT TRANSFER, GLASGOW, VOL.1, 1988, PP.861-870
000194 1988 IIUKNHTC LITSURVEY ELECTROFIELD CONDENSATION POOLBOIL

ARAJS;S. LEGVOLD;S.
"ELECTROCONVECTIONAL HEAT TRANSFER IN GASES"
JOURNAL OF CHEMICAL PHYSICS, VOL.29, NO.3, 1958, PP.531-536
121006 1958 ** ELECTROFIELD POOLBOIL CONDENSATION 1FORCECONV

ASCH;V. FOUST;A.S.
"THE EFFECT OF UNIFORM ELECTROSTATIC FIELDS ON BUBBLE BEHAVIOR AND BOILING HEAT TRANSFER IN FREON-113"
HEAT TRANSFER 1970, VOL.6, PAPER B8.12, ELSEVIER PUBLISHING COMPANY, AMSTERDAM, 1970
123022 1970 IVIHTC ELECTROFIELD POOLBOIL

BOLOGA;M.K. KOZHUKHAR;I.A. MARDARSKIY;O.I.
"HEAT TRANSFER IN A LIQUID FILM RESULTING FROM DISPERSION IN AN ELECTRIC FIELD"
HEAT TRANSFER-SOVIET RESEARCH, VOL.20, NO.5, 1988, PP.594-
123041 1988 HTSR ELECTROFIELD POOLBOIL

BONJOUR;E. VERDIER;J. WEIL;L.
"ELECTROCONVECTION EFFECTS ON HEAT TRANSFER"
CHEMICAL ENGINEERING PROGRESS, VOL.58, NO.7, 1962, PP.63-66
123002 1962 CEP ELECTROFIELD POOLBOIL

COOPER;P.
"EHD ENHANCEMENT OF NUCLEATE BOILING"
JOURNAL OF HEAT TRANSFER, VOL.112, 1990, PP.458-464
123038 1990 JHT ELECTROFIELD POOLBOIL

FUJII;M. HANASAKI;M. YASOJIMA;Y. YAMANAKA;G.
"BOILING HEAT TRANSFER AND ELECTRIC BREAKDOWN OF FLUOROCARBON C2CL3F3 AND C8F16O IN A UNIFORM ELECTRIC FIELD"
HEAT TRANSFER - JAPANESE RESEARCH, VOL.16, NO.4, 1987, PP.1-16
123042 1987 HTJR ELECTROFIELD POOLBOIL

JONES;T.B.
"AN ELECTROHYDRODYNAMIC HEAT PIPE"
AMERICAN SOCIETY OF MECHANICAL ENGINEERS PAPER NO. 72-WA/HT-35, 1972
125006 1972 ASME ELECTROFIELD CONDENSATION POOLBOIL

JONES;T.B. SCHAEFFER;R.C.
"ELECTROHYDRODYNAMICALLY COUPLED MINIMUM FILM BOILING IN DIELECTRIC LIQUIDS"
AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS PAPER NO. 75-690,1975
123020 1975 AIAA ELECTROFIELD POOLBOIL

JONES;T.B.
"ELECTROHYDRODYNAMICALLY COUPLED FILM BOILING"
AMERICAN SOCIETY OF MECHANICAL ENGINEERS PAPER NO.76-WA/HT-48,1976
123018 1976 ASME ELECTROFIELD POOLBOIL

JONES;T.B. HALLOCK;K.R.
"SURFACE WAVE MODEL OF ELECTROHYDRODYNAMICALLY COUPLED MINIMUM FILM BOILING"
JOURNAL OF ELECTROSTATICS, VOL.5, 1978, PP.273-284
123021 1978 ** ELECTROFIELD POOLBOIL

KLIMOV;S.M. BOLOGA;M.K. SMIRNOV;G.F.
"THE MECHANISM OF FORMATION AND SUPPRESSION OF DRY SPOTS DURING BOILING IN SLOTS IN THE PRESENCE OF AN ELECTRIC FIELD"
ELECTROCHEMISTRY IN INDUSTRIAL PROCESSING AND BIOLOGY, NO.5, 1980, PP.48-52
123029 1980 ** ELECTROFIELD POOLBOIL

KLIMOV;S.M. BOLOGA;M.K. SMIRNOV;G.F.
"THE MECHANISM AND INTERNAL CHARACTERISTICS OF THE BOILING IN HORIZONTAL SLOTS IN THE PRESENCE OF AN ELECTRIC FIELD"
ELECTROCHEMISTY IN INDUSTRIAL PROCESSING AND BIOLOGY, NO.1, 1980, PP.63-68
123031 1980 ** ELECTROFIELD POOLBOIL

LOVENGUTH;R.F. HANESIAN;D.
"BOILING HEAT TRANSFER IN THE PRESENCE OF NONUNIFORM, DIRECT CURRENT ELECTRIC FIELDS"
INDUSTRIAL AND ENGINEERING CHEMISTRY FUNDAMENTALS, VOL.10, NO.4, 1971, PP.570-576
123013 1971 ** ELECTROFIELD POOLBOIL

OHADI;M.M. PAPAR;R.A. KUMAR;A. ANSARI;A.I.
"SOME OBSERVATIONS ON EHD-ENHANCED BOILING OF R-123 IN THE PRESENCE OF OIL CONTAMINATION"
PROCEEDINGS OF THE ENGINEERING FOUNDATION CONFERENCE ON POOL AND EXTERNAL FLOW BOILING, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1992, PP.387-396
123047 1992 ASME ELECTROFIELD POOLBOIL

SERDITOV;V.N. KLIMOV;S.M. BOLOGA;M.K.
"THE ACTION OF ELECTRIC FIELD ON HEAT TRANSFER DURING BOILING IN VERTICAL SLOTS"
ELECTROCHEMISTRY IN INDUSTRIAL PROCESSING AND BIOLOGY, NO.5, 1981, PP.69-71
123033 1981 ** ELECTROFIELD POOLBOIL

UEMURA;M. NISHIO;S. TANASAWA;I.
"ENHANCEMENT OF POOL BOILING HEAT TRANSFER BY STATIC ELECTRIC FIELD"
HEAT TRANSFER 1990, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, VOL.4, 1990, PP.75-80
123040 1990 IXIHTC ELECTROFIELD POOLBOIL

YABE;A. IGUCHI;M. TAKETANI;T. KIKUCHI;K.
"AUGMENTATION MECHANISM OF BURNOUT HEAT FLUX BY APPLYING ELECTRIC FIELDS (1ST REPORT : LATENT HEAT FLUX AND ITS ENHANCEMENT BY ELECTRIC FIELDS)"
PROCEEDINGS OF THE 1987 ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE, VOL.4, JSME, TOKYO, AND ASME, NEW YORK, 1987, PP.417-424
123045 1987 ASME-JSME ELECTROFIELD POOLBOIL

YOKOYAMA;T. YAMAZAKI;T. KUBO;Y. OGATA;J. KAWADA;A. OOKI;Y.
"THE EFFECT OF AN ELECTRIC FIELD ON BOILING HEAT TRANSFER OF FLUOROCARBON R-11"
HEAT AND MASS TRANSFER IN REFRIGERATION AND CRYOGENICS, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, 1987, PP.140-151
143010 1987 ** COMPOUNDTECH ELECTROFIELD TREATSURF POOLBOIL

JET IMPINGEMENT - POOL BOILING

CHO;C.S.K. WU;K.
"COMPARISON OF BURNOUT CHARACTERISTICS IN JET IMPINGEMENT COOLING AND SPRAY COOLING"
ASME PROCEEDINGS OF THE 1988 NATIONAL HEAT TRANSFER CONFERENCE, HTD-96, VOL.1, ASME, NEW YORK, 1988, PP.561-567
173009 1988 ASME JETIMPINGE POOLBOIL

KATTO;Y. ISHII;K.
"BURNOUT IN A HIGH HEAT FLUX BOILING SYSTEM WITH A FORCED SUPPLY OF LIQUID THROUGH A PLANAR JET"
PROCEEDINGS OF SIXTH INTERNATIONAL HEAT TRANSFER CONFERENCE, VOL.1, 1978, PP.435-440
173017 1978 VIIHTC JETIMPINGE POOLBOIL

MA;C.F. BERGLES;A.E.
"BOILING JET IMPINGEMENT COOLING OF SIMULATED MICROELECTRONIC CHIPS"
HEAT TRANSFER IN ELECTRONIC EQUIPMENT-1983, HTD-VOL.28, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1983, PP.5-12
173007 1983 ASME JETIMPINGE POOLBOIL

MA;C.F. BERGLES;A.E.
"ENHANCEMENT OF IMMERSION COOLING OF MICROELECTRONIC DEVICES BY FOREIGN GAS JET IMPINGEMENT"
HEAT TRANSFER IN ELECTRONIC AND MICROELECTRONIC EQUIPMENT, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, 1990, PP.537-549
173004 1990 ** JETIMPINGE POOLBOIL 1NATCONV

MONDE;M. KATTO;Y.
"BURNOUT IN A HIGH HEAT FLUX BOILING SYSTEM WITH AN IMPINGING JET"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.21, 1978, PP.295-305
173018 1978 IJHMT JETIMPINGE POOLBOIL

MONDE;A. FURUKAWA;Y.
"CRITICAL HEAT FLUX IN SATURATED FORCED CONVECTIVE BOILING WIH AN IMPINGING JET COEXISTENCE OF POOL AND FORCED CONVECTIVE BOILINGS"
HEAT TRANSFER - JAPANESE RESEARCH, VOL.17, NO.5, 1988, PP.81-91
173008 1988 HTJR JETIMPINGE POOLBOIL FLOBOIL

MONDE;M. INOUE;T.
"CRITICAL HEAT FLUX IN SATURATED FORCED CONVECTIVE BOILING ON A HEATED DISK WITH MULTIPLE IMPINGING JETS"
JOURNAL OF HEAT TRANSFER, VOL.113, 1991, PP.722-727
173010 1991 JHT JETIMPINGE POOLBOIL

MUDAWAR;I. WADSWORTH;D.C.
"CRITICAL HEAT FLUX FROM A SIMULATED CHIP TO A CONFINED RECTANGULAR IMPINGING JET OF DIELECTRIC LIQUID"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.34, 1991, PP.1465-1479
173012 1991 IJHMT JETIMPINGE POOLBOIL

RUCH;M.A. HOLMAN;J.P.
"BOILING HEAT TRANSFER TO A FREON-113 JET IMPINGING UPWARD ONTO A FLAT HEATED SURFACE"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.10, 1975, PP.51-60
173019 1975 IJHMT JETIMPINGE POOLBOIL

YANG;N.S. SHEN;Z.Q.
"HEAT TRANSFER CHARACTERISTICS AND THE AUGMENTATION MECHANISM OF CARRYING GAS IMPINGEMENT ON MINUTE HEAT SOURCE IN LIQUID COOLANT BATH"
HEAT TRANSFER 1990, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, VOL.4, 1990, PP.45-50
173006 1990 IXIHTC JETIMPINGE

COMPOUND ENHANCEMENT - POOL BOILING

ALLEN;P.H.G. COOPER;P.
"THE POTENTIAL OF ELECTRICALLY ENHANCED EVAPORATORS"
THIRD INTERNATIONAL SYMPOSIUM ON THE LARGE SCALE
APPLICATIONS OF HEAT PUMPS, OXFORD, ENGLAND, 1987,
PP.221-229
143009 1987 ** COMPOUNDTECH
ELECTROFIELD EXTENDEDSURF POOLBOIL

MCMANUS;S.M. MARTO;P.J. WANNIARACHCHI;A.S.
"AN EVALUATION OF ENHANCED HEAT TRANSFER TUBING FOR USE
IN R-114 WATER CHILLERS"
HEAT TRANSFER IN AIR CONDITIONING AND REFRIGERATION
EQUIPMENT, HTD-VOL.65, ASME, NEW YORK, 1986, PP.11-19
013195 1986 ASME TREATSURF
POOLBOIL COMPOUNDTECH

NAKAYAMA;W. NAKAJIMA;T. HIRASAWA;S.
"HEAT SINK STUDS HAVING ENHANCED BOILING SURFACES FOR
COOLING OF MICROELECTRONIC COMPONENTS"
AMERICAN SOCIETY OF MECHANICAL ENGINEERS PAPER NO.
84-WA/HT-89, 1989
143008 1984 ASME COMPOUNDTECH
TREATSURF EXTENDEDSURF POOLBOIL

YOKOYAMA;T. YAMAZAKI;T. KUBO;Y.
OGATA;J. KAWADA;A. OOKI;Y.
"THE EFFECT OF AN ELECTRIC FIELD ON BOILING HEAT TRANSFER OF
FLUOROCARBON R-11"
HEAT AND MASS TRANSFER IN REFRIGERATION AND CRYOGENICS,
HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, 1987,
PP.140-151
143010 1987 ** COMPOUNDTECH
ELECTROFIELD TREATSURF POOLBOIL

PERFORMANCE EVALUATION - POOL BOILING

LORENZ;J.J. YUNG;D.
"AN EVALUATION OF THE COST-EFFECTIVENESS OF SURFACE ENHANCEMENTS FOR OTEC HEAT EXCHANGERS"
PROCEEDINGS OF THE SEVENTH OCEAN ENERGY CONFERENCE, CONF-800633, VOL.2, 1980, PP.12.3-1 - 12.3-8
150057 1980 ** PERFORMANCE
POOLBOIL CONDENSATION

PANCHAL;C.B. HILLIS;D.L. LORENZ;J.J. YUNG;D.T.
"OTEC PERFORMANCE TESTS OF THE TRANE PLATE-FIN HEAT EXCHANGER"
ARGONNE NATIONAL LABORATORY, REPORT NO. ANL/OTEC-PS-7, APRIL 1981.
150053 1981 ANL PERFORMANCE
EXTENDEDSURF POOLBOIL CONDENSATION

WEBB;R.L.
"PERFORMANCE, COST EFFECTIVENESS, AND WATER-SIDE FOULING CONSIDERATIONS OF ENHANCED TUBE HEAT EXCHANGERS FOR BOILING SERVICE WITH TUBE-SIDE WATER FLOW"
HEAT TRANSFER ENGINEERING, VOL.3, NOS.3-4, 1982, PP.84-98
150070 1982 HTE PERFORMANCE
TREATEDSURF POOLBOIL ROUGHSURF 1FORCECONV

LITERATURE SURVEYS - FLOW BOILING

BERGLES;A.E.
"SURVEY OF AUGMENTATION OF TWO-PHASE HEAT TRANSFER"
PREPRINTED AND PRESENTED AT ASHRAE SEMIANNUAL MEETING, DALLAS,1976,ASHRAE TRANSACTIONS,VOL.82,PT.1,1976,PP.891-905.
000053 1976 ASHRAET LITSURVEY
POOLBOIL FLOBOIL CONDENSATION

BERGLES;A.E.
"HEAT TRANSFER AUGMENTATION"
TWO-PHASE FLOW HEAT EXCHANGERS: THERMAL-HYDRAULIC FUNDAMENTALS AND DESIGN, KLUWER ACADEMIC PUBLISHERS, DORDRECHT, THE NETHERLANDS, 1988, PP.343-373
000161 1988 ** LITSURVEY
1FORCECONV POOLBOIL FLOBOIL CONDENSATION

CARNAVOS;T.C.
"SOME RECENT DEVELOPMENTS IN AUGMENTED HEAT EXCHANGE ELEMENTS"
HEAT EXCHANGERS: DESIGN AND THEORY SOURCE BOOK, SCRIPTA BOOK COMPANY, WASHINGTON, D.C. 1974, PP.441-489
000034 1972 ** LITSURVEY
ROUGHSURF FLOBOIL CONDENSATION MASSTRAN

JENSEN;M.K.
"ENHANCED FORCED CONVECTIVE VAPORIZATION AND CONDENSATION INSIDE TUBES"
HEAT TRANSFER EQUIPMENT DESIGN, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, 1988, PP.681-695
000193 1988 ** LITSURVEY
FLOBOIL CONDENSATION

LAL;S. VARMA;H.K. AGRAWAL;K.N.
"HEAT TRANSFER AND PRESSURE DROP WITH SWIRL FLOW"
PROCEEDINGS OF THE SECOND NATIONAL SYMPOSIUM ON REFRIGERATION AND AIR CONDITIONING, DEPARTMENT OF MECHANICAL ENGINEERING, UNIVERSITY OF ROORKEE, ROORKEE, INDIA, 1973, PP.119-127
000203 1973 ** LITSURVEY
FLOBOIL SWIRLFLO

NAKAYAMA;W.
"ENHANCEMENT OF HEAT TRANSFER"
HEAT TRANSFER 1982, VOL.1, HEMISPHERE PUBLISHING COMPANY, WASHINGTON, D.C., 1982, PP.223-240
000110 1982 VIIIHTC LITSURVEY
1FORCECONV POOLBOIL FLOBOIL CONDENSATION

ROTHFUS;R.R. LAVI;G.H.
"VERTICAL FALLING FILM HEAT TRANSFER: A LITERATURE SURVEY"
PROCEEDINGS OF THE FIFTH OCEAN THERMAL ENERGY CONVERSION CONFERENCE, VOL.3, 1978, PP.VI-90-VI-110
000069 1978 OTEC LITSURVEY
FLOBOIL

SCHLAGER;L.M. PATE;M.B. BERGLES;A.E.
"A SURVEY OF REFRIGERANT HEAT TRANSFER AND PRESSURE DROP EMPHASIZING OIL EFFECTS AND IN-TUBE AUGMENTATION"
ASHRAE TRANSACTIONS, VOL.93, PART 1, 1987, PP.392-416
000136 1987 ASHRAE LITSURVEY
FLOBOIL CONDENSATION

SCHLAGER;L.M. PATE;M.B. BERGLES;A.E.
"PERFORMANCE PREDICTIONS OF REFRIGERANT-OIL MIXTURES IN SMOOTH AND INTERNALLY FINNED TUBES-PART I: LITERATURE REVIEW"
ASHRAE TRANSACTIONS, VOL.96, PART 1, 1990, PP.160-169
000196 1990 ASHRAE LITSURVEY
FLOBOIL CONDENSATION

TAN;Y.-K.
"HEAT TRANSFER ENHANCEMENT WITH PHASE CHANGES RESEARCH AND DEVELOPMENT IN SOUTH CHINA UNIVERSITY OF TECHNOLOGY"
HEAT TRANSFER ENHANCEMENT AND ENERGY CONSERVATION, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, 1990, PP.297-304
000144 1990 ** LITSURVEY
FLOBOIL CONDENSATION

TAN;Y.K.
"SOME RECENT RESEARCHES AND DEVELOPMENTS ON HEAT TRANSFER ENHANCEMENT OF ORGANIC COMPOUNDS WITH PHASE CHANGE"
SECOND INTERNATIONAL SYMPOSIUM ON MULTIPHASE FLOW AND HEAT TRANSFER, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, VOL.1, 1989, PP.613-620
000208 1989 ** LITSURVEY
FLOBOIL CONDENSATION

TREATED SURFACES - FLOW BOILING

BERGLES;A.E. BAKHRU;N. SHIRES JR.;J.W.
"COOLING OF HIGH-POWER-DENSITY COMPUTER COMPONENTS"
MASSACHUSETTS INSTITUTE OF TECHNOLOGY ENGINEERING PROJECTS LABORATORY REPORT 70712-60, 1968
013025 1968 MIT TREATSURF POOLBOIL FLOBOIL

DANILOVA;G.N. GUYGO;E.I. BORISHANSKAYA;A.V. BUKIN;V.G. DYUNDIN;V.A. KOZYREV;A.A. MALKOV;L.S. MALYUGIN;G.I.
"ENHANCEMENT OF HEAT TRANSFER DURING BOILING OF LIQUID REFRIGERANTS AT LOW HEAT FLUXES"
HEAT TRANSFER - SOVIET RESEARCH, VOL.8, NO.4, 1976, PP.1-8
013060 1976 HTSR TREATSURF ROUGHSURF POOLBOIL FLOBOIL

DANILOVA;G.N. DYUNDIN;V.A. BORISHANSKAYA;A.V. SOLOVIYOV;A.G. VOL'NYKH;Y.A. KOZYREV;A.A.
"EFFECT OF SURFACE CONDITIONS ON BOILING HEAT TRANSFER OF REFRIGERANTS IN SHELL-AND-TUBE EVAPORATORS"
HEAT TRANSFER - SOVIET RESEARCH, VOL.22, NO.1, 1990, PP.56-65
014027 1990 HTSR TREATSURF FLOBOIL

DANILOVA;G.N. DUNDIN;V.A. SOLOVEYOV;A.G. TIKHONOV;A.V.
"EXPERIMENTAL STUDY ON REFRIGERATION BOILING HEAT TRANSFER OUTSIDE TUBES IN THE BUNDLES"
EXPERIMENTAL HEAT TRANSFER, FLUID MECHANICS, AND THERMODYNAMICS 1991, ELSEVIER SCIENCE PUBLISHING, NEW YORK, 1991, PP.1401-1406
014026 1991 IIWCEHTFMT TREATSURF ROUGHSURF FLOBOIL

DYUNDIN;V.A. SOLOV'YEV;A.G. BORISHANSKAYA;A.V. VOL'NYKH;YU.A.
"EFFECT OF THE KIND OF SURFACE ROUGHNESS ON THE HEAT TRANSFER CORFFICIENT IN BOILING OF REFRIGERANTS"
HEAT TRANSFER-SOVIET RESEARCH, VOL.16, N0.1, 1984, PP. 53-58
013197 1984 HTSR TREATSURF POOLBOIL ROUGHSURF FLOBOIL

DYUNDIN;V.A. DANILOVA;G.N. VOL'NYKH;Y.A. TOVARAS;N.V.
"SURFACE OF INTENSIVE HEAT TRANSFER FOR TUBE-IN-SHELL EVAPORATORS"
THERMAL ENGINEERING, VOL.37, NO.12, 1990, PP.632-636
014029 1990 TENG TREATSURF FLOBOIL

FAGERHOLM;N.-E. GHAZANFARI;A.-R. JAERVINEN;E. JARVINEN;E.
"BOILING HEAT TRANSFER PERFORMANCE OF PLAIN AND POROUS TUBES IN FALLING FILM FLOW OF REFRIGERANT R114"
WAERME- UND STOFFUEBERTRAGUNG, VOL.21, 1987, PP.343-353
014017 1987 ** TREATSURF FLOBOIL

FUJITA;Y.
"ENHANCEMENT AND PERFORMANCE LIMIT FOR BOILING AND EVAPORATION HEAT TRANSFER IN HEAT EXCHANGERS"
RESEARCH ON EFFECTIVE USE OF THERMAL ENERGY, REPORT OF SPECIAL PROJECTS, SPEY 23, MINISTRY OF EDUCATION, SCIENCE, AND CULTURE, JAPAN, 1987, PP.27-32
014030 1987 SPEY TREATSURF FLOBOIL

GOTTZMANN;C.F. O'NEILL;P.S. MINTON;P.E.
"HIGH EFFICIENCY HEAT EXCHANGERS"
CHEMICAL ENGINEERING PROGRESS, VOL.69, NO.7, 1973, PP.69-75
013044 1973 CEP TREATSURF EXTENDEDSURF POOLBOIL FLOBOIL

IKEUCHI;M. YUMIKURA;T. FUJII;M. YAMANAKA;G.
"HEAT-TRANSFER CHARACTERISTICS OF AN INTERNAL MICROPOROUS TUBE WITH REFRIGERANT 22 UNDER EVAPORATING CONDITIONS"
ASHRAE TRANSACTIONS, VOL.90, PART 1A, 1984, PP.196-211
014019 1984 ASHRAE TREATSURF FLOBOIL

JENSEN;M.K. TREWIN;R.R. BERGLES;A.E.
"CROSSFLOW BOILING IN ENHANCED TUBE BUNDLES"
TWO-PHASE FLOW IN ENERGY EXCHANGE SYSTEMS, HTD VOL.220, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1992, PP.11-17
014031 1992 ASME TREATSURF FLOBOIL

JENSEN;M.K. TREWIN;R.R. BERGLES;A.E.
"CROSSFLOW BOILING IN ENHANCED TUBE BUNDLES"
PROCEEDINGS OF THE ENGINEERING FOUNDATION CONFERENCE ON POOL AND EXTERNAL FLOW BOILING, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1992, PP.373-379
014032 1992 ASME TREATSURF FLOBOIL

KUWAHARA;H. YASUKAWA;A. NAKAYAMA;W. YANAGIDA;T.
"EVAPORATIVE HEAT TRANSFER FROM HORIZONTAL ENHANCED TUBES IN THIN FILM FLOW"
HEAT TRANSFER - JAPANESE RESEARCH, VOL.19, NO.3, 1990, PP.83-97
014025 1990 HTJR TREATSURF FLOBOIL

LIN;Z.H. VEZIROGLU;T.N. KAKAC;S. GUERGENCI;H. MENTES;A.
"HEAT TRANSFER IN OSCILLATING TWO-PHASE FLOWS AND EFFECT OF HEATER SURFACE CONDITIONS"
HEAT TRANSFER 1982, VOL.5, HEMISPHERE PUBLISHING COMPANY, WASHINGTON, D.C., 1982, PP.331-336
014011 1982 VIIIHTC TREATSURF FLOBOIL

MENTES;A. YILDIRIM;O.T. FU;L.Q. KAKAC;S. VEZIROGLU;T.N.
"EXPERIMENTAL INVESTIGATION OF BOILING FLOW INSTABILITIES WITH HEAT TRANSFER ENHANCEMENT"
PROCEEDINGS OF CONDENSED PAPERS OF THE THIRD MULTI-PHASE FLOW AND HEAT TRANSFER SYMPOSIUM-WORKSHOP, MIAMI BEACH, FLORIDA, APRIL 1983, P.156
024045 1983 ** ROUGHSURF TREATSURF DISPENHDEVICE FLOBOIL

MENTES;A. KAKAC;S. VEZIROGLU;T.N. ZHANG;H.Y.
"EFFECT OF INLET SUBCOOLING ON TWO-PHASE FLOW OSCILLATIONS IN A VERTICAL BOILING CHANNEL"
WAERME- UND STOFFUEBERTRAGUNG, VOL.24, 1989, PP.25-36
014018 1989 ** TREATSURF FLOBOIL ROUGHSURF

MENTES;A. KAKAC;S. VEZIROGLU;T.N. ZHANG;H.Y. CHEN;X.J. LIN;Z.H.
"TWO-PHASE FLOW BOILING INSTABILITIES AND OSCILLATION THRESHOLDS IN A VERTICAL SINGLE CHANNEL WITH HEAT TRANSFER ENHANCEMENT"
HEAT TRANSFER ENHANCEMENT AND ENERGY CONSERVATION, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, 1990, PP.407-415
014020 1990 ** TREATSURF FLOBOIL ROUGHSURF

MURPHY;R.W. BERGLES;A.E.
"SUBCOOLED FLOW BOILING OF FLUOROCARBONS"
MASSACHUSETTS INSTITUTE OF TECHNOLOGY ENGINEERING PROJECTS LABORATORY REPORT DSR NO. 71903-73, 1971
014003 1971 MIT TREATSURF FLOBOIL

MURPHY;R.W. BERGLES;A.E.
"SUBCOOLED FLOW BOILING OF FLUOROCARBONS--HYSTERESIS AND DISSOLVED GAS EFFECTS ON HEAT TRANSFER"
PROCEEDINGS OF THE 1972 HEAT TRANSFER AND FLUID MECHANICS INSTITUTE, STANFORD UNIVERSITY PRESS, 1972, PP.400-416
014004 1972 HTFMI TREATSURF FLOBOIL

NAKAOKA;T. UEHARA;H.

"PERFORMANCE TEST OF A SHELL-AND-PLATE TYPE EVAPORATOR FOR OTEC"
EXPERIMENTAL THERMAL AND FLUID SCIENCE, VOL.1, 1988, PP.283-291
144006 1988 ETFS COMPOUNDTECH
FLOBOIL TREATSURF ROUGHSURF 1FORCECONV

PANCHAL;C.B. HILLIS;D.L. THOMAS;A.
"CONVECTIVE BOILING OF AMMONIA AND FREON 22 IN PLATE HEAT EXCHANGERS"
ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE PROCEEDINGS, HONOLULU, HAWAII, MARCH 1983, VOL.2, PP.261-268
014012 1983 ** TREATSURF
FLOBOIL

TAN;Y. WANG;G. WANG;S.
CUI;N.
"AN EXPERIMENTAL RESEARCH OF SPRAY FALLING FILM BOILING ON THE SECOND GENERATION MECHANICALLY MADE POROUS SURFACE TUBES"
HEAT TRANSFER 1990, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, VOL.6, 1990, PP.269-274
014023 1990 IXIHTC TREATSURF
FLOBOIL

WANG;G. TAN;Y. WANG;S.
CUI;N.
"A STUDY OF SPRAY FALLING FILM BOILING ON HORIZONTAL MECHANICALLY MADE POROUS SURFACE TUBES"
HEAT TRANSFER ENHANCEMENT AND ENERGY CONSERVATION, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, 1990, PP.425-432
014021 1990 ** TREATSURF
FLOBOIL

WEBB;R.L. APPARAO;T.V.V.R.
"PERFORMANCE OF FLOODED REFRIGERANT EVAPORATORS WITH ENHANCED TUBES"
HEAT TRANSFER ENGINEERING, VOL.11, NO.2, 1990, PP.29-43
150098 1990 HTE PERFORMANCE
EXTENDEDSURF TREATSURF FLOBOIL

ROUGH SURFACES - FLOW BOILING

BRYAN;W.L. QUAINT;G.W.
"HEAT TRANSFER COEFFICIENTS IN HORIZONTAL TUBE EVAPORATORS"
REFRIGERATING ENGINEERING, VOL.59, NO.1, 1951, PP.67-72
024002 1951 ** ROUGHSURF
FLOBOIL

BRYAN;W.L. SEIGEL;L.G.
"HEAT TRANSFER COEFFICIENTS IN HORIZONTAL TUBE EVAPORATORS"
REFRIGERATING ENGINEERING, VOL.63, NO.5, 1955, PP.36-45, 120
024003 1955 ** ROUGHSURF
FLOBOIL

CARNAVOS;T.C.
"SOME RECENT DEVELOPMENTS IN AUGMENTED HEAT EXCHANGE ELEMENTS"
HEAT EXCHANGERS: DESIGN AND THEORY SOURCE BOOK, SCRIPTA BOOK COMPANY, WASHINGTON, D.C. 1974, PP.441-489
000034 1972 ** LITSURVEY
ROUGHSURF FLOBOIL CONDENSATION MASSTRAN

COHEN;M. CAREY;V.P.
"A COMPARISON OF THE FLOW BOILING PERFORMANCE CHARACTERISTICS OF PARTIALLY-HEATED CROSS-RIBBED CHANNELS WITH DIFFERENT RIB GEOMETRIES"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.32, NO.12, 1989, PP.2459-2474
024049 1989 IJHMT ROUGHSURF
FLOBOIL

DANILOVA;G.N. DUNDIN;V.A. SOLOVEYOV;A.G.
TIKHONOV;A.V.
"EXPERIMENTAL STUDY ON REFRIGERATION BOILING HEAT TRANSFER OUTSIDE TUBES IN THE BUNDLES"
EXPERIMENTAL HEAT TRANSFER, FLUID MECHANICS, AND THERMODYNAMICS 1991, ELSEVIER SCIENCE PUBLISHING, NEW YORK, 1991, PP.1401-1406
014026 1991 IIWCEHTFMT TREATSURF
ROUGHSURF FLOBOIL

DANILOVA;G.N. GUYGO;E.I. BORISHANSKAYA;A.V.
BUKIN;V.G. DYUNDIN;V.A. KOZYREV;A.A.
MALKOV;L.S. MALYUGIN;G.I.
"ENHANCEMENT OF HEAT TRANSFER DURING BOILING OF LIQUID REFRIGERANTS AT LOW HEAT FLUXES"
HEAT TRANSFER - SOVIET RESEARCH, VOL.8, NO.4, 1976, PP.1-8
013060 1976 HTSR TREATSURF
ROUGHSURF POOLBOIL FLOBOIL

DYUNDIN;V.A. SOLOV'YEV;A.G. BORISHANSKAYA;A.V.
VOL'NYKH;YU.A.
"EFFECT OF THE KIND OF SURFACE ROUGHNESS ON THE HEAT TRANSFER CORFFICIENT IN BOILING OF REFRIGERANTS"
HEAT TRANSFER-SOVIET RESEARCH, VOL.16, NO.1, 1984, PP. 53-58
013197 1984 HTSR TREATSURF
POOLBOIL ROUGHSURF FLOBOIL

DEMBI;N.J. DHAR;P.L. ARORA;C.P.
"AN INVESTIGATION INTO THE USE OF WIRE SCREENS IN DX-EVAPORATORS"
PAPER B1-25 PRESENTED AT 15TH INTERNATIONAL CONGRESS OF REFRIGERATION, VENICE, ITALY, SEPTEMBER 1979
024039 1979 ** ROUGHSURF
FLOBOIL

HINTON;D.L. CONKLIN;J.C. VINEYARD;E.A.
"EVAPORATION OF AN R143A AND R124 NARM INSIDE SMOOTH AND CORRUGATED TUBES"
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, PAPER NO. 92-WA/HT-5, 1992
024071 1992 ASME ROUGHSURF
FLOBOIL

HINTON;D.L. CONKLIN;J.C. VINEYARD;E.A.
"EVAPORATION CHARACTERISTICS OF R22 FLOWING INSIDE A CORRUGATED TUBE"
ENHANCED HEAT TRANSFER, HTD VOL.202, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1992, PP.127-132
024075 1992 ASME ROUGHSURF
FLOBOIL

ITO;M. KIMURA;H.
"BOILING HEAT TRANSFER AND PRESSURE DROP IN INTERNAL SPIRAL-GROOVED TUBES"
BULLETIN OF THE JAPAN SOCIETY OF MECHANICAL ENGINEERS, VOL. 22, 1979, PP.1251-1257.
024029 1979 BJSME ROUGHSURF
FLOBOIL

KANDLIKAR;S.G.
"A MODEL FOR CORRELATING FLOW BOILING HEAT TRANSFER IN AUGMENTED TUBES AND COMPACT EVAPORATORS"
JOURNAL OF HEAT TRANSFER, VOL.113, 1991, PP.966-972
024073 1991 JHT ROUGHSURF
FLOBOIL

KAWAI;S. YAMADA;H.
"EXPERIMENTAL INVESTIGATION OF THE HEAT TRANSFER CHARACTERISTICS OF CORRUGATED TUBES FOR TUBE SIDE BOILING OF REFRIGERANTS"
REFRIGERATION, VOL.52, 1977, PP.449-456
024032 1977 ** ROUGHSURF
FLOBOIL

KOEHLER;W. KASTNER;W.
"POST-CHF HEAT TRANSFER IN BOILER TUBES"
TWO-PHASE FLOW HEAT EXCHANGERS: THERMAL-HYDRAULIC FUNDAMENTALS AND DESIGN, KLUWER ACADEMIC PUBLISHERS, DORDRECHT, THE NETHERLANDS, 1988, PP.553-574
024057 1988 ** ROUGHSURF
FLOBOIL

LARSON;R.L. QUAINT;G.W. BRYAN;W.L.
"EFFECTS OF TURBULENCE PROMOTERS IN REFRIGERANT EVAPORATOR COILS"
REFRIGERATING ENGINEERING, VOL.57, 1949, PP.1193-1195
024001 1949 ** ROUGHSURF
FLOBOIL

LOVICH;M.A. CAREY;V.P.
"ASSESSMENT OF THE COMBINED PRESSURE DROP AND HEAT TRANSFER PERFORMANCE OF A CROSS-RIBBED CHANNEL GEOMETRY IN A COMPACT EVAPORATOR COLD PLATE"
HEAT TRANSFER 1990, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, VOL.5, 1990, PP.27-32
024055 1990 IXIHTC ROUGHSURF
FLOBOIL

MENTES;A. YILDIRIM;O.T. FU;L.Q.
KAKAC;S. VEZIROGLU;T.N.
"EXPERIMENTAL INVESTIGATION OF BOILING FLOW INSTABILITIES WITH HEAT TRANSFER ENHANCEMENT"
PROCEEDINGS OF CONDENSED PAPERS OF THE THIRD MULTI-PHASE FLOW AND HEAT TRANSFER SYMPOSIUM-WORKSHOP, MIAMI BEACH, FLORIDA, APRIL 1983, P.156
024045 1983 ** ROUGHSURF
TREATSURF DISPENHDEVICE FLOBOIL

MENTES;A. YILDIRIN;O.T. GUERGENCI;H.
KAKAC;S. VEZIROGLU;T.N.
"EFFECT OF HEAT TRANSFER AUGMENTATION TWO-PHASE FLOW INSTABILITIES IN A VERTICAL BOILING CHANNEL"
WAERME-UND STOFFUEBERTRAGUNG, VOL.17, 1983, PP.161-169
024046 1983 ** ROUGHSURF
FLOBOIL

MENTES;A. KAKAC;S. VEZIROGLU;T.N.
ZHANG;H.Y.
"EFFECT OF INLET SUBCOOLING ON TWO-PHASE FLOW OSCILLATIONS IN A VERTICAL BOILING CHANNEL"
WAERME- UND STOFFUEBERTRAGUNG, VOL.24, 1989, PP.25-36
014018 1989 ** TREATSURF
FLOBOIL ROUGHSURF

MENTES;A. KAKAC;S. VEZIROGLU;T.N.
ZHANG;H.Y. CHEN;X.J. LIN;Z.H.
"TWO-PHASE FLOW BOILING INSTABILITIES AND OSCILLATION THRESHOLDS IN A VERTICAL SINGLE CHANNEL WITH HEAT TRANSFER ENHANCEMENT"
HEAT TRANSFER ENHANCEMENT AND ENERGY CONSERVATION, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, 1990, PP.407-415

014020 1990 ** TREATSURF
FLOBOIL ROUGHSURF

NAKAOKA;T. UEHARA;H.
"PERFORMANCE TEST OF A SHELL-AND-PLATE TYPE EVAPORATOR FOR OTEC"
EXPERIMENTAL THERMAL AND FLUID SCIENCE, VOL.1, 1988, PP.283-291
144006 1988 ETFS COMPOUNDTECH
FLOBOIL TREATSURF ROUGHSURF 1FORCECONV

OHARA;T. YAMAMOTO;T. MATSUZAKI;K.
"EXPERIMENTAL STUDY ON BOILING HEAT TRANSFER IN RIB-ROUGHENED FLAT TUBES FOR AN EVAPORATOR (WALL TEMPERATURE DISTRIBUTION IN VERTICAL CHANNELS WITH A SHARP 180-DEGREE TURN)"
HEAT TRANSFER - JAPANESE RESEARCH, VOL.19, NO.3, 1990, PP.52-67
024063 1990 HTJR ROUGHSURF
FLOBOIL

OHARA;T. YAMAMOTO;T. FUJITA;H.
"HEAT TRANSFER AND PRESSURE DROP OF BOILING FLOW IN A CROSS-RIBBED FLAT CHANNEL"
INTERNATIONAL COMMUNICATIONS IN HEAT AND MASS TRANSFER, VOL.17, 1990, PP.555-566
024064 1990 ICHMT ROUGHSURF
FLOBOIL

OHARA;T. YAMAMOTO;T. MATSUZAKI;K.
"EXPERIMENTAL STUDY ON BOILING HEAT TRANSFER IN RIB-ROUGHENED FLAT TUBES FOR AN EVAPORATOR (WALL TEMPERATURE DISTRIBUTION IN VERTICAL CHANNELS WITH A SHARP 180-DEGREE TURN)"
HEAT TRANSFER - JAPANESE RESEARCH, VOL.19, NO.3, 1990, PP.52-67
024074 1990 HTJR ROUGHSURF
FLOBOIL

OHARA;T. YAMAMOTO;T. FUJITA;H.
"EVAPORATIVE HEAT TRANSFER AND PRESSURE DROP IN A RIB-ROUGHENED FLAT CHANNEL (EFFECTS OF HEIGHT AND SPACING OF REPEATED TRANSVERSE RIB ROUGHNESS)"
PROCEEDINGS OF THE 1991 ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE, VOL.4, JSME, TOKYO, AND ASME, NEW YORK, 1991, PP.399-406
024077 1991 ASME-JSME ROUGHSURF
FLOBOIL

SHOLLENBERGER;K. CAREY;V.P. TERVO;P.
"ONSET OF DRYOUT AND POST-DRYOUT HEAT TRANSFER IN ENHANCED PASSAGE GEOMETRIES FOR COMPACT EVAPORATORS"
TWO-PHASE FLOW AND HEAT TRANSFER, HTD VOL. 197, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1992, PP.83-91
024072 1992 ASME ROUGHSURF
EXTENDEDSURF FLOBOIL

TOJO;S. HOSOKAWA;K. ARIMOTO;T.
YAMADA;H. OHTA;Y.
"PERFORMANCE CHARACTERISTICS OF MULTI-GROOVED TUBES FOR AIR CONDITIONERS"
AUSTRALIAN REFRIGERATION, AIR CONDITIONING AND HEATING, AUGUST, 1984, PP.45-
025059 1984 ** ROUGHSURF
CONDENSATION FLOBOIL

WITHERS;J.G. HABDAS;E.P.
"HEAT TRANSFER CHARACTERISTICS OF HELICAL CORRUGATED TUBES FOR INTUBE BOILING OF REFRIGERANT R-12"
AMERICAN INSTITUTE OF CHEMICAL ENGINEERS SYMPOSIUM SERIES NO.138, VOL.70, 1974, PP.98-106
024017 1973 AICHE ROUGHSURF
FLOBOIL

YOSHIDA;S. MATSUNAGA;T. -HONG;H.P.
"HEAT TRANSFER TO REFRIGERANTS IN HORIZONTAL EVAPORATOR-TUBES WITH INTERNAL, SPIRAL GROOVES"
PROCEEDINGS OF THE 1987 ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE, VOL.5, JSME, TOKYO, AND ASME, NEW YORK, 1987, PP.165-172
024069 1987 ASME-JSME ROUGHSURF
FLOBOIL

YOSHIDA;S. MATSUNAGA;T.
"INFLUENCE OF OIL ON HEAT TRANSFER TO REFRIGERANT FLOWING IN A HORIZONTAL, SPIRALLY GROOVED EVAPORATOR TUBE"
PROCEEDINGS OF THE 1991 ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE, VOL.2, JSME, TOKYO, AND ASME, NEW YORK, 1991, PP.327-332
024076 1991 ASME-JSME ROUGHSURF
FLOBOIL

ZEMANEK;J.
"SOME POSSIBILITIES FOR ENHANCEMENT OF HEAT TRANSPORT IN HEAT TRANSFER SYSTEMS MADE OF LOW TEMPERATURE, GRAVITY-OPERATED HEAT PIPES"
ABSTRACT FROM THE SIXTH ALL-UNION HEAT AND MASS TRANSFER CONFERENCE, MINSK, USSR, 1980, HEAT TRANSFER - SOVIET RESEARCH, VOL.13, NO.6, 1981, P.132
024035 1981 HTSR ROUGHSURF
FLOBOIL CONDENSATION

EXTENDED SURFACES - FLOW BOILING

ANDERSON;J.H. ANDERSON,JR.;J.H.
"COMPACT HEAT EXCHANGERS FOR SEA THERMAL POWER PLANTS"
PROCEEDINGS FOURTH ANNUAL CONFERENCE ON OCEAN THERMAL ENERGY
CONVERSION, MARCH 1977, PP. VI-3 - VI-14.
150051 1977 ** PERFORMANCE
FLOBOIL EXTENDEDSURF

AZER;N.Z. SIVAKUMAR;V.
"ENHANCEMENT OF SATURATED BOILING HEAT TRANSFER BY INTERNALLY FINNED TUBES"
ASHRAE TRANSACTIONS, VOL.90, PART 1A, 1984, PP.58-73
034050 1984 ASHRAE EXTENDEDSURF
FLOBOIL

BOLING;C. DONOVAN;W.J. DECKER;A.S.
"HEAT TRANSFER OF EVAPORATING FREON WITH INNER FIN TUBING"
REFRIGERATING ENGINEERING, VOL.61, 1953, PP.1338-1340, 1384
034001 1953 ** EXTENDEDSURF
FLOBOIL

CAREY;V.P. SHAH;R.K.
"DESIGN OF COMPACT AND ENHANCED HEAT EXCHANGERS FOR LIQUID-VAPOR PHASE-CHANGE APPLICATIONS"
TWO-PHASE FLOW HEAT EXCHANGERS: THERMAL-HYDRAULIC FUNDAMENTALS AND DESIGN, KLUWER ACADEMIC PUBLISHERS, DORDRECHT, THE NETHERLANDS, 1988, PP.909-968
034060 1988 ** EXTENDEDSURF
SWIRLFLO FLOBOIL CONDENSATION

CHEN;C.C. LOH;J.V. WESTWATER;J.W.
"PREDICTION OF BOILING HEAT TRANSFER DUTY IN A COMPACT PLATE-FIN HEAT EXCHANGER USING THE IMPROVED LOCAL ASSUMPTION"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.24, 1981, PP.1907-1912
034035 1981 IJHMT EXTENDEDSURF
FLOBOIL

CHEN;C.C. WESTWATER;J.W.
"APPLICATION OF THE LOCAL ASSUMPTION FOR THE DESIGN OF COMPACT HEAT EXCHANGERS FOR BOILING HEAT TRANSFER"
ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE PROCEEDINGS, HONOLULU,HAWAII, MARCH 1983, VOL.1, PP.471-477
034041 1983 ** EXTENDEDSURF
FLOBOIL

CONKLIN;J.C. VINEYARD;E.A.
"TUBESIDE EVAPORATION OF NONAZEOTROPIC REFRIGERANT MIXTURES FROM TWO ENHANCED SURFACES"
AMERICAN SOCIETY OF MECHANICAL ENGINEERS PAPER NO. 90-WA/HT-8, 1990
034095 1990 ASME EXTENDEDSURF
FLOBOIL

CORNWELL;K. SCOONES;D.J.
"ANALYSIS OF LOW QUALITY BOILING ON PLAIN AND LOW-FINNED TUBE BUNDLES"
SECOND UK NATIONAL CONFERENCE ON HEAT TRANSFER, GLASGOW, VOL.1, 1988, PP.21-32
034074 1988 IIUKNHTC EXTENDEDSURF
FLOBOIL

CUI;S. TAN;Y. LU;Y.
"HEAT TRANSFER AND FLOW RESISTANCE OF R-502 FLOW BOILING INSIDE HORIZONTAL ISF TUBES"
SECOND INTERNATIONAL SYMPOSIUM ON MULTIPHASE FLOW AND HEAT TRANSFER, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, VOL.1, 1989, PP.662-670
034096 1989 ** EXTENDEDSURF
FLOBOIL

D'YACHKOV;F.N.
"INVESTIGATION OF HEAT TRANSFER AND HYDRAULICS FOR BOILING FREON-22 IN INTERNALLY FINNED TUBES"
HEAT TRANSFER - SOVIET RESEARCH, VOL.10, NO.2, 1978, PP. 10-19
034014 1978 HTSR EXTENDEDSURF
FLOBOIL

DITZLER;J.W.
"FORCED CONVECTION BOILING OF REFRIGERANTS IN AN INTERNALLY-FINNED HORIZONTAL TUBE"
M.S. THESIS, PURDUE UNIVERSITY, 1963
034002 1963 ** EXTENDEDSURF
FLOBOIL NHC

ECKELS;S.J. PATE;M.B.
"EVAPORATION AND CONDENSATION OF HFC-134A AND CFC-12 IN A SMOOTH AND A MICRO-FIN TUBE"
ASHRAE TRANSACTIONS, VOL.97, PART 2, 1991, PP.71-81
035251 1991 ASHRAE EXTENDEDSURF
CONDENSATION FLOBOIL

ECKELS;S.J. PATE;M.B. BEMISDERFER;C.H.
"EVAPORATION HEAT TRANSFER COEFFICIENTS FOR R-22 IN MICRO-FIN TUBES OF DIFFERENT CONFIGURATIONS"
ENHANCED HEAT TRANSFER, HTD VOL.202, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, 1992, PP.117-125
034078 1992 ASME EXTENDEDSURF
FLOBOIL

GATCHILOV;T.S. IVANOVA;V.S. KALTCHEV;K.I.
"INVESTIGATIONS ON THE INFLUENCE OF THE REFRIGERANT SUPPLY ON THE EFFICIENCY OF EXTENDED SURFACE AIR COOLERS"
HEAT AND MASS TRANSFER IN REFRIGERATION SYSTEMS AND IN AIR CONDITIONING, INTERNATIONAL INSTITUTE OF REFRIGERATION, PARIS, FRANCE, 1972, PP.365-372
034082 1972 ** EXTENDEDSURF
FLOBOIL

GOTTZMANN;C.F. O'NEILL;P.S. MINTON;P.E.
"HIGH EFFICIENCY HEAT EXCHANGERS"
CHEMICAL ENGINEERING PROGRESS, VOL.69, NO.7, 1973, PP.69-75
013044 1973 CEP TREATSURF
EXTENDEDSURF POOLBOIL FLOBOIL

GRIMLEY;T.A. MUDAWWAR;I. INCROPERA;F.P.
"ENHANCEMENT OF BOILING HEAT TRANSFER IN FALLING FILMS"
PROCEEDINGS OF THE 1987 ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE, VOL.3, JSME, TOKYO, AND ASME, NEW YORK, 1987, PP.411-418
034071 1987 ASME-JSME EXTENDEDSURF
FLOBOIL

GRIMLEY;T.A. MUDAWWAR;I. INCROPERA;F.P.
"CHF ENHANCEMENT IN FLOWING FLUOROCARBON LIQUID FILMS USING STRUCTURED SURFACES AND FLOW DEFLECTORS"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.31, NO.1, 1988, PP.55-65
034044 1988 IJHMT EXTENDEDSURF
FLOBOIL

GRIMLEY;T.A. MUDAWWAR;I. INCROPERA;F.P.
"LIMITS TO CRITICAL HEAT FLUX ENHANCEMENT IN A LIQUID FILM FALLING OVER A STRUCTURED SURFACE THAT SIMULATES A MICROELECTRONIC CHIP"
JOURNAL OF HEAT TRANSFER, VOL.110, 1988, PP.535-538
034046 1988 JHT EXTENDEDSURF
FLOBOIL

HEIMBACH;P.
"BOILING COEFFICIENTS OF REFRIGERANT-OIL-MIXTURES OUTSIDE A FINNED-TUBE BUNDLE"
HEAT AND MASS TRANSFER IN REFRIGERATION SYSTEMS AND IN AIR CONDITIONING, INTERNATIONAL INSTITUTE OF REFRIGERATION, PARIS, FRANCE, 1972, PP.117-125
034079 1972 ** EXTENDEDSURF
FLOBOIL

HOFMANN;E.
"EFFICIENCY OF DRY EXPANSION EVAPORATORS WITH BARE AND INSIDE-FINNED TUBES"
HEAT AND MASS TRANSFER IN REFRIGERATION SYSTEMS AND IN AIR CONDITIONING, INTERNATIONAL INSTITUTE OF REFRIGERATION, PARIS, FRANCE, 1972, PP.305-318
034081 1972 ** EXTENDEDSURF
FLOBOIL

ITO;M. KIMURA;H. SENSHU;T.
"DEVELOPMENT OF HIGH EFFICIENCY AIR-COOLED HEAT EXCHANGERS"
HITACHI REVIEW, VOL.20, 1977, PP.323-326
032194 1977 ** EXTENDEDSURF

1FORCECONV FLOBOIL

KHANPARA;J.C. BERGLES;A.E. PATE;M.B.
"AUGMENTATION OF R-113 IN-TUBE EVAPORATION WITH MICRO-FIN TUBES"
ASHRAE TRANSACTIONS, VOL.92, PART 2B, 1986, PP.506-524
034051 1986 ASHRAE EXTENDEDSURF FLOBOIL

KHANPARA;J.C. BERGLES;A.E. PATE;M.B.
"A COMPARISON OF IN-TUBE EVAPORATION OF REFRIGERANT 113 IN ELECTRICALLY HEATED AND FLUID HEATED SMOOTH AND INNER-FIN TUBES"
ADVANCES IN ENHANCED HEAT TRANSFER-1987, HTD-VOL.68, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1987, PP.35-45
034063 1987 ASME EXTENDEDSURF FLOBOIL

KHANPARA;J.C. PATE;M.B. BERGLES;A.E.
"LOCAL EVAPORATION HEAT TRANSFER IN A SMOOTH TUBE AND A MICRO-FIN TUBE USING REFRIGERANTS 22 AND 113"
BOILING AND CONDENSATION IN HEAT TRANSFER EQUIPMENT, HTD-VOL.84, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1987, PP.31-39
034070 1987 ASME EXTENDEDSURF FLOBOIL

KIMURA;H. ITO;M.
"EVAPORATING HEAT TRANSFER IN SPIRALLY GROOVED HORIZONTAL TUBES IN FLOW REGION"
BULLETIN OF THE JAPAN SOCIETY OF MECHANICAL ENGINEERS, VOL.24, 1981, PP.1602-1607
034036 1981 BJSME EXTENDEDSURF FLOBOIL

KUBANEK;G.R. MILETTI;D.L.
"EVAPORATIVE HEAT TRANSFER AND PRESSURE DROP PERFORMANCE OF FORCE-FIN TUBES WITH REFRIGERANT-22"
NORANDA RESEARCH CENTRE REPORT NO.340, POINTE CLAIRE, QUEBEC, CANADA, JULY 1976
034013 1976 ** EXTENDEDSURF FLOBOIL

KUBANEK;G.R. MILETTI;D.L.
"EVAPORATIVE HEAT TRANSFER AND PRESSURE DROP PERFORMANCE OF INTERNALLY-FINNED TUBES WITH REFRIGERANT 22"
JOURNAL OF HEAT TRANSFER, VOL.101, 1979, PP.447-452.
034025 1977 JHT EXTENDEDSURF FLOBOIL

LAVIN;J.G. YOUNG;E.H.
"HEAT TRANSFER TO EVAPORATING REFRIGERANTS IN TWO PHASE FLOW"
AMERICAN INSTITUTE OF CHEMICAL ENGINEERS JOURNAL, VOL.11, 1965, PP.1124-1132
034003 1964 AICHEJ EXTENDEDSURF FLOBOIL

MADDOX;D.E. MUDAWWAR;I.
"SINGLE AND TWO-PHASE CONVECTIVE HEAT TRANSFER FROM SMOOTH AND ENHANCED MICROELECTRONIC HEAT SOURCES IN A RECTANGULAR CHANNEL"
ASME PROCEEDINGS OF THE 1988 NATIONAL HEAT TRANSFER CONFERENCE, HTD-96, VOL.1, ASME, NEW YORK, 1988, PP.533-541
034066 1988 ASME EXTENDEDSURF FLOBOIL

MANDRUSIAK;G.D. CAREY;V.P.
"CONVECTIVE BOILING IN VERTICAL CHANNELS WITH DIFFERENT OFFSET STRIP FIN GEOMETRIES"
JOURNAL OF HEAT TRANSFER, VOL.111, 1989, PP.156-165
034073 1989 JHT EXTENDEDSURF FLOBOIL

MATHUR;G.D. MCDONALD;T.W.
"EVAPORATOR PERFORMANCE OF FINNED AIR-TO-AIR TWO-PHASE THERMOSIPHON LOOP HEAT EXCHANGERS"
ASHRAE TRANSACTIONS, VOL.93, PART 2, 1987, PP.247-257
034052 1987 ASHRAE EXTENDEDSURF FLOBOIL

MC GOWAN;J.G. HERONEMUS;W.E. BRAREN;R.
"DEVELOPMENT OF COMPACT HEAT EXCHANGERS FOR OCEAN THERMAL ENERGY CONVERSION (OTEC) SYSTEMS"
AMERICAN SOCIETY OF MECHANICAL ENGINEERS PAPER NO.78-WA/HT-34, 1978
034019 1978 ASME EXTENDEDSURF FLOBOIL CONDENSATION

MOSKVICHEVA;V.N. GOGONIN;I.I. DOROKHOV;A.R.
"HEAT EXCHANGE IN R-21 BOILING AND CONDENSATION"
HEAT EXCHANGE IN REFRIGERATING SYSTEMS, INTERNATIONAL INSTITUTE OF REFRIGERATION, PARIS, FRANCE, 1970, PP.259-268
034092 1970 ** EXTENDEDSURF FLOBOIL CONDENSATION

PANCHAL;C.B. FRANCE;D.M. BELL;K.J.
"EXPERIMENTAL INVESTIGATION OF SINGLE-PHASE, CONDENSATION, AND FLOW BOILING HEAT TRANSFER FOR A SPIRALLY FLUTED TUBE"
HEAT TRANSFER ENGINEERING, VOL.13, NO.1, 1992, PP.42-52
035238 1992 HTE EXTENDEDSURF CONDENSATION FLOBOIL

PANDOLFINI;P.P. KEIRSEY;J.L. FUNK;J.A. CUSICK;R.T.
"TESTS OF THE APL/JH6 FOLDED-TUBE, OTEC HEAT EXCHANGER CORE UNIT"
HEAT TRANSFER IN OCEAN THERMAL ENERGY (OTEC) SYSTEMS, HTD-VOL. 12, ASME, NEW YORK 1980, PP. 9-15.
034033 1980 ** EXTENDEDSURF FLOBOIL CONDENSATION

PANITSIDIS;H. GRESHAM;R.D. WESTWATER;J.W.
"BOILING OF LIQUIDS IN A COMPACT PLATE-FIN HEAT EXCHANGER"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.18, 1975, PP.37-42
034023 1975 IJHMT EXTENDEDSURF FLOBOIL

PATE;M.B.
"DESIGN CONSIDERATIONS FOR AIR-CONDITIONING EVAPORATOR AND CONDENSER COILS"
TWO-PHASE FLOW HEAT EXCHANGERS: THERMAL-HYDRAULIC FUNDAMENTALS AND DESIGN, KLUWER ACADEMIC PUBLISHERS, DORDRECHT, THE NETHERLANDS, 1988, PP.849-884
034059 1988 ** EXTENDEDSURF FLOBOIL CONDENSATION SWIRLFLO MASSTRAN

PEARSON;J.F. YOUNG;E.H.
"SIMULATED PERFORMANCE OF REFRIGERANT-22 BOILING INSIDE OF TUBES IN A FOUR TUBE PASS SHELL AND TUBE HEAT EXCHANGER"
CHEMICAL ENGINEERING PROGRESS SYMPOSIUM SERIES NO.102, VOL.66,1970,PP.164-173
034015 1970 CEPSS EXTENDEDSURF FLOBOIL

REID;R.S. PATE;M.B. BERGLES;A.E.
"A COMPARISON OF AUGMENTATION TECHNIQUES DURING IN-TUBE EVAPORATION OF R-113"
BOILING AND CONDENSATION IN HEAT TRANSFER EQUIPMENT, HTD-VOL.85, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1987, PP.21-30
034069 1987 ASME EXTENDEDSURF FLOBOIL SWIRLFLO

ROBERTSON;J.M. LOVEGROVE;P.C.
"BOILING HEAT TRANSFER WITH FREON 11 IN BRAZED-ALUMINIUM PLATE-FIN HEAT EXCHANGERS"
AMERICAN SOCIETY OF MECHANICAL ENGINEERS PAPER NO. 80-HT-58, 1980.
034028 1980 ASME EXTENDEDSURF FLOBOIL

ROBERTSON;J.M. LOVEGROVE;P.C.
"BOILING HEAT TRANSFER WITH FREON 11 (R11) IN BRAZED ALUMINUM, PLATE-FIN HEAT EXCHANGERS"
JOURNAL OF HEAT TRANSFER, VOL.105, 1983, PP.605-610
034048 1983 JHT EXTENDEDSURF FLOBOIL

RUBIN;I.R. DUL'KIN;I.N. ROIZEN;L.I.
"BURNOUT IN THE BOILING OF WATER AND FREON-113 ON TUBES WITH ANNULAR FINS"
HIGH TEMPERATURE, VOL.23, NO.5, 1985, PP.739-742
034080 1985 ** EXTENDEDSURF FLOBOIL

SAMI;S.M. DUONG;T.N.
"EXPERIMENTAL STUDY OF THE HEAT TRANSFER CHARACTERISTICS OF REFRIGERANT MIXTURE R-22/R-114 IN THE ANNULUS OF ENHANCED SURFACE TUBING"
INTERNATIONAL COMMUNICATIONS IN HEAT AND MASS TRANSFER, VOL.18, 1991, PP.547-558
034077 1991 ICHMT EXTENDEDSURF FLOBOIL

SAMI;S.M. DUONG;T.N.
"FLOW BOILING CHARACTERISTICS OF REFRIGERANT MIXTURE R22/R114 IN THE ANNULUS OF ENHANCED SURFACE TUBING"
INTERNATIONAL JOURNAL OF ENERGY RESEARCH, VOL.16, 1992, PP.241-252
034076 1992 IJER EXTENDEDSURF FLOBOIL

SAMI;S.M. SCHNOTALE;J.
"FORCED CONVECTIVE BOILING OF NONAZEOTROPIC REFRIGERANT MIXTURES INSIDE ENHANCED SURFACE TUBING"
INTERNATIONAL JOURNAL OF ENERGY RESEARCH, VOL.16, 1992, PP.637-651
034083 1992 IJER EXTENDEDSURF FLOBOIL

SAMI;S.M. DUONG;T.N. SNELSON;W.K.
"TWO PHASE BOILING CHARACTERISTICS OF R-134A AND R-12 IN ANNULI OF ENHANCED SURFACE TUBING"
INTERNATIONAL COMMUNICATIONS IN HEAT AND MASS TRANSFER, VOL.19, 1992, PP.203-214
034088 1992 ICHMT EXTENDEDSURF FLOBOIL

SAMI;S.M. SCHNOTALE;J.
"COMPARATIVE STUDY OF TWO PHASE FLOW BOILING OF REFRIGERANT MIXTURES AND PURE REFRIGERANTS INSIDE ENHANCED SURFACE TUBING"
INTERNATIONAL COMMUNICATIONS IN HEAT AND MASS TRANSFER, VOL.19, 1992, PP.137-148
034089 1992 ICHMT EXTENDEDSURF FLOBOIL

SAMI;S.M. DUONG;T.N.
"FLOW BOILING CHARACTERISTICS OF REFRIGERANT MIXTURE R-22/R-114 IN THE ANNULUS OF ENHANCED SURFACE TUBING"
HEAT RECOVERY SYSTEMS AND CHP, VOL.12, 1992, PP.39-48
034090 1992 HRS EXTENDEDSURF FLOBOIL

SCHLAGER;L.M. PATE;M.B. BERGLES;A.E.
"EVAPORATION AND CONDENSATION OF REFRIGERANT-OIL MIXTURES IN A SMOOTH TUBE AND A MICRO-FIN TUBE"
ASHRAE TRANSACTIONS, VOL.94, PART 1, 1988, PP.149-166
034053 1988 ASHRAE EXTENDEDSURF FLOBOIL CONDENSATION

SCHLAGER;L.M. PATE;M.B. BERGLES;A.E.
"EVAPORATION AND CONDENSATION OF REFRIGERANT-OIL MIXTURES IN A LOW-FIN TUBE"
ASHRAE TRANSACTIONS, VOL.94, PART 2, 1988, PP.1176-1194
034054 1988 ASHRAE EXTENDEDSURF FLOBOIL CONDENSATION

SCHLAGER;L.M. PATE;M.B. BERGLES;A.E.
"EVAPORATION AND CONDENSATION HEAT TRANSFER AND PRESSURE DROP IN HORIZONTAL, 12.7-MM MICRO-FIN TUBES WITH REFRIGERANT 22"
HEAT TRANSFER EQUIPMENT FUNDAMENTALS, DESIGN APPLICATIONS, AND OPERATING PROBLEMS, HTD-VOL.108, ASME, NEW YORK, 1989, PP.205-213
034067 1989 ASME EXTENDEDSURF FLOBOIL CONDENSATION

SCHLAGER;L.M. PATE;M.B. BERGLES;A.E.
"HEAT TRANSFER AND PRESSURE DROP PERFORMANCE OF SMOOTH AND INTERNALLY FINNED TUBES WITH OIL AND REFRIGERANT 22 MIXTURES"
ASHRAE TRANSACTIONS, VOL.95, PART 2, 1989, PP.375-385
150081 1989 ASHRAE PERFORMANCE EXTENDEDSURF FLOBOIL CONDENSATION

SCHLAGER;L.M. PATE;M.B. BERGLES;A.E.
"PERFORMANCE PREDICTIONS OF REFRIGERANT-OIL MIXTURES IN SMOOTH AND INTERNALLY FINNED TUBES - PART 2: DESIGN EQUATIONS"
ASHRAE TRANSACTIONS, VOL.96, PART 1, 1990, PP.170-182
034084 1990 ASHRAE EXTENDEDSURF FLOBOIL

SCHLAGER;L.M. PATE;M.B. BERGLES;A.E.
"EVAPORATION AND CONDENSATION HEAT TRANSFER AND PRESSURE DROP IN HORIZONTAL, 12.7-MM MICROFIN TUBES WITH REFRIGERANT 22"
JOURNAL OF HEAT TRANSFER, VOL.112, 1990, PP.1041-1047
035235 1990 JHT EXTENDEDSURF CONDENSATION FLOBOIL

SCHLAGER;L.M. PATE;M.B. BERGLES;A.E.
"OIL QUANTITY MEASUREMENTS IN SMOOTH AND MICRO-FIN TUBES DURING EVAPORATION AND CONDENSATION OF REFRIGERANT-OIL MIXTURES"
ASHRAE TRANSACTIONS, VOL.96, PART 2, 1990, PP.465-469
035252 1990 ASHRAE EXTENDEDSURF CONDENSATION FLOBOIL

SCHLUENDER;E.U. CHAWLA;J.M.
"OERTLICHER WAERMEUEBERGANG UND DRUCKABFALL BEI DER STROEMUNG VERDAMPFENDER KAELTEMITTEL IN INNENBERIPPTEN, WAAGERECHTEN ROHREN"
KAELTETECHNIK-KLIMATISIERUNG, VOL.21, NO.5, 1961, PP.136-139
034009 1961 ** EXTENDEDSURF FLOBOIL

SHINOHARA;Y. TOBE;M.
"DEVELOPMENT OF AN IMPROVED 'THERMOFIN TUBE'"
HITACHI CABLE REVIEW, NO.4, AUGUST 1985, PP.47-50
034068 1985 ** EXTENDEDSURF FLOBOIL CONDENSATION

SHOLLENBERGER;K. CAREY;V.P. TERVO;P.
"ONSET OF DRYOUT AND POST-DRYOUT HEAT TRANSFER IN ENHANCED PASSAGE GEOMETRIES FOR COMPACT EVAPORATORS"
TWO-PHASE FLOW AND HEAT TRANSFER, HTD VOL. 197, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1992, PP.83-91
024072 1992 ASME ROUGHSURF EXTENDEDSURF FLOBOIL

STAJIC;Z. MARKOSKI;M. HRNJAK;P.
"EXPERIMENTAL STUDY OF HEAT TRANSFER BETWEEN INSIDE EVAPORATING AND OUTSIDE CONDENSING R12 ON LOW EXTERNAL SPIRALLY FINNED TUBES"
PROCEEDINGS OF THE XVIII INTERNATIONAL CONGRESS OF REFRIGERATION, VOL.3, INTERNATIONAL INSTITUTE OF REFRIGERATION, PARIS, FRANCE, 1991, PP.1312-1315
035248 1991 ** EXTENDEDSURF CONDENSATION FLOBOIL

TAKAMATSU;H. MIYARA;A. KOYAMA;S.
FUJII;T. YONEMOTO;K.
"FORCED CONVECTIVE BOILING OF NONAZEOTROPIC REFRIGERANT MIXTURES OF R22 AND R114 INSIDE A HORIZONTAL TUBE"
HEAT TRANSFER - JAPANESE RESEARCH, VOL.19, NO.3, 1990, PP.68-82
034091 1990 HTJR EXTENDEDSURF FLOBOIL

UEKUSA;T. TOJO;S. KAWAI;S.
"EXPERIMENTAL STUDIES ON LOCAL EVAPORATING HEAT TRANSFER OF INTERNAL SPIRAL-GROOVED TUBE"
ABSTRACTED IN BULLETIN OF BJSME, VOL.28, 1985, PP.2818
034093 1985 BJSME EXTENDEDSURF FLOBOIL

WADEKAR;V.V.
"FLOW BOILING OF HEPTANE IN A PATE-FIN HEAT EXCHANGER

PASSAGE"
COMPACT HEAT EXCHANGERS FOR POWER AND PROCESS INDUSTRIES, HTD VOL.201, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1992, PP.1-6
034075 1992 ASME EXTENDEDSURF FLOBOIL

WEBB;R.L. APPARAO;T.V.V.R.
"PERFORMANCE OF FLOODED REFRIGERANT EVAPORATORS WITH ENHANCED TUBES"
HEAT TRANSFER ENGINEERING, VOL.11, NO.2, 1990, PP.29-43
150098 1990 HTE PERFORMANCE EXTENDEDSURF TREATSURF FLOBOIL

YUNG;D. LORENZ;J.J. PANCHAL;C.
"CONVECTIVE VAPORIZATION AND CONDENSATION IN SERRATED-FIN CHANNELS"
HEAT TRANSFER IN OCEAN THERMAL ENERGY (OTEC) SYSTEMS, HTD-VOL. 12, ASME, NEW YORK, 1980, PP. 29-37.
034034 1980 ** EXTENDEDSURF FLOBOIL CONDENSATION

ZHUANG;L. LU;Y. RUAN;Z.
XIE;Y. LIU;H.
"AN EXPERIMENTAL STUDY ON HEAT TRANSFER ENHANCEMENT OF FREON DRY EVAPORATOR"
HEAT TRANSFER ENHANCEMENT AND ENERGY CONSERVATION, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, 1990, PP.485-491
034055 1990 ** EXTENDEDSURF FLOBOIL

DISPLACED ENHANCEMENT DEVICES - FLOW BOILING

AZER;N.Z. LIN;S.T. FAN;L.T.
"AUGMENTATION OF FORCED FLOW BOILING HEAT TRANSFER WITH KENICS MOTIONLESS MIXERS"
INDUSTRIAL AND ENGINEERING CHEMISTRY PROCESS DESIGN AND DEVELOPMENT, VOL.19, NO.2, 1980, PP.246-250
042026 1980 ** DISPENHDEVICE
1FORCECONV FLOBOIL

CONKLIN;J.C. VINEYARD;E.A.
"FLOW BOILING ENHANCEMENT OF R-22 AND A NONAZEOTROPIC MIXTURE OF R-143A AND R-124 USING PERFORATED FOILS"
ASHRAE TRANSACTIONS, VOL.98, PART 2, 1992, PP.402-410
044010 1992 ASHRAE DISPENHDEVICE
FLOBOIL

FAN;L.T. LIN;S.T. AZER;N.Z.
"AUGMENTATION OF THE RATE OF FORCED FLOW BOILING HEAT TRANSFER BY MEANS OF IN-LINE STATIC MIXERS"
LETTERS IN HEAT AND MASS TRANSFER, VOL.4, NO.6, 1977
PP.425-428.
044003 1977 LHMT DISPENHDEVICE
FLOBOIL

LIN;S.
"AUGMENTATION OF TWO PHASE HEAT TRANSFER WITH IN-LINE STATIC MIXERS"
PH.D. DISSERTATION, KANSAS STATE UNIVERSITY, 1979.
044004 1979 ** DISPENHDEVICE
FLOBOIL 1FORCECONV CONDENSATION NHC

MENTES;A. YILDIRIM;O.T. FU;L.Q.
KAKAC;S. VEZIROGLU;T.N.
"EXPERIMENTAL INVESTIGATION OF BOILING FLOW INSTABILITIES WITH HEAT TRANSFER ENHANCEMENT"
PROCEEDINGS OF CONDENSED PAPERS OF THE THIRD MULTI-PHASE FLOW AND HEAT TRANSFER SYMPOSIUM-WORKSHOP, MIAMI BEACH, FLORIDA, APRIL 1983, P.156
024045 1983 ** ROUGHSURF
TREATSURF DISPENHDEVICE FLOBOIL

PALM;B.
"HEAT TRANSFER AUGMENTATION IN FLOW BOILING BY AID OF PERFORATED METAL FOILS"
AMERICAN SOCIETY OF MECHANICAL ENGINEERS PAPER NO.90-WA/HT-10
044011 1990 ASME DISPENHDEVICE
FLOBOIL NHC

PALM;B.
"ENHANCEMENT OF BOILING HEAT TRANSFER BY AID OF PERFORATED METAL FOILS"
PH.D. DISSERATATION, DEPARTMENT OF APPLIED THERMODYNAMICS AND REFRIGERATION, THE ROYAL INSTITUTE OF TECHNOLOGY, STOCKHLOM, SWEDEN.
044012 1991 ** DISPENHDEVICE
FLOBOIL NHC

ROMET'KO;R.S. PESKOV;O.L. GORBAN';L.M.
"HEAT EXCHANGE ENHANCEMENT IN STEAM GENERATING CHANNELS WITH LOCAL FLOW SPOILERS"
THERMAL ENGINEERING, VOL.31, NO.10, 1984, PP.564-567
044007 1984 TENG DISPENHDEVICE
FLOBOIL

SWIRL FLOW DEVICES - FLOW BOILING

AGARWAL;K.N. VARMA;H.K. LAL;S.
"BOILING OF R-12 UNDER SWIRL FLOW"
PROCEEDINGS FIFTH NATIONAL HEAT AND MASS TRANSFER CONFERENCE, HYDERABAD, INDIA, FEBRUARY 1980, PP.101-106
054063 1980 ** SWIRLFLO
FLOBOIL

AGRAWAL;K.N. VARMA;H.K. LAL;S.
"PRESSURE DROP DURING FORCED CONVECTION BOILING OF R-12 UNDER SWIRL FLOW"
JOURNAL OF HEAT TRANSFER, VOL.104, 1982, PP.758-762
054073 1982 JHT SWIRLFLO
FLOBOIL

AGRAWAL;K.N. VARMA;H.K. LAI;S.
"HEAT TRANSFER DURING FORCED CONVECTION BOILING OF R-12 UNDER SWIRL FLOW"
JOURNAL OF HEAT TRANSFER, VOL.108, 1986, PP.567-573
054078 1986 JHT SWIRLFLO
FLOBOIL

AGRAWAL;K.N. VARMA;H.K. LAL;S.
"A NEW GENERALISED CORRELATION FOR PREDICTING SWIRL FLOW PRESSURE DROPS IN A HORIZONTAL REFRIGERANT 12 EVAPORATOR"
INTERNATIONAL COMMUNICATIONS IN HEAT AND MASS TRANSFER, VOL. 13, 1986, PP.701-706
054080 1986 ICHMT SWIRLFLO
FLOBOIL

AGRAWAL;K.N. VARMA;H.K. LAL;S.
"AN EXPERIMENTAL STUDY OF THE TEMPERATURE DISTRIBUTION IN A HORIZONTAL REFRIGERANT 12 EVAPORATOR FITTED WITH TWISTED TAPES"
PROGRESS IN THE DESIGN AND CONSTRUCTION OF REFRIGERATION SYSTEMS, INTERNATIONAL INSTITUTE OF REFRIGERATION, PARIS, FRANCE, 1986, PP.343-349
054085 1986 ** SWIRLFLO
FLOBOIL

AGRAWAL;K.N. VARMA;H.K.
"EXPERIMENTAL STUDY OF HEAT TRANSFER AUGMENTATION VERSUS PUMPING POWER IN A HORIZONTAL R12 EVAPORATOR"
INTERNATIONAL JOURNAL OF REFRIGERATION, VOL.14, 1991, PP.273-281
054084 1991 IJR SWIRLFLO
FLOBOIL

BLATT;T.A. ADT JR.;R.R.
"THE EFFECTS OF TWISTED TAPE SWIRL GENERATORS ON THE HEAT TRANSFER RATE AND PRESSURE DROP OF BOILING FREON 11 AND WATER"
AMERICAN SOCIETY OF MECHANICAL ENGINEERS PAPER NO. 63-WA-42, 1963
054009 1963 ASME SWIRLFLO
FLOBOIL

CAREY;V.P. SHAH;R.K.
"DESIGN OF COMPACT AND ENHANCED HEAT EXCHANGERS FOR LIQUID-VAPOR PHASE-CHANGE APPLICATIONS"
TWO-PHASE FLOW HEAT EXCHANGERS: THERMAL-HYDRAULIC FUNDAMENTALS AND DESIGN, KLUWER ACADEMIC PUBLISHERS, DORDRECHT, THE NETHERLANDS, 1988, PP.909-968
034060 1988 ** EXTENDEDSURF
SWIRLFLO FLOBOIL CONDENSATION

CUMO;M. FARELLO;G.E. FERRARI;G.
MACIUCA;C.
"HYPERCRITICAL ONCE-THROUGH VAPOUR GENERATORS IN COUNTER FLOW WITH AND WITHOUT TWISTED TAPES"
LA TERMOTECNICA, VOL. XXVIII, 1974, PP.483-490.
054041 1974 ** SWIRLFLO
FLOBOIL

CUMO;M. FARELLO;G.E. FERRARI;G.
PALAZZI;G.
"THE INFLUENCE OF TWISTED TAPES IN SUBCRITICAL, ONCE-THROUGH VAPOR GENERATORS IN COUNTER FLOW"
JOURNAL OF HEAT TRANSFER,VOL.96,1974,PP.365-370
054060 1974 JHT SWIRLFLO
FLOBOIL

DHIR;V.K. SCOTT;J.H.
"ON THE SUPERPOSITION OF INJECTION INDUCED SWIRL DURING ENHANCEMENT OF SUBCOOLED CRITICAL HEAT FLUX"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.30, NO.10, 1987, PP.2013-2022
054076 1987 IJHMT SWIRLFLO
FLOBOIL

GINWALA;K. BLATT;T. BILGER;R.W.
"ENGINEERING STUDY OF VAPOR CYCLE COOLING COMPONENTS FOR SPACE VEHICLES"
AERONAUTICAL SYSTEMS DIVISION REPORT ASD-TDR-63-582, SEPTEMBER 1963
054048 1963 ** SWIRLFLO
FLOBOIL

JENSEN;M.K.
"A CORRELATION FOR PREDICTING THE CRITICAL HEAT FLUX CONDITION WITH TWISTED-TAPE SWIRL GENERATORS"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.27, NO.11, 1984, PP.2172-2173
054077 1984 IJHMT SWIRLFLO
FLOBOIL

JENSEN;M.K.
"AN EVALUATION OF THE EFFECT OF TWISTED-TAPE SWIRL GENERATORS IN TWO-PHASE FLOW HEAT EXCHANGERS"
HEAT TRANSFER ENGINEERING, VOL.6, NO.4, 1985, PP.19-30
054081 1985 HTE SWIRLFLO
FLOBOIL

JENSEN;M.K. BENSLER;H.P.
"SATURATED FORCED-CONVECTIVE BOILING HEAT TRANSFER WITH TWISTED-TAPE INSERTS"
JOURNAL OF HEAT TRANSFER, VOL.108, 1986, PP.93-99
054079 1986 JHT SWIRLFLO
FLOBOIL

LAL;S. VARMA;H.K. AGRAWAL;K.N.
"HEAT TRANSFER AND PRESSURE DROP WITH SWIRL FLOW"
PROCEEDINGS OF THE SECOND NATIONAL SYMPOSIUM ON REFRIGERATION AND AIR CONDITIONING, DEPARTMENT OF MECHANICAL ENGINEERING, UNIVERSITY OF ROORKEE, ROORKEE, INDIA, 1973, PP.119-127
000203 1973 ** LITSURVEY
FLOBOIL SWIRLFLO

PAPADOPOULOS;P. CHANG;C. FRANCE;D.M.
MINKOWYCZ;W.J.
"MASS FLUX EFFECTS IN POST-CHF SWIRL HEAT TRANSFER"
INTERNATIONAL COMMUNICATIONS IN HEAT AND MASS TRANSFER, VOL.18, 1991, PP.297-307
054083 1991 ICHMT SWIRLFLO
FLOBOIL

PATE;M.B.
"DESIGN CONSIDERATIONS FOR AIR-CONDITIONING EVAPORATOR AND CONDENSER COILS"
TWO-PHASE FLOW HEAT EXCHANGERS: THERMAL-HYDRAULIC FUNDAMENTALS AND DESIGN, KLUWER ACADEMIC PUBLISHERS, DORDRECHT, THE NETHERLANDS, 1988, PP.849-884
034059 1988 ** EXTENDEDSURF
FLOBOIL CONDENSATION SWIRLFLO MASSTRAN

PEREPELITSA;N.I. POMET'KO;R.S. SAPANKEVICH;A.P.
"BURNOUT AND INTENSIFICATION OF HEAT REMOVAL IN A FOUR-ROD BUNDLE WITH FLOWS OF WATER AND FREON-12"
THERMAL ENGINEERING, VOL.26, 1979, PP.42-44
054055 1979 TENG SWIRLFLO
FLOBOIL

REID;R.S. PATE;M.B. BERGLES;A.E.
"A COMPARISON OF AUGMENTATION TECHNIQUES DURING IN-TUBE EVAPORATION OF R-113"
BOILING AND CONDENSATION IN HEAT TRANSFER EQUIPMENT, HTD-VOL.85, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1987, PP.21-30
034069 1987 ASME EXTENDEDSURF
FLOBOIL SWIRLFLO

WEEDE;J. DHIR;K.

"EXPERIMENTAL STUDY OF THE ENHANCEMENT OF CRITICAL HEAT FLUX USING TANGENTIAL FLOW INJECTION"
FUNDAMENTALS OF HEAT TRANSFER IN FUSION ENERGY SYSTEMS, HTD - VOL.24, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1983, PP.11-18

134003	1983	ASME	INJECTORSUCT
FLOBOIL	SWIRLFLO		

COILED TUBES - FLOW BOILING

BARSKII;M.A. CHUKHMAN;G.I.
"STUDY OF HEAT TRANSFER IN BOILING FREONS IN SPIRAL TUBES"
KHOLODIL'NAYA TEKHNIKA, NO.2, 1971, PP.18-21.
164035 1971 ** COILEDTUBE
FLOBOIL

CHUKHMAN;G.I.
"THE INTERNAL HEAT TRANSFER IN EVAPORATIVE AIR COOLERS WITH FLOW TURBULIZATION"
HEAT TRANSFER - SOVIET RESEARCH, VOL.4, NO.4, 1972, PP.67-70
164002 1972 HTSR COILEDTUBE
FLOBOIL

CUMO;M. FARELLO;G.E. FERRARI;G.
PALAZZI;G.
"THE INFLUENCE OF CURVATURE IN POST DRY-OUT HEAT TRANSFER"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.15, 1972, PP.2045-2065
164003 1972 IJHMT COILEDTUBE
FLOBOIL

CUMO;M. FARELLO;G.E. FERRARI;G.
"INFLUENCE OF CURVATURE IN POST-DRYOUT HEAT TRANSFER"
LA TERMOTECNICA, VOL.XXVI, 1972, PP.129-142
164034 1972 ** COILEDTUBE
FLOBOIL

FISHER;S.A. YU;S.K.W.
"DRYOUT IN SERPENTINE EVAPORATORS"
INTERNATIONAL JOURNAL OF MULTIPHASE FLOW, VOL.1, 1975, PP.771-791
164005 1975 ** COILEDTUBE
FLOBOIL

GU;C.B. CHOW;L.C. BEAM;J.E.
"FLOW BOILING IN A CURVED CHANNEL"
HEAT TRANSFER IN HIGH ENERGY/HIGH HEAT FLUX APPLICATIONS, HTD-VOL.119, ASME, NEW YORK, 1989, PP.25-32
164063 1989 ASME COILEDTUBE
FLOBOIL

HUGHES;T.G. OLSON;D.R.
"CRITICAL HEAT FLUXES FOR CURVED SURFACES DURING SUBCOOLED FLOW BOILING"
TRANSACTIONS OF THE CANADIAN SOCIETY OF MECHANICAL ENGINEERS, VOL.3, NO.3, 1975, PP.122-130
164009 1975 ** COILEDTUBE
FLOBOIL

JENSEN;M.K. BERGLES;A.E.
"CRITICAL HEAT FLUX IN HELICALLY COILED TUBES"
JOURNAL OF HEAT TRANSFER, VOL. 103, 1981, PP. 660-666.
164046 1981 JHT COILEDTUBE
FLOBOIL

JENSEN;M.K. BERGLES;A.E.
"CRITICAL HEAT FLUX IN HELICAL COILS WITH A CIRCUMFERENTIAL HEAT FLUX TILT TOWARDS THE OUTSIDE SURFACE"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.25,1982 PP.1383-1395
164050 1982 IJHMT COILEDTUBE
FLOBOIL

KOMAREV;V.S. AVDEYEV;Y.S.
"EXPERIMENTAL DATA ON HEAT TRANSFER AND HYDRODYNAMICS OF TWO-PHASE FLOW OF FREON-22 IN HORIZONTAL COILED-TUBE BANKS"
HEAT TRANSFER-SOVIET RESEARCH, VOL.11,NO.2,1979,PP.66-73.
164044 1979 HTSR COILEDTUBE
FLOBOIL

LAUTENSCHLAGER;G. MAYINGER;F.
"EXPERIMENTAL INVESTIGATION OF DISPERSED FLOW HEAT TRANSFER IN CURVED TUBES"
ADVANCES IN PHASE CHANGE HEAT TRANSFER, INTERNATIONAL ACADEMIC PUBLISHERS, CHONGQING, CHINA, AND PERGAMON PRESS, NEW YORK, 1988, PP.196-202
164061 1988 ** COILEDTUBE
FLOBOIL

PANCHAL;C.B. YAMPOLSKY;J. BUYCO;E.H.
BELL;K.J.
"A SPIRALLY FLUTED TUBE HEAT EXCHANGER AS A CONDENSER AND EVAPORATOR"
HEAT TRANSFER 1986, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, 1986, VOL.6, PP.2787-2972
165007 1986 VIIIIHTC COILEDTUBE
CONDENSATION FLOBOIL

ADDITIVES FOR LIQUIDS - FLOW BOILING

CAWTE;H.
"EFFECT OF LUBRICATING OIL CONTAMINATION ON CONDENSATION IN REFRIGERANT R22"
INTERNATIONAL JOURNAL OF ENERGY RESEARCH, VOL.16, 1992, PP.327-340
074037 1992 IJER ADDFORLIQUIDS
FLOBOIL CONDENSATION

CHADDOCK;J.B.
"INFLUENCE OF OIL ON REFRIGERANT EVAPORATOR PERFORMANCE"
ASHRAE TRANSACTIONS, VOL.82, PART 1, 1976, PP.474-486.
074016 1979 ASHRAET ADDFORLIQUIDS
FLOBOIL

CHADDOCK;J.B. MATHUR;A.P.
"HEAT TRANSFER TO OIL REFRIGERANT MIXTURES EVAPORATING IN TUBES"
PROCEEDINGS OF THE MULTIPHASE TRANSPORT: FUNDAMENTALS, REACTOR SAFETY, APPLICATIONS, HEMISPHERE PUBLISHING CORP., VOL.2, 1979, PP.861-884
074017 1979 ** ADDFORLIQUIDS
FLOBOIL

FUKUSHIMA;T. KUDOU;M.
"HEAT TRANSFER COEFFICIENTS AND PRESSURE DROP FOR FORCED CONVECTION BOILING AND CONDENSATION OF HFC 134A"
PROCEEDINGS OF THE USNC/IIR-PURDUE REFRIGERATION CONFERENCE, PURDUE UNIVERSITY, PURDUE, 1990, PP.196-204
074035 1990 ** ADDFORLIQUIDS
FLOBOIL CONDENSATION

HAMBRAEUS;K.
"HEAT TRANSFER COEFFICIENT, TWO-PHASE FLOW BOILING OF HFC134A"
PROCEEDINGS OF THE USNC/IIR-PURDUE REFRIGERATION CONFERENCE, PURDUE UNIVERSITY, PURDUE, 1990, PP.205-214
074038 1990 ** ADDFORLIQUIDS
FLOBOIL

MATHUR;A.P.
"HEAT TRANSFER TO OIL REFRIGERANT MIXTURE EVAPORATING IN TUBES"
PH.D. THESIS, DEPARTMENT OF MECHANICAL ENGINEERING AND MATERIAL SCIENCE, DUKE UNIVERSITY, 1976
074015 1976 ** ADDFORLIQUIDS
FLOBOIL NHC

MC MULLAN;J.T. HEWITT;N.J. MASSON;A.J. MURPHY;N.E.
"THE INFLUENCE OF OIL VISCOSITY AND REFRIGERANT QUALITY ON EVAPORATOR PERFORMANCE"
INTERNATIONAL JOURNAL OF ENERGY RESEARCH, VOL.16, 1992, PP.567-581
074036 1992 IJER ADDFORLIQUIDS
FLOBOIL

MISHRA M.P. VARMA;H.K. SHARMA;C.P.
"HEAT TRANSFER COEFFICIENTS IN FORCED CONVECTION EVAPORATION OF REFRIGERANTS MIXTURES"
LETTERS IN HEAT AND MASS TRANSFER, VOL.8, NO.2, 1981, PP. 127-136
074022 1981 LHMT ADDFORLIQUIDS
FLOBOIL

SPATZ;M.W. ZHENG;J.
"AN EXPERIMENTAL EVALUATION OF THE HEAT TRANSFER COEFFICIENTS OF R-134A RELATIVE TO R-12"
PREPRINTS OF THE 1990 USNC/IIR - PURDUE REFRIGERATION CONFERENCE, PURDUE UNIVERSITY, INDIANA, 1990, PP.225-233
074041 1990 ** ADDFORLIQUIDS
FLOBOIL CONDENSATION

ELECTRIC OR MAGNETIC FIELDS - FLOW BOILING

BOLOGA;M.K. SMIRNOV;G.F. KLIMOV;S.M.
"HEAT TRANSFER TO DIELECTRICS BOILING IN HORIZONTAL SLOTS PLACED IN ELECTRIC FIELDS"
HEAT TRANSFER - SOVIET RESEARCH, VOL.14, NO.2, 1982, PP. 104-110
124009 1982 HTSR ELECTROFIELD FLOBOIL

BOLOGA;M.K. KLIMOV;S.M. MAIBORODA;A.N.
"HEAT EXCHANGE AND BOILING CRISIS IN SLOT CHANNELS UNDER THE ACTION OF AN ELECTRIC FIELD"
JOURNAL OF ENGINEERING PHYSICS, VOL.54, 1988, PP.59-66
124012 1988 JEP ELECTROFIELD FLOBOIL

BOLOGA;M.K. VASILIEV;L.L. KOZUHAR;I.A. SKILEV;V.D.
"EFFECTS OF ELECTRIC FIELDS ON HEAT-PIPE CHARACTERISTICS"
JOURNAL OF ENGINEERING PHYSICS, VOL.36, 1979, PP.748-756
125017 1979 JEP ELECTROFIELD CONDENSATION FLOBOIL

KARAYIANNIS;T.G. COLLINS;M.W. ALLEN;P.H.G.
"ELECTROHYDRODYNAMIC ENHANCEMENT OF NUCLEATE BOILING HEAT TRANSFER IN HEAT EXCHANGERS"
PROCEEDINGS OF THE SIXTH ITALIAN NATIONAL CONGRESS ON HEAT TRANSFER, BARI, ITALY, 1988, PP.263-274
124013 1988 ** ELECTROFIELD FLOBOIL

KARAYIANNIS;T.G. COLLINS;M.W. ALLEN;P.H.G.
"ELECTROHYDRODYNAMIC ENHANCEMENT OF NUCLEATE BOILING HEAT TRANSFER IN HEAT EXCHANGERS"
CHEMICAL ENGINEERING COMMUNICATIONS, VOL.81, 1989, PP.15-24
124010 1989 CHEC ELECTROFIELD FLOBOIL

KARAYIANNIS;T.G. COLLINS;M.W. ALLEN;P.H.G.
"ELECTROHYDRODYNAMIC ENHANCEMENT OF NUCLEATE BOILING HEAT TRANSFER IN HEAT EXCHANGERS"
HEAT AND TECHNOLOGY, VOL.7, NO.2, 1989, PP.36-44
124015 1989 ** ELECTROFIELD FLOBOIL

POULTER;R. ALLEN;P.H.G.
"ELECTROHYDRODYNAMICALLY AUGMENTED HEAT AND MASS TRANSFER IN THE SHELL/TUBE HEAT EXCHANGER"
HEAT TRANSFER 1986, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, 1986, VOL.6, PP.2963-2968
122053 1986 VIIIIHTC · ELECTROFIELD 1FORCECONV FLOBOIL CONDENSATION

YABE;A. MAKI;H.
"AUGMENTATION OF CONVECTIVE AND BOILING HEAT TRANSFER BY APPLYING AN ELECTRO-HYDRODYNAMICAL LIQUID JET"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.31, NO.2, 1988, PP.407-417
144005 1988 IJHMT COMPOUNDTECH FLOBOIL JETIMPINGE ELECTROFIELD 1FORCECONV

INJECTION OR SUCTION - FLOW BOILING

DHIR;V.K. SCOTT;J.H.
"ON THE SUPERPOSITION OF INJECTION INDUCED SWIRL DURING ENHANCEMENT OF SUBCOOLED VERTICAL HEAT FLUX"
AUGMENTATION OF HEAT TRANSFER IN ENERGY SYSTEMS,
HTD-VOL.52, ASME, NEW YORK, 1985, PP.37-45
134004 1985 ASME INJECTORSUCT
FLOBOIL

WEEDE;J. DHIR;K.
"EXPERIMENTAL STUDY OF THE ENHANCEMENT OF CRITICAL HEAT FLUX USING TANGENTIAL FLOW INJECTION"
FUNDAMENTALS OF HEAT TRANSFER IN FUSION ENERGY SYSTEMS,
HTD - VOL.24, AMERICAN SOCIETY OF MECHANICAL ENGINEERS,
NEW YORK, 1983, PP.11-18
134003 1983 ASME INJECTORSUCT
FLOBOIL SWIRLFLO

JET IMPINGEMENT - FLOW BOILING

KANDULA;M.
"MECHANISMS AND PREDICTIONS OF BURNOUT IN FLOW BOILING OVER HEATED SURFACES WITH AN IMPINGING JET"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.33, NO.9, 1990, PP.1795-1803
174011 1990 IJHMT JETIMPINGE FLOBOIL

KATTO;Y. YOKOYA;S.
"CRITICAL HEAT FLUX ON A DISK HEATER COOLED BY A CIRCULAR JET OF SATURATED LIQUID IMPINGING AT THE CENTER"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.31, NO.2, 1988, PP.219-227
174003 1988 IJHMT JETIMPINGE FLOBOIL

MA;C.-F. BERGLES;A.E.
"JET IMPINGEMENT NUCLEATE BOILING"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.29, NO.8, 1986, PP.1095-1101
174004 1986 IJHMT JETIMPINGE FLOBOIL

MONDE;M. OKUMA;Y.
"CRITICAL HEAT FLUX IN SATURATED FORCED CONVECTIVE BOILING ON A HEATED DISK WITH AN IMPINGING JET - CHF IN L-REGIME"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.28, NO.3, 1985, PP.547-552
174005 1985 IJHMT JETIMPINGE FLOBOIL

MONDE;M.
"CRITICAL HEAT FLUX IN SATURATED FORCED CONVECTION BOILING ON A HEATED DISK WITH AN IMPINGING JET"
JOURNAL OF HEAT TRANSFER, VOL.109, 1987, PP.991-996
174006 1987 JHT JETIMPINGE FLOBOIL

MONDE;M. NAGAE;O. ISHIBASHI;Y.
"CRITICAL HEAT FLUX IN SATURATED FORCED CONVECTIVE BOILING ON A HEATED DISK WITH AN IMPINGING JET"
HEAT TRANSFER - JAPANESE RESEARCH, VOL.16, NO.5, 1987, PP.70-82
174012 1987 HTJR JETIMPINGE FLOBOIL

MONDE;A. FURUKAWA;Y.
"CRITICAL HEAT FLUX IN SATURATED FORCED CONVECTIVE BOILING WIH AN IMPINGING JET COEXISTENCE OF POOL AND FORCED CONVECTIVE BOILINGS"
HEAT TRANSFER - JAPANESE RESEARCH, VOL.17, NO.5, 1988, PP.81-91
173008 1988 HTJR JETIMPINGE POOLBOIL FLOBOIL

SHARAN;A. LIENHARD;J.H.
"ON PREDICTING BURNOUT IN THE JET-DISK CONFIGURATION"
JOURNAL OF HEAT TRANSFER, VOL.107, 1985, PP.398-401
174007 1985 JHT JETIMPINGE FLOBOIL

YABE;A. MAKI;H.
"AUGMENTATION OF CONVECTIVE AND BOILING HEAT TRANSFER BY APPLYING AN ELECTRO-HYDRODYNAMICAL LIQUID JET"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.31, NO.2, 1988, PP.407-417
144005 1988 IJHMT COMPOUNDTECH FLOBOIL JETIMPINGE ELECTROFIELD 1FORCECONV

COMPOUND ENHANCEMENT - FLOW BOILING

NAKAOKA;T. UEHARA;H.
"PERFORMANCE TEST OF A SHELL-AND-PLATE TYPE EVAPORATOR FOR OTEC"
EXPERIMENTAL THERMAL AND FLUID SCIENCE, VOL.1, 1988, PP.283-291

144006	1988	ETFS	COMPOUNDTECH
FLOBOIL	TREATSURF	ROUGHSURF	1FORCECONV

YABE;A. MAKI;H.
"AUGMENTATION OF CONVECTIVE AND BOILING HEAT TRANSFER BY APPLYING AN ELECTRO-HYDRODYNAMICAL LIQUID JET"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.31, NO.2, 1988, PP.407-417

144005	1988	IJHMT	COMPOUNDTECH
FLOBOIL	JETIMPINGE	ELECTROFIELD	1FORCECONV

PERFORMANCE EVALUATION - FLOW BOILING

ANDERSON;J.H. ANDERSON,JR.;J.H.
"COMPACT HEAT EXCHANGERS FOR SEA THERMAL POWER PLANTS"
PROCEEDINGS FOURTH ANNUAL CONFERENCE ON OCEAN THERMAL ENERGY
CONVERSION, MARCH 1977, PP. VI-3 - VI-14.
150051 1977 ** PERFORMANCE
FLOBOIL EXTENDEDSURF

GU;N. ZHANG;Z.X.
"A NEW METHOD TO EVALUATE AUGMENTATIVE HEAT TRANSFER TECHNIQUE"
SECOND INTERNATIONAL SYMPOSIUM ON MULTIPHASE FLOW AND HEAT TRANSFER, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, VOL.1, 1989, PP.764-773
150108 1989 ** PERFORMANCE
1FORCECONV FLOBOIL CONDENSATION

REID;R.S. PATE;M.B. BERGLES;A.E.
"A COMPARISON OF AUGMENTATION TECHNIQUES DURING IN-TUBE EVAPORATION OF R-113"
JOURNAL OF HEAT TRANSFER, VOL.113, 1991, PP.451-458
150097 1991 JHT PERFORMANCE
FLOBOIL

SCHLAGER;L.M. PATE;M.B. BERGLES;A.E.
"HEAT TRANSFER AND PRESSURE DROP PERFORMANCE OF SMOOTH AND INTERNALLY FINNED TUBES WITH OIL AND REFRIGERANT 22 MIXTURES"
ASHRAE TRANSACTIONS, VOL.95, PART 2, 1989, PP.375-385
150081 1989 ASHRAE PERFORMANCE
EXTENDEDSURF FLOBOIL CONDENSATION

WEBB;R.L. APPARAO;T.V.V.R.
"PERFORMANCE OF FLOODED REFRIGERANT EVAPORATORS WITH ENHANCED TUBES"
HEAT TRANSFER ENGINEERING, VOL.11, NO.2, 1990, PP.29-43
150098 1990 HTE PERFORMANCE
EXTENDEDSURF TREATSURF FLOBOIL

LITERATURE SURVEYS - CONDENSATION

ALLEN;P.H.G.
"HEAT TRANSFER ENHANCEMENT BY DIELECTROPHORESIS"
SECOND UK NATIONAL CONFERENCE ON HEAT TRANSFER, GLASGOW, VOL.1, 1988, PP.861-870
000194 1988 IIUKNHTC LITSURVEY
ELECTROFIELD CONDENSATION POOLBOIL

BERGLES;A.E.
"SURVEY OF AUGMENTATION OF TWO-PHASE HEAT TRANSFER"
PREPRINTED AND PRESENTED AT ASHRAE SEMIANNUAL MEETING, DALLAS,1976,ASHRAE TRANSACTIONS,VOL.82,PT.1,1976,PP.891-905.
000053 1976 ASHRAET LITSURVEY
POOLBOIL FLOBOIL CONDENSATION

BERGLES;A.E.
"HEAT TRANSFER CHARACTERISTICS OF TURBOTEC TUBING"
HEAT TRANSFER LABORATORY REPORT NO. HTL-24, ISU-ERI-AMES-81018, IOWA STATE UNIVERSITY, 1980
000085 1980 ISU LITSURVEY
ROUGHSURF EXTENDEDSURF 1NATCONV 1FORCECONV
CONDENSATION MASSTRAN

BERGLES;A.E.
"HEAT TRANSFER AUGMENTATION"
TWO-PHASE FLOW HEAT EXCHANGERS: THERMAL-HYDRAULIC FUNDAMENTALS AND DESIGN, KLUWER ACADEMIC PUBLISHERS, DORDRECHT, THE NETHERLANDS, 1988, PP.343-373
000161 1988 ** LITSURVEY
1FORCECONV POOLBOIL FLOBOIL CONDENSATION

CARNAVOS;T.C.
"SOME RECENT DEVELOPMENTS IN AUGMENTED HEAT EXCHANGE ELEMENTS"
HEAT EXCHANGERS: DESIGN AND THEORY SOURCE BOOK, SCRIPTA BOOK COMPANY, WASHINGTON, D.C. 1974, PP.441-489
000034 1972 ** LITSURVEY
ROUGHSURF FLOBOIL CONDENSATION MASSTRAN

LAZAREK;G.M.
AUGMENTATION OF TWO-PHASE HEAT TRANSFER AND PRESSURE DROP OF REFRIGERANTS IN HORIZONTAL TUBES"
INTERNATIONAL JOURNAL OF REFRIGERATION, VOL.3, NO.5, 1980, PP.261-272
000090 1980 IJHMT LITSURVEY
CONDENSATION

MARTO;P.J .
"HEAT TRANSFER AND TWO-PHASE FLOW DURING SHELL-SIDE CONDENSATION"
ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE PROCEEDINGS, HONOLULU, HAWAII, MARCH 1983, VOL.2, PP.561-591
000116 1983 ** LITSURVEY
CONDENSATION

MARTO;P.J.
"HEAT TRANSFER AND TWO-PHASE FLOW DURING SHELL-SIDE CONDENSATION"
HEAT TRANSFER ENGINEERING, VOL.5, NOS.1-2, 1984, PP.31-
000174 1984 HTE LITSURVEY
CONDENSATION EXTENDEDSURF

MARTO;P.J.
"RECENT PROGRESS IN ENHANCING FILM CONDENSATION HEAT TRANSFER ON HORIZONTAL TUBES"
HEAT TRANSFER 1986, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, 1986, VOL.1, PP.161-170
000147 1986 VIIIIHTC LITSURVEY
CONDENSATION EXTENDEDSURF ROUGHSURF TREATSURF

MARTO;P.J.
"RECENT PROGRESS IN ENHANCING FILM CONDENSATION HEAT TRANSFER ON HORIZONTAL TUBES"
HEAT TRANSFER ENGINEERING, VOL.7, NOS.3-4, 1986, PP.53-
000175 1986 HTE LITSURVEY
CONDENSATION EXTENDEDSURF ROUGHSURF

MARTO;P.J.
"AN EVALUATION OF FILM CONDENSATION ON HORIZONTAL INTEGRAL-FIN TUBES"
JOURNAL OF HEAT TRANSFER, VOL.110, 1988, PP.1287-1305
000133 1988 JHT LITSURVEY
CONDENSATION EXTENDEDSURF

NAKAYAMA;W.
"ENHANCEMENT OF HEAT TRANSFER"
HEAT TRANSFER 1982, VOL.1, HEMISPHERE PUBLISHING COMPANY, WASHINGTON, D.C., 1982, PP.223-240
000110 1982 VIIIHTC LITSURVEY
1FORCECONV POOLBOIL FLOBOIL CONDENSATION

PATE;M.B.
"RECENT DEVELOPMENTS IN CONDENSERS AND CONDENSATION FOR REFRIGERATION AND AIR-CONDITIONING APPLICATIONS"
PROCEEDINGS OF THE SECOND INTERNATIONAL SYMPOSIUM ON CONDENSERS AND CONDENSATION, UNIVERSITY OF BATH, UK, HEAT TRANSFER AND FLUID FLOW SERVICE, UK, 1990, PP.1-25
000166 1990 ** LITSURVEY
CONDENSATION EXTENDEDSURF TREATSURF

ROSE;J.W.
"SOME ASPECTS OF CONDENSATION HEAT TRANSFER THEORY"
INTERNATIONAL COMMUNICATIONS IN HEAT AND MASS TRANSFER, VOL.15, 1988, PP.449-473
000170 1988 ICHMT LITSURVEY
CONDENSATION

SCHLAGER;L.M. PATE;M.B. BERGLES;A.E.
"A SURVEY OF REFRIGERANT HEAT TRANSFER AND PRESSURE DROP EMPHASIZING OIL EFFECTS AND IN-TUBE AUGMENTATION"
ASHRAE TRANSACTIONS, VOL.93, PART 1, 1987, PP.392-416
000136 1987 ASHRAE LITSURVEY
FLOBOIL CONDENSATION

SCHLAGER;L.M. PATE;M.B. BERGLES;A.E.
"PERFORMANCE PREDICTIONS OF REFRIGERANT-OIL MIXTURES IN SMOOTH AND INTERNALLY FINNED TUBES-PART I: LITERATURE REVIEW"
ASHRAE TRANSACTIONS, VOL.96, PART 1, 1990, PP.160-169
000196 1990 ASHRAE LITSURVEY
FLOBOIL CONDENSATION

SUKHATME;S.P.
"CONDENSATION ON ENHANCED SURFACE HORIZONTAL TUBES"
HEAT TRANSFER 1990, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, VOL.1, 1990, PP.305-328
000155 1990 IXIHTC LITSURVEY
CONDENSATION EXTENDEDSURF

TAN;Y.-K.
"SOME RECENT RESEARCHES AND DEVELOPMENTS ON HEAT TRANSFER ENHANCEMENT OF ORGANIC COMPOUNDS WITH PHASE CHANGE"
SECOND INTERNATIONAL SYMPOSIUM ON MULTIPHASE FLOW AND HEAT TRANSFER, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, VOL.1, 1989, PP.613-620
000208 1989 ** LITSURVEY
FLOBOIL CONDENSATION

TAN;Y.-K.
"HEAT TRANSFER ENHANCEMENT WITH PHASE CHANGES RESEARCH AND DEVELOPMENT IN SOUTH CHINA UNIVERSITY OF TECHNOLOGY"
HEAT TRANSFER ENHANCEMENT AND ENERGY CONSERVATION, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, 1990, PP.297-304
000144 1990 ** LITSURVEY
FLOBOIL CONDENSATION

TANASAWA;I.
"HIGH-PERFORMANCE SURFACES FOR NON-BOILING HEAT TRANSFER"
HEAT TRANSFER IN ENERGY PROBLEMS, PROCEEDINGS OF THE JAPAN-UNITED STATES JOINT SEMINAR, TOKYO, JAPAN, SEPTEMBER 1980, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, 1982, PP. 101-108
000101 1982 ** LITSURVEY
1NATCONV 1FORCECONV CONDENSATION

TANASAWA;I.
"CONDENSATION HEAT TRANSFER - JAPANESE RESEARCH IN 1980S"
PROCEEDINGS OF THE SECOND INTERNATIONAL SYMPOSIUM ON CONDENSERS AND CONDENSATION, UNIVERSITY OF BATH, UK, HEAT TRANSFER AND FLUID FLOW SERVICE, UK, 1990, PP.377-395
000167 1990 ** LITSURVEY

CONDENSATION EXTENDEDSURF TREATSURF

THOME;J.R.
"MECHANISMS OF ENHANCED NUCLEATE POOL BOILING"
PROCEEDINGS OF THE ENGINEERING FOUNDATION CONFERENCE ON POOL AND EXTERNAL FLOW BOILING, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1992, PP.337-343
000197 1992 ASME LITSURVEY
POOLBOIL

WEBB;R.L.
"THE USE OF ENHANCED SURFACE GEOMETRIES IN CONDENSERS: AN OVERVIEW"
POWER CONDENSER HEAT TRANSFER TECHNOLOGY, HEMISPHERE PUBLISHING CORPORATION, 1981, PP.287-324
000106 1981 ** LITSURVEY
CONDENSATION

WEBB;R.L.
"HIGH PERFORMANCE HEAT TRANSFER SURFACES FOR BOILING AND CONDENSATION"
HEAT TRANSFER IN ENERGY PROBLEMS, PROCEEDINGS OF THE JAPAN-UNITED STATES JOINT SEMINAR, TOKYO, JAPAN. SEPTEMBER 1980, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, 1982, PP. 127-132
000100 1982 ** LITSURVEY
POOLBOIL CONDENSATION

WEBB;R.L.
"SHELL-SIDE CONDENSATION IN REFRIGERANT CONDENSER"
ASHRAE TRANSACTIONS, VOL.90, PART 1B, 1984, PP.5-25
000134 1984 ASHRAE LITSURVEY
ROUGHSURF EXTENDEDSURF CONDENSATION

WEBB;R.L.
"ENHANCEMENT OF FILM CONDENSATION"
INTERNATIONAL COMMUNICATIONS IN HEAT AND MASS TRANSFER, VOL.15, 1988, PP.475-507
000171 1988 ICHMT LITSURVEY
CONDENSATION EXTENDEDSURF

WILLIAMS;A.G. NADAPURKAR;S.S. HOLLAND;A.F.
"A REVIEW OF METHODS FOR ENHANCING HEAT TRANSFER RATES IN SURFACE CONDENSERS"
THE CHEMICAL ENGINEER, NO.223, NOVEMBER 1968, PP.367-373
000036 1968 TCE LITSURVEY
CONDENSATION

WITTE;L.C.
"CONDENSATION HEAT TRANSFER"
HEAT TRANSFER IN HIGH TECHNOLOGY AND POWER ENGINEERING, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, 1987, PP.239-254
000181 1987 ** LITSURVEY
CONDENSATION EXTENDEDSURF TREATSURF

YABE;A. MORI;Y. HIJIKATA;K.
"HEAT TRANSFER ENHANCEMENT TECHNIQUES UTILIZING ELECTRIC FIELDS"
HEAT TRANSFER IN HIGH TECHNOLOGY AND POWER ENGINEERING, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, 1987, PP.394-405
000183 1987 ** LITSURVEY
ELECTROFIELD 1FORCECONV CONDENSATION

TREATED SURFACES - CONDENSATION

ARAI;A. ARAI;N. FUSHIMA;T.
NAKAYAMA;W. FUJIE;K.
"HEAT TRANSFER CHARACTERISTICS OF "THERMOEXCEL" TUBES IN HEAT EXCHANGERS OF TURBO-REFRIGERATING MACHINES"
IIF-IIR COMMISSIONS B1, B2, AND B3, BELGRADE, YUGOSLAVIA, 1977, PP.15-20
013068 1977 ** TREATSURF
POOLBOIL CONDENSATION

CZIKK;A.M. FRICKE;H.D. GANIC;E.N.
SHARMA;B.I.
"FLUID DYNAMIC AND HEAT TRANSFER STUDIES OF OTEC HEAT EXCHANGERS"
PROCEEDINGS OF THE FIFTH OCEAN THERMAL ENERGY CONVERSION CONFERENCE, MIAMI BEACH, FLORIDA, 1978, PP.VI181-VI236.
013078 1978 OTEC TREATSURF
POOLBOIL EXTENDEDSURF CONDENSATION

HONDA;H. NOZU;S. MITSUMORI;K.
"AUGMENTATION OF CONDENSATION ON HORIZONTAL FINNED TUBES BY ATTACHING A POROUS DRAINAGE PLATE"
ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE PROCEEDINGS, HONOLULU, HAWAII, MARCH 1983, VOL.3, PP.289-296
035134 1983 ** EXTENDEDSURF
CONDENSATION TREATSURF

HORAZAK;D.A. RABAS;T.J.
"CAPITOL COST SYSTEM OPTIMIZATION OF OTEC POWER MODULES"
ENERGY TECHNOLOGY CONFERENCE, HOUSTON, TEXAS, NOVEMBER 1978
150064 1978 ** PERFORMANCE
TREATSURF ROUGHSURF EXTENDEDSURF CONDENSATION

ILTSCHEFF;S.
"CONCERNING TESTS FOR ACHIEVING DROP CONDENSATION WITH FLUORINATED REFRIGERANTS"
KAELTETECHNIK-KLIMATISIERUNG, VOL.23, 1971, PP.237-241
015011 1971 ** TREATSURF
CONDENSATION

KAJIKAWA;T. TAKAZAWA;H. NISHIYAMA;K.
AGAWA;T. IIDAKA;H. AMANO;M.
"DEVELOPMENT OF ENHANCEMENT OF THE WORKING FLUID SIDE HEAT TRANSFER FOR OTEC"
PROCEEDINGS OF THE SEVENTH OCEAN ENERGY CONFERENCE, CONF-800633, VOL.2, 1980, PP.12.2-1 - 12.2-9
013113 1980 ** TREATSURF
POOLBOIL EXTENDEDSURF CONDENSATION

MARTO;P.J.
"RECENT PROGRESS IN ENHANCING FILM CONDENSATION HEAT TRANSFER ON HORIZONTAL TUBES"
HEAT TRANSFER 1986, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, 1986, VOL.1, PP.161-170
000147 1986 VIIIIHTC LITSURVEY
CONDENSATION EXTENDEDSURF ROUGHSURF TREATSURF

SAASKI;E.W. HARTL;J.H.
"HIGH PERFORMANCE HEAT PIPES FOR HEAT RECOVERY APPLICATIONS"
SIGMA RESEARCH, INC. FINAL REPORT FOR CONTRACT NO. NAS5-25357, RICHLAND, WASHINGTON, SEPTEMBER 1979.
013084 1979 ** TREATSURF
POOLBOIL CONDENSATION

SATHER;N.F. LEWIS;L.G. LORENZ;J.J.
YUNG;D.
"PERFORMANCE TESTS OF 1 MWT OTEC HEAT EXCHANGERS"
PROCEEDINGS OF THE FIFTH OCEAN THERMAL ENERGY CONVERSION CONFERENCE, VOL.3, 1978 PP.VI-1-VI-19
013079 1978 ** TREATSURF
POOLBOIL ROUGHSURF CONDENSATION

SHEKARRIZ;A. PLUMB;O.A.
"ENHANCEMENT OF FILM CONDENSATION USING POROUS FINS"
JOURNAL OF THERMOPHYSICS AND HEAT TRANSFER, VOL.3, NO.3, 1989, PP.309-314
145004 1989 JTHT COMPOUNDTECH
CONDENSATION TREATSURF EXTENDEDSURF

PATE;M.B.
"RECENT DEVELOPMENTS IN CONDENSERS AND CONDENSATION FOR REFRIGERATION AND AIR-CONDITIONING APPLICATIONS"
PROCEEDINGS OF THE SECOND INTERNATIONAL SYMPOSIUM ON CONDENSERS AND CONDENSATION, UNIVERSITY OF BATH, UK, HEAT TRANSFER AND FLUID FLOW SERVICE, UK, 1990, PP.1-25
000166 1990 ** LITSURVEY
CONDENSATION EXTENDEDSURF TREATSURF

THOMAS;A. HILLIS;D. PANCHAL;C.
LORENZ;J. YUNG;D. SATHER;N.
"EXPERIMENTAL TESTS OF 1 MWT OTEC HEAT EXCHANGERS AT ARGONNE NATIONAL LABORATORY"
PROCEEDINGS OF THE SEVENTH OCEAN ENERGY CONFERENCE, CONF-800633, VOL.2, 1980, PP.12.1-1 - 12.1-8
013112 1980 ** TREATSURF
POOLBOIL EXTENDEDSURF CONDENSATION

WITTE;L.C.
"CONDENSATION HEAT TRANSFER"
HEAT TRANSFER IN HIGH TECHNOLOGY AND POWER ENGINEERING, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, 1987, PP.239-254
000181 1987 ** LITSURVEY
CONDENSATION EXTENDEDSURF TREATSURF

ROUGH SURFACES - CONDENSATION

ANAND;G. CHRISTENSEN;R.N. RICHARDS;D.E.
"FORCED CONVECTION CONDENSATION OF AMMONIA INSIDE COILED FLUTED TUBES"
ASHRAE TRANSACTIONS, VOL.94, PART 2, 1988, PP.1132-1158
145005 1988 ASHRAE COMPOUNDTECH
CONDENSATION ROUGHSURF COILEDTUBE

ANAND;G. CHRISTENSEN;R.N.
"DESIGN MODEL FOR THIN FILM CONDENSATION IN FLUTED TUBES"
HEAT TRANSFER EQUIPMENT FUNDAMENTALS, DESIGN, APPLICATIONS, AND OPERATING PROBLEMS, HTD-VOL.108, ASME, NEW YORK, 1989, PP.105-110
025052 1989 ASME ROUGHSURF
CONDENSATION

ARAI;N. FUKUSHIMA;T. ARAI;A.
NAKAJIMA;T. FUJIE;K. NAKAYAMA;Y.
"HEAT TRANSFER TUBES ENHANCING BOILING AND CONDENSATION IN HEAT EXCHANGER OF A REFRIGERATING MACHINE"
ASHRAE TRANSACTIONS, VOL.83, PT.2, 1977, PP.58-70
023008 1977 ASHRAE ROUGHSURF
POOLBOIL CONDENSATION 1FORCECONV

BERGLES;A.E.
"HEAT TRANSFER CHARACTERISTICS OF TURBOTEC TUBING"
HEAT TRANSFER LABORATORY REPORT NO. HTL-24, ISU-ERI-AMES-81018, IOWA STATE UNIVERSITY, 1980
000085 1980 ISU LITSURVEY
ROUGHSURF EXTENDEDSURF 1NATCONV 1FORCECONV
CONDENSATION MASSTRAN

CARNAVOS;T.C.
"SOME RECENT DEVELOPMENTS IN AUGMENTED HEAT EXCHANGE ELEMENTS"
HEAT EXCHANGERS: DESIGN AND THEORY SOURCE BOOK, SCRIPTA BOOK COMPANY, WASHINGTON, D.C. 1974, PP.441-489
000034 1972 ** LITSURVEY
ROUGHSURF FLOBOIL CONDENSATION MASSTRAN

CHANG;K.I. SPENCER;D.L.
"EFFECTS OF REGULARLY SPACED SURFACE RIDGES ON FILM CONDENSATION HEAT TRANSFER COEFFICIENTS FOR CONDENSATION IN THE PRESENCE OF NONCONDENSABLE GAS"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.14, 1971, PP.502-505
025002 1971 IJHMT ROUGHSURF
CONDENSATION

COMBS;S.K.
"EXPERIMENTAL DATA FOR AMMONIA CONDENSATION ON VERTICAL AND INCLINED FLUTED TUBES"
OAK RIDGE NATIONAL LABORATORY, NO.ORNL-5488, JANUARY 1979
025005 1979 ORNL ROUGHSURF
CONDENSATION

COMBS;S.K. MAILEN;G.S. MURPHY;R.W.
"CONDENSATION OF REFRIGERANTS ON VERTICAL FLUTED TUBES"
OAK RIDGE NATIONAL LABORATORY REPORT NO.ORNL/TM-5848, AUGUST 1978
025022 1978 ORNL ROUGHSURF
CONDENSATION EXTENDEDSURF

COMBS;S.K. MURPHY;R.W.
"EXPERIMENTAL STUDIES OF OTEC HEAT TRANSFER CONDENSATION OF AMMONIA ON VERTICAL FLUTED TUBES"
PROCEEDINGS OF THE FIFTH OCEAN THERMAL ENERGY CONVERSION CONFERENCE, MIAMI BEACH, FLORIDA, FEBRUARY 1978
025028 1978 OTEC ROUGHSURF
CONDENSATION

FUJII;T. WANG;W.C. KOYAMA;S.
SHIMIZU;Y.
"HEAT TRANSFER ENHANCEMENT FOR GRAVITY CONTROLLED CONDENSATION ON A HORIZONTAL TUBE BY A COILED WIRE"
ABSTRACTED IN BULLETIN OF JSME, VOL.29, 1986, PP.1069
025062 1986 BJSME ROUGHSURF
CONDENSATION

HONDA;H. NOZU;S.
"AUGMENTATION OF CONDENSATION OF HORIZONTAL FINNED TUBES BY ATTACHING A DRAINAGE STRIP (EFFECTS OF MATERIAL AND HEIGHT OF THE DRAINAGE STRIP)"
ABSTRACTED IN BULLETIN OF JSME, VOL.29, 1986, PP.1966
025061 1986 BJSME ROUGHSURF
CONDENSATION

HONDA;H. NOZU;S. MATSUOKA;Y.
AOYAMA;T. NAKATA;H.
"CONDENSATION OF REFRIGERANTS R-11 AND R-113 IN HORIZONTAL ANNULI WITH AN ENHANCED INNER TUBE"
EXPERIMENTAL HEAT TRANSFER, FLUID MECHANICS, AND THERMODYNAMICS 1988, ELSEVIER SCIENCE PUBLISHING, NEW YORK, 1988, PP.1069-1076
025044 1988 IWCEHTFMT ROUGHSURF
CONDENSATION COMPOUNDTECH

HONDA;H. NOZU;S. MATSUOKA;Y.
AOYAMA;T. NAKATA;H.
"CONDENSATION OF REFRIGERANTS R-11 AND R-113 IN THE ANNULI OF HORIZONTAL DOUBLE-TUBE CONDENSERS WITH AN ENHANCED INNER TUBE"
EXPERIMENTAL THERMAL AND FLUID SCIENCE, VOL.2, 1989, PP.173-182
145007 1989 ETFS COMPOUNDTECH
CONDENSATION EXTENDEDSURF ROUGHSURF

HORAZAK;D.A. RABAS;T.J.
"CAPITOL COST SYSTEM OPTIMIZATION OF OTEC POWER MODULES"
ENERGY TECHNOLOGY CONFERENCE, HOUSTON, TEXAS, NOVEMBER 1978
150064 1978 ** PERFORMANCE
TREATSURF ROUGHSURF EXTENDEDSURF CONDENSATION

KABOV;O.A. PADYUKOV;I.V.
"CONDENSATION HEAT TRANSFER ON HORIZONTAL TUBES WITH RIBS OF CONSTANT CURVATURE"
HEAT TRANSFER - SOVIET RESEARCH, VOL.23, NO.2, 1991, PP.275-283
025058 1991 HTSR ROUGHSURF
CONDENSATION

KAUSHIK;N. AZER;N.Z.
"CONDENSATION HEAT TRANSFER ENHANCEMENT BY DOUBLY AUGMENTED TUBES"
ASHRAE TRANSACTIONS, VOL.94, PART 2, 1988, PP.1159-1175
035169 1988 ASHRAE EXTENDEDSURF
CONDENSATION ROUGHSURF 1FORCECONV

LUU;M. BERGLES;A.E.
"ENHANCEMENT OF HORIZONTAL IN-TUBE CONDENSATION OF R-113"
ASHRAE TRANSACTIONS, VOL.85, PART 2, 1979, PP.293-312.
025031 1979 ASHRAET ROUGHSURF
CONDENSATION EXTENDEDSURF SWIRLFLO

LUU;M. BERGLES;A.E.
"AUGMENTATION OF IN-TUBE CONDENSATION OF R-113"
HEAT TRANSFER LABORATORY REPORT NO. HTL-23, ISU-ERI-AMES-80175, IOWA STATE UNIVERSITY,1980.
025035 1979 ISU ROUGHSURF
EXTENDEDSURF CONDENSATION SWIRLFLO

MARTO;P.J.
"RECENT PROGRESS IN ENHANCING FILM CONDENSATION HEAT TRANSFER ON HORIZONTAL TUBES"
HEAT TRANSFER 1986, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, 1986, VOL.1, PP.161-170
000147 1986 VIIIIHTC LITSURVEY
CONDENSATION EXTENDEDSURF ROUGHSURF TREATSURF

MARTO;P.J.
"RECENT PROGRESS IN ENHANCING FILM CONDENSATION HEAT TRANSFER ON HORIZONTAL TUBES"
HEAT TRANSFER ENGINEERING, VOL.7, NOS.3-4, 1986, PP.53-
000175 1986 HTE LITSURVEY
CONDENSATION EXTENDEDSURF ROUGHSURF

MEDWELL;J.O. NICOL;A.A.
"SURFACE ROUGHNESS EFFECTS ON CONDENSATE FILMS"
AMERICAN SOCIETY OF MECHANICAL ENGINEERS PAPER NO. 65-HT-43, 1965
025001 1965 ASME ROUGHSURF
CONDENSATION

MICHEL;J.W. MURPHY;R.W.

"ENHANCED CONDENSATION HEAT TRANSFER"
AMERICAN INSTITUTE OF CHEMICAL ENGINERS SYMPOSIUM SERIES, VOL.76, NO.199, 1980, PP.183-191.
025018 1980 AICHESS ROUGHSURF CONDENSATION

MURPHY;R.W. MICHEL;J.W.
"ENHANCEMENT OF REFRIGERANT CONDENSATION"
ASHRAE TRANSACTIONS, VOL.90, PART 1B, 1984, PP.72-79
035165 1984 ASHRAE EXTENDEDSURF CONDENSATION ROUGHSURF

NAKAOKA;T. UEHARA;H.
"PERFORMANCE TEST OF A SHELL-AND-PLATE-TYPE CONDENSER FOR OTEC"
EXPERIMENTAL THERMAL AND FLUID SCIENCE, VOL.1, 1988, PP.275-281
145006 1988 ETFS COMPOUNDTECH CONDENSATION EXTENDEDSURF ROUGHSURF 1FORCECONV

NAKAYAMA;W. DAIKOKU;T. KUWAHARA;H. KAKIZAKI;K.
"HIGH-FLUX HEAT TRANSFER SURFACE "THERMOEXCEL""
HITACHI REVIEW, VOL. 24, 1975, PP. 329-333
023011 1975 ** ROUGHSURF POOLBOIL CONDENSATION

NOZU;S. OZAKI;K. INABA;H. HONDA;H.
"CONDENSATION OF A NONAZEOTROPIC REFRIGERANT MIXTURE R114/R113 IN HORIZONTAL ANNULI WITH AN ENHANCED INNER TUBE"
JOURNAL OF HEAT TRANSFER, VOL.114, 1992, PP.201-210
025057 1992 JHT ROUGHSURF CONDENSATION

SAID;S.A. AZER;N.Z.
"HEAT TRANSFER AND PRESSURE DROP DURING CONDENSATION INSIDE HORIZONTAL FINNED TUBES"
ASHRAE TRANSACTIONS, VOL.89, PT.1, 1983, PP.114-135
025041 1983 ASHRAET ROUGHSURF CONDENSATION

SATHER;N.F. LEWIS;L.G. LORENZ;J.J. YUNG;D.
"PERFORMANCE TESTS OF 1 MWT OTEC HEAT EXCHANGERS"
PROCEEDINGS OF THE FIFTH OCEAN THERMAL ENERGY CONVERSION CONFERENCE, VOL.3, 1978 PP.VI-1-VI-19
013079 1978 ** TREATSURF POOLBOIL ROUGHSURF CONDENSATION

SARTOR;W.E.
"EXTENDED AND ENHANCED TUBE SURFACES TO IMPROVE HEAT TRANSFER"
PROCEEDINGS OF THE SECOND SYMPOSIUM ON SHELL AND TUBE HEAT EXCHANGERS, HOUSTON, TEXAS, SEPTEMBER 1981, PP. 411-418, 1982
025042 1982 ** ROUGHSURF CONDENSATION EXTENDEDSURF

SHIZUYA;M. ITOH;M. HIJIKATA;K.
"CONDENSATION OF NON-AZEOTROPIC BINARY REFRIGERANT MIXTURES INCLUDING R22 AS A MORE VOLATILE COMPONENT INSIDE A HORIZONTAL TUBE"
PROCEEDINGS OF THE SECOND INTERNATIONAL SYMPOSIUM ON CONDENSERS AND CONDENSATION, UNIVERSITY OF BATH, UK, HEAT TRANSFER AND FLUID FLOW SERVICE, UK, 1990, PP.27-38
025046 1990 ** ROUGHSURF CONDENSATION

TOJO;S. HOSOKAWA;K. ARIMOTO;T. YAMADA;H. OHTA;Y.
"PERFORMANCE CHARACTERISTICS OF MULTI-GROOVED TUBES FOR AIR CONDITIONERS"
AUSTRALIAN REFRIGERATION, AIR CONDITIONING AND HEATING, AUGUST, 1984, PP.45-
025059 1984 ** ROUGHSURF CONDENSATION FLOBOIL

TORII;T. HIRASAWA;S. KUWAHARA;H. YANAGIDA;T. FUJIE;K.
"THE USE OF HEAT EXCHANGERS WITH THERMOEXCEL'S TUBING IN OCEAN THERMAL ENERGY POWER PLANTS"
AMERICAN SOCIETY OF MECHANICAL ENGINEERS PAPER NO.78-WA/HT-65, 1978
023004 1978 ASME ROUGHSURF POOLBOIL CONDENSATION 1FORCECONV

UEHARA;H. MATSUTANI;K.
"HEAT TRANSFER COEFFICIENTS OF CONDENSATION ON VERTICAL FLUTED TUBES"
PROCEEDINGS OF THE FIFTH OCEAN THERMAL ENERGY CONVERSION CONFERENCE, MIAMI BEACH, FLORIDA, FEBRUARY 1978, PP.IV146-IV160
025029 1978 OTEC ROUGHSURF CONDENSATION

EXTENDED SURFACES - CONDENSATION

SCHLAGER;L.M. PATE;M.B. BERGLES;A.E.
"EVAPORATION AND CONDENSATION OF REFRIGERANT-OIL MIXTURES IN A SMOOTH TUBE AND A MICRO-FIN TUBE"
ASHRAE TRANSACTIONS, VOL.94, PART 1, 1988, PP.149-166
ADAMEK;T.
"BESTIMMUNG DER KONDENSATIONSGROESSEN AUF FEINGEWELLTEN OBERFLAECHEN ZUR AUSLEGUNG OPTIMALER WANDPROFILE"
WAERME-UND STOFFUEBERTRAGUNG, VOL.15, 1981, PP.255-270
034053 1988 ASHRAE EXTENDEDSURF
FLOBOIL CONDENSATION

035108 1981 ** EXTENDEDSURF
CONDENSATION

ADAMEK;T. WEBB;R.L.
"PREDICTION OF FILM CONDENSATION ON HORIZONTAL INTEGRAL FIN TUBES"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.33, NO.8, 1990, PP.1721-1735
035181 1990 IJHMT EXTENDEDSURF
CONDENSATION

ADAMEK;T. WEBB;R.L.
"PREDICTION OF FILM CONDENSATION ON VERTICAL FINNED PLATES AND TUBES : A MODEL FOR THE DRAINAGE CHANNEL"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.33, NO.8, 1990, PP.1737-1749
035182 1990 IJHMT EXTENDEDSURF
CONDENSATION

ANONYMOUS
"CONDENSER AND FAN DEVELOPMENT FOR AUTOMOTIVE RANKINE ENGINES"
ENVIRONMENTAL PROTECTION AGENCY, DIVISION OF ADVANCED AUTOMOTIVE POWER SYSTEMS DEVELOPMENT, AUTOMOTIVE RANKINE CYCLE CONTRACTORS COORDINATION MEETING, ANN ARBOR, MICHIGAN, DECEMBER 1972
035041 1972 ** EXTENDEDSURF
CONDENSATION

AZER;N.Z. SAID;S.A.
"AUGMENTATION OF CONDENSATION HEAT TRANSFER BY INTERNALLY FINNED TUBES AND TWISTED TAPE INSERTS"
DEPARTMENT OF MECHANICAL ENGINEERING, KANSAS STATE UNIVERSITY FINAL TECHNICAL REPORT, JUNE 1981
035112 1981 ** EXTENDEDSURF
CONDENSATION SWIRLFLO

AZER;N.Z. SAID;S.A.
"AUGMENTATION OF CONDENSATION HEAT TRANSFER BY INTERNALLY FINNED TUBES AND TWISTED TAPE INSERTS"
HEAT TRANSFER 1982, VOL.5, HEMISPHERE PUBLISHING COMPANY, WASHINGTON, D.C., 1982, PP.33-38
035124 1982 VIIIHTC EXTENDEDSURF
CONDENSATION

BARNES,JR.;C.G. ROHSENOW;W.M.
"VERTICAL FLUTED TUBE CONDENSER PERFORMANCE PREDICTION"
HEAT TRANSFER 1982, VOL.5, HEMISPHERE PUBLISHING COMPANY, WASHINGTON, D.C., 1982, PP.39-43
035123 1982 VIIIHTC EXTENDEDSURF
CONDENSATION

BEATTY;K.O. KATZ;D.L.
"CONDENSATION OF VAPORS ON OUTSIDE OF FINNED TUBES"
CHEMICAL ENGINEERING PROGRESS, VOL.44, NO.1, 1948, PP.55-70
035036 1948 CEP EXTENDEDSURF
CONDENSATION

BERGLES;A.E.
"HEAT TRANSFER CHARACTERISTICS OF TURBOTEC TUBING"
HEAT TRANSFER LABORATORY REPORT NO. HTL-24, ISU-ERI-AMES-81018, IOWA STATE UNIVERSITY, 1980
000085 1980 ISU LITSURVEY
ROUGHSURF EXTENDEDSURF 1NATCONV 1FORCECONV
CONDENSATION MASSTRAN

BERNDT;T. CONNELL;J.W.
"PLATE HEAT EXCHANGERS FOR OTEC"
PROCEEDINGS OF THE FIFTH OCEAN THERMAL ENERGY CONVERSION CONF., MIAMI BEACH, FLORIDA, FEBRUARY 1978, PP.VI/288-VI/320
033032 1978 ** EXTENDEDSURF
POOLBOIL CONDENSATION

CAREY;V.P. SHAH;R.K.
"DESIGN OF COMPACT AND ENHANCED HEAT EXCHANGERS FOR LIQUID-VAPOR PHASE-CHANGE APPLICATIONS"
TWO-PHASE FLOW HEAT EXCHANGERS: THERMAL-HYDRAULIC FUNDAMENTALS AND DESIGN, KLUWER ACADEMIC PUBLISHERS, DORDRECHT, THE NETHERLANDS, 1988, PP.909-968
034060 1988 ** EXTENDEDSURF
FLOBOIL CONDENSATION SWIRLFLO

CARNAVOS;T.C.
"AN EXPERIMENTAL STUDY: CONDENSING R-11 ON AUGMENTED TUBES"
AMERICAN SOCIETY OF MECHANICAL ENGINEERS PAPER NO.80-HT-54, 1980.
035091 1980 ASME EXTENDEDSURF
CONDENSATION

CHAIKOVSKII;V.F. BAKHTIOZIN;R.A. LUKANOV;I.I. PUCHKOV;B.V.
"HEAT AND MASS TRANSFER DURING THE CONDENSATION OF MIXTURES OF FREON-12 AND -22 ON HORIZONTAL FINNED TUBES"
KHOLODIL'NAYA TEKHNIKA, VOL.50, NO.2, 1973, PP.24-28
035058 1973 ** EXTENDEDSURF
CONDENSATION

CHENG;K.C. TAKUMA;M.
"FILM CONDENSATION OF R113 ON HORIZONTAL SMOOTH AND FINNED TUBES WIH VAPOR FLOW PARALLEL TO TUBE AXIS"
HEAT TRANSFER EQUIPMENT FUNDAMENTALS, DESIGN, APPLICATIONS, AND OPERATING PROBLEMS, HTD-VOL.108, ASME, NEW YORK, 1989, PP.87-95
035215 1989 ASME EXTENDEDSURF
CONDENSATION

COMBS;S.K.
"AN EXPERIMENTAL STUDY OF HEAT TRANSFER ENHANCEMENT FOR AMMONIA CONDENSING ON VERTICAL FLUTED TUBES"
OAK RIDGE NATIONAL LABORATORY REPORT NO.ORNL-5356, JANUARY 1978
035080 1978 ORNL EXTENDEDSURF
CONDENSATION

COMBS;S.K. MAILEN;G.S. MURPHY;R.W.
"CONDENSATION OF REFRIGERANTS ON VERTICAL FLUTED TUBES"
OAK RIDGE NATIONAL LABORATORY REPORT NO.ORNL/TM-5848, AUGUST 1978
025022 1978 ORNL ROUGHSURF
CONDENSATION EXTENDEDSURF

CONKLIN;J.C. VINEYARD;E.A.
"TUBESIDE CONDENSATION OF NONAZEOTROPIC REFRIGERANT MIXTURES FOR TWO ENHANCED SURFACES"
PROCEEDINGS OF THE 1991 ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE, VOL.3, JSME, TOKYO, AND ASME, NEW YORK, 1991, PP.251-256
035255 1991 ASME-JSME EXTENDEDSURF
CONDENSATION

COOPER;P. ALLEN;P.H.G.
"THE POTENTIAL OF ELECTRICALLY ENHANCED CONDENSERS"
SECOND INTERNATIONAL SYMPOSIUM ON THE LARGE SCALE APPLICATIONS OF HEAT PUMPS, YORK, ENGLAND, 1984, PP.295-309
145010 1984 ** COMPOUNDTECH
ELECTROFIELD EXTENDEDSURF CONDENSATION

CZIKK;A.M. FRICKE;H.D. GANIC;E.N. SHARMA;B.I.
"FLUID DYNAMIC AND HEAT TRANSFER STUDIES OF OTEC HEAT EX-CHANGERS"
PROCEEDINGS OF THE FIFTH OCEAN THERMAL ENERGY CONVERSION CONFERENCE, MIAMI BEACH, FLORIDA, 1978, PP.VI181-VI236.
013078 1978 OTEC TREATSURF
POOLBOIL EXTENDEDSURF CONDENSATION

DEROV;V.T. KOLYKHAN;L.I. NESTERENKO;V.B. PULYAEV;V.F.
"GENERALIZATION OF EXPERIMENTAL DATA ON HEAT TRANSFER DURING CONDENSATION IN HORIZONTAL PIPES WITH CROSS FINNING"
AKADEMIYA NAUK BSSR, VESTSI SERYIA FIZIKA-ENERHETYCHNYKH

NAVUK, NO.3, 1974, PP.66-70
035050 1974 ** EXTENDEDSURF
CONDENSATION

DIGHE;S.V.
"CONDENSATION OF VAPORS ON AXIALLY FLUTED VERTICAL TUBES"
DISSERTATION, CARNEGIE-MELLON UNIVERSITY, 1979
035105 1979 ** EXTENDEDSURF
CONDENSATION

DIGHE;S.V. ROTHFUS;R.R. WILLIAMS;D.F.
"CONDENSATION HEAT TRANSFER ON LONG VERTICAL AXIALLY RIDGED TUBES"
HEAT TRANSFER IN OCEAN THERMAL ENERGY (OTEC) SYSTEMS,
HTD-VOL. 12, ASME, NEW YORK 1980, PP. 1-8.
035103 1980 ** EXTENDEDSURF
CONDENSATION

DOMINGO;N.
"CONDENSATION OF REFRIGERANT-11 ON THE OUTSIDE OF VERTICAL ENHANCED TUBES"
OAK RIDGE NATIONAL LABORATORY, REPORT NO. ORNL/TM-7797,
AUGUST 1981.
035100 1981 ORNL EXTENDEDSURF
CONDENSATION

DOMINGO;N.
"CONDENSATION OF REFRIGERANT-11 ON THE OUTSIDE OF HORIZONTAL AND INCLINED ENHANCED TUBES"
OAK RIDGE NATIONAL LABORATORY, REPORT NO. ORNL/TM-8494,
DECEMBER 1982
035126 1982 ORNL EXTENDEDSURF
CONDENSATION

DOROKHOV;A.R.
"EXPERIMENTAL STUDY OF CONDENSATION OF FLOWING FREON-21 VAPOR ON HORIZONTAL FINNED TUBES"
HEAT TRANSFER-SOVIET RESEARCH, VOL.11,NO.2, 1979, PP.123-127
035092 1979 HTSR EXTENDEDSURF
CONDENSATION

EDWELS;S.J. PATE;M.B.
"EVAPORATION AND CONDENSATION OF HFC-134A AND CFC-12 IN A SMOOTH AND A MICRO-FIN TUBE"
ASHRAE TRANSACTIONS, VOL.97, PART 2, 1991, PP.71-81
035251 1991 ASHRAE EXTENDEDSURF
CONDENSATION FLOBOIL

FRICKE;H.D. WEBSTER;D.J. MC ILROY;K.
BARTZ;J.A.
"HEAT TRANSFER PERFORMANCE OF A DRY AND WET ADVANCED COOLING TOWER CONDENSER"
AMERICAN SOCIETY OF MECHANICAL ENGINEERS PAPER NO.80-HT-99, 1980.
035090 1980 ASME EXTENDEDSURF
CONDENSATION

GANIC;E.N. WU;J.
"ON THE SELECTION OF WORKING FLUIDS FOR OTEC POWER PLANTS"
ENERGY CONVERSION AND MANAGEMENT, VOL.20, NO.1, 1980,
PP.9-22
033061 1980 ** EXTENDEDSURF
POOLBOIL CONDENSATION

GOGONIN;I.I. DOROKHOV;A.R.
"ENHANCEMENT OF HEAT TRANSFER IN HORIZONTAL SHELL-AND-TUBE CONDENSERS"
HEAT TRANSFER - SOVIET RESEARCH, VOL.13, NO.3, 1981, PP.
119-126
035111 1981 HTSR EXTENDEDSURF
CONDENSATION

GOGONIN;I.I. KABOV;O.A. PADYUKOV;I.V.
"FILM CONDENSATION OF A STATIONARY VAPOR ON A FINNED SURFACE"
JOURNAL OF ENGINEERING PHYSICS, VOL.49, 1985, PP.1247-1254
035220 1985 JEP EXTENDEDSURF
CONDENSATION

GOGONIN;I.I. KABOV;O.A.
"INFLUENCE OF IRRIGATION DENSITY OF HEAT TRANSFER DURING CONDENSATION IN FINNED TUBE BUNDLES"
JOURNAL OF ENGINEERING PHYSICS, VOL.51, 1986, PP.759-764
035221 1986 JEP EXTENDEDSURF
CONDENSATION

GOGONIN;I.I. KABOV;O.A.
"ENHANCEMENT OF HEAT TRANSFER FOR VAPOR CONDENSATION IN EVAPORATIVE SYSTEMS OF COOLING"
HEAT TRANSFER IN ELECTRONIC AND MICROELECTRONIC EQUIPMENT,
HEMISPHERE PUBLISHING CORPORATION, NEW YORK, 1990,
PP.509-520
035172 1990 ** EXTENDEDSURF
CONDENSATION

GOPIN;S.R. USYUKIN;I.P. AVER'YANOV;I.G.
"HEAT TRANSFER IN CONDENSATION OF FREONS ON FINNED SURFACES"
HEAT TRANSFER - SOVIET RESEARCH, VOL.8, NO.6, 1976
PP.114-119
035077 1976 HTSR EXTENDEDSURF
CONDENSATION

HIJIKATA;K. HIMENO;N.
"SYSTEMATIC RESEARCH ON OPTIMIZED CONDITION FOR CONDENSATION OF BINARY MIXTURE OF VAPORS"
RESEARCH ON EFFICIENT USE OF THERMAL ENERGY, SPEY 23,
MINISTRY OF EDUCATION, SCIENCE, AND CULTURE, JAPAN, 1987,
PP.21-26
035227 1987 SPEY EXTENDEDSURF
CONDENSATION

HIJIKATA;K. MORI;Y. WEI;P.
"NONCONDENSABLE GAS EFFECT ON HIGH PERFORMANCE VERTICAL CONDENSING SURFACE WITH PARALLEL LOW FINS"
ABSTRACTED IN BULLETIN OF JSME, VOL.29, 1987, PP.1067-1068
035258 1987 BJSME EXTENDEDSURF
CONDENSATION

HIJIKATA;K. SIMODA;K. MORI;Y.
"CONDENSATION HEAT TRANSFER ENHANCEMENT ON A DOWNWARD FACING SURFACE BY THE GRAVITY"
PROCEEDINGS OF THE 1987 ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE, VOL.4, JSME, TOKYO, AND ASME, NEW YORK, 1987,
PP.393-400
145009 1987 ASME-JSME COMPOUNDTECH
CONDENSATION EXTENDEDSURF SURFTENSION

HIJIKATA;K. HIMENO;N. ZHOU;Y.-Q.
GOTO;S.
"FREE CONVECTIVE CONDENSATION OF FLUOROALCOHOL-WATER MIXTURES"
HEAT TRANSFER ENHANCEMENT AND ENERGY CONSERVATION,
HEMISPHERE PUBLISHING CORPORATION, NEW YORK, 1990,
PP.305-317
035173 1990 ** EXTENDEDSURF
CONDENSATION

HIRASAWA;S. HIJIKATA;K. MORI;Y.
NAKAYAMA;W.
"EFFECT OF SURFACE TENSION ON LAMINAR FILM CONDENSATION ALONG A VERTICAL PLATE WITH A SMALL LEADING RADIUS"
HEAT TRANSFER 1978, VOL.2, HEMISPHERE, 1978, PP.413-418
035070 1978 VIIHTC EXTENDEDSURF
CONDENSATION

HIRASAWA;S. HIJIKATA;K. MORI,Y.
NAKAYAMA;W.
"EFFECT OF SURFACE TENSION ON CONDENSATE MOTION IN LAMINAR FILM CONDENSATION (STUDY OF LIQUID FILM IN A SMALL TROUGH)"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.23,
1980, PP.1471-1478
035140 1980 IJHMT EXTENDEDSURF
CONDENSATION

HONDA;H. NOZU;S. MITSUMORI;K.
"AUGMENTATION OF CONDENSATION ON HORIZONTAL FINNED TUBES BY ATTACHING A POROUS DRAINAGE PLATE"
ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE PROCEEDINGS,
HONOLULU, HAWAII, MARCH 1983, VOL.3, PP.289-296
035134 1983 ** EXTENDEDSURF
CONDENSATION TREATSURF

HONDA;A. FUJII;T.
"SEMI-EMPIRICAL EQUATION FOR CONDENSATION HEAT TRANSFER

ON VERTICAL FLUTED TUBES"
"FUNDAMENTALS OF PHASE CHANGE: BOILING AND CONDENSATION, HTD-VOL.38, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1984, PP.99-106
035190 1984 ASME EXTENDEDSURF CONDENSATION

HONDA;H. NOZU;S.
"A PREDICTION METHOD FOR HEAT TRANSFER DURING FILM CONDENSATION ON HORIZONTAL LOW INTEGRAL-FIN TUBES"
FUNDAMENTALS OF PHASE CHANGE: BOILING AND CONDENSATION, HTD-VOL.38, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1984, PP.107-114
035191 1984 ASME EXTENDEDSURF CONDENSATION

HONDA;H. FUJII;T.
"A DIMENSIONLESS CORRELATION FOR HEAT TRANSFER DURING FILM CONDENSATION ON VERTICAL FLUTED SURFACES"
ABSTRACTED IN BULLETIN OF BJSME, VOL.28, 1985, PP.1802
035256 1985 BJSME EXTENDEDSURF CONDENSATION

HONDA;H. NOZU;S.
"A PREDICTION METHOD FOR HEAT TRANSFER DURING FILM CONDENSATION ON HORIZONTAL LOW INTEGRAL-FIN TUBES"
JOURNAL OF HEAT TRANSFER, VOL.109, 1987, PP.218-225
035155 1987 JHT EXTENDEDSURF CONDENSATION

HONDA;H. NOZU;S. TAKEDA;Y.
"A THEORETICAL MODEL OF FILM CONDENSATION IN A BUNDLE OF HORIZONTAL LOW FINNED TUBES"
BOILING AND CONDENSATION IN HEAT TRANSFER EQUIPMENT, HTD-VOL.85, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1987, PP.79-85
035216 1987 ASME EXTENDEDSURF CONDENSATION

HONDA;H. NOZU;S. TAKEDA;Y.
"FLOW CHARACTERISTICS OF CONDENSATE ON A VERTICAL COLUMN OF HORIZONTAL LOW FINNED TUBES"
PROCEEDINGS OF THE 1987 ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE, VOL.1, JSME, TOKYO, AND ASME, NEW YORK, 1987, PP.517-524
035223 1987 ASME-JSME EXTENDEDSURF CONDENSATION

HONDA;H. NOZU;S. UCHIMA;B.
"A GENERALIZED PREDICTION METHOD FOR HEAT TRANSFER DURING FILM CONDENSATION ON A HORIZONTAL LOW FINNED TUBE"
PROCEEDINGS OF THE 1987 ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE, VOL.4, JSME, TOKYO, AND ASME, NEW YORK, 1987, PP.385-392
035225 1987 ASME-JSME EXTENDEDSURF CONDENSATION

HONDA;H. NOZU;S. TAKEDA;Y.
"A THEORETICAL MODEL OF FILM CONDENSATION IN A BUNDLE OF HORIZONTAL LOW FINNED TUBES"
JOURNAL OF HEAT TRANSFER, VOL.111, 1989, PP.525-532
035153 1989 JHT EXTENDEDSURF CONDENSATION

HONDA;H. UCHIMA;B. NOZU;S.
NAKATA;H. TORIGOE;E.
"FILM CONDENSATION OF DOWNWARD FLOWING R-113 VAPOR ON IN-LINE BUNDLES OF HORIZONTAL FINNED TUBES"
HEAT TRANSFER EQUIPMENT FUNDAMENTALS, DESIGN, APPLICATIONS, AND OPERATING PROBLEMS, HTD-VOL.108, ASME, NEW YORK, 1989, PP.117-125
035213 1989 ASME EXTENDEDSURF CONDENSATION

HONDA;H. NOZU;S. MATSUOKA;Y.
AOYAMA;T. NAKATA;H.
"CONDENSATION OF REFRIGERANTS R-11 AND R-113 IN THE ANNULI OF HORIZONTAL DOUBLE-TUBE CONDENSERS WITH AN ENHANCED INNER TUBE"
EXPERIMENTAL THERMAL AND FLUID SCIENCE, VOL.2, 1989, PP.173-182
145007 1989 ETFS COMPOUNDTECH CONDENSATION EXTENDEDSURF ROUGHSURF

HONDA;H. NOZU;S. UCHIMA;B.
FUKUMORI;H. KOBAYASHI;T.
"EXPERIMENTAL STUDY OF THE ENHANCEMENT OF CONDENSATION HEAT TRANSFER ON DOWNWARD-FACING HORIZONTAL SURFACES"
HEAT TRANSFER 1990, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, VOL.3, 1990, PP.103-108
035178 1990 IXIHTC EXTENDEDSURF CONDENSATION

HONDA;H. NOZU;S.
"EFFECTS OF BUNDLE DEPTH AND WORKING FLUID ON THE OPTIMIZED FIN GEOMETRY OF A HORIZONTAL LOW FINNED CONDENSER TUBE"
PROCEEDINGS OF THE SECOND INTERNATIONAL SYMPOSIUM ON CONDENSERS AND CONDENSATION, UNIVERSITY OF BATH, UK, HEAT TRANSFER AND FLUID FLOW SERVICE, UK, 1990, PP.407-416
035200 1990 ** EXTENDEDSURF CONDENSATION

HONDA;H. UCHIMA;B. NOZU;S.
NAKATA;H. TORIGOE;E.
"FILM CONDENSATION OF R-113 ON INLINE BUNDLES OF HORIZONTAL FINNED TUBES"
JOURNAL OF HEAT TRANSFER, VOL.113, 1991, PP.479-486
035230 1991 JHT EXTENDEDSURF CONDENSATION

HONDA;H. UCHIMA;B. NOZU;S.
TORIGOE;E. IMAI;S.
"FILM CONDENSATION OF DOWNWARD FLOWING R-113 VAPOR ON STAGGERED BUNDLES OF HORIZONTAL FINNED TUBES"
PROCEEDINGS OF THE 1991 ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE, VOL.2, JSME, TOKYO, AND ASME, NEW YORK, 1991, PP.487-494
035253 1991 ASME-JSME EXTENDEDSURF CONDENSATION

HONDA;H. UCHIMA;B. NOZU;S.
TORIGOE;E. IMAI;S.
"FILM CONDENSATION OF R-113 ON STAGGERED BUNDLES OF HORIZONTAL FINNED TUBES"
JOURNAL OF HEAT TRANSFER, VOL.114, 1992, PP.442-449
035229 1992 JHT EXTENDEDSURF CONDENSATION

HORAZAK;D.A. RABAS;T.J.
"CAPITOL COST SYSTEM OPTIMIZATION OF OTEC POWER MODULES"
ENERGY TECHNOLOGY CONFERENCE, HOUSTON, TEXAS, NOVEMBER 1978
150064 1978 ** PERFORMANCE TREATSURF ROUGHSURF EXTENDEDSURF CONDENSATION

INDULKAR;M.V. SUKHATME;S.P.
"EFFECT OF FIN HEIGHT ON HEAT TRANSFER DURING CONDENSATION OF R-11 ON HORIZONTAL INTEGRAL-FIN TUBES"
INDIAN JOURNAL OF TECHNOLOGY, VOL.30, 1992, PP.387-391
035244 1992 IJT EXTENDEDSURF CONDENSATION

IVANOV;O.P., BUTYRSKAYA;S.T. MAMCHENKO;V.O.
"HEAT TRANSFER ATTENDING THE CONDENSATION OF F-12 VAPOR MOVING AT BUNDLES OF SMOOTH AND FINNED TUBES"
HEAT TRANSFER-SOVIET RESEARCH,VOL.4,NO.6,1972,PP.143-149
035061 1972 HTSR EXTENDEDSURF CONDENSATION

IVANOV;O.P. KHIZHNYAKOV;S.V.
"ENHANCEMENT OF HEAT TRANSFER IN CONDENSATION OF REFRIGERANT VAPOR ON HORIZONTAL FINNED TUBES"
HEAT TRANSFER - SOVIET RESEARCH, VOL.23, NO.3, 1991, PP.344-351
035240 1991 HTJR EXTENDEDSURF CONDENSATION

KABOV;O.A.
"FILM CONDENSATION OF IMMOBILE VAPOR ON A HORIZONTAL FINNED CYLINDER"
HEAT TRANSFER-SOVIET RESEARCH, VOL.16, NO.6, 1984, PP.76-
035207 1984 HTSR EXTENDEDSURF

CONDENSATION

KARKHU;V.A. BOROVKOV;V.P.
"FILM CONDENSATION OF VAPOR AT FINELY-FINNED HORIZONTAL TUBES"
HEAT TRANSFER-SOVIET RESEARCH, VOL.3, NO.2, 1971, PP.183-191
035018 1971 HTSR EXTENDEDSURF CONDENSATION

KATZ;D.L. HOPE;R.E. DATSKO;S.C. ROBINSON;D.B.
"CONDENSATION OF FREON-12 WITH FINNED TUBES"
REFRIGERATING ENGINEERING, VOL.53, 1947, PP.211-217
035024 1947 ** EXTENDEDSURF CONDENSATION

KATZ;D.L. HOPE;R.E. DATSKO;S.C. ROBINSON;D.B.
"CONDENSATION OF FREON-12 WITH FINNED TUBES. PART II"
REFRIGERATING ENGINEERING, VOL.53, 1947, PP.315-319, 352, 354
035025 1947 ** EXTENDEDSURF CONDENSATION

KAUSHIK;N. AZER;N.Z.
"A GENERAL HEAT TRANSFER CORRELATION FOR CONDENSATION INSIDE INTERNALLY FINNED TUBES"
ASHRAE TRANSACTIONS, VOL.94, PART 2, 1988, PP.261-279
035168 1988 ASHRAE EXTENDEDSURF CONDENSATION

KAUSHIK;N. AZER;N.Z.
"CONDENSATION HEAT TRANSFER ENHANCEMENT BY DOUBLY AUGMENTED TUBES"
ASHRAE TRANSACTIONS, VOL.94, PART 2, 1988, PP.1159-1175
035169 1988 ASHRAE EXTENDEDSURF CONDENSATION ROUGHSURF 1FORCECONV

KAJIKAWA;T. TAKAZAWA;H. NISHIYAMA;K.
AGAWA;T. IIDAKA;H. AMANO;M.
"DEVELOPMENT OF ENHANCEMENT OF THE WORKING FLUID SIDE HEAT TRANSFER FOR OTEC"
PROCEEDINGS OF THE SEVENTH OCEAN ENERGY CONFERENCE, CONF-800633, VOL.2, 1980, PP.12.2-1 - 12.2-9
013113 1980 ** TREATSURF POOLBOIL EXTENDEDSURF CONDENSATION

KAWANO;S.
"CONDENSATION OF BINARY MIXTURE IN VERTICAL CONDENSERS"
PROCEEDINGS OF THE SECOND INTERNATIONAL SYMPOSIUM ON CONDENSERS AND CONDENSATION, UNIVERSITY OF BATH, UK, HEAT TRANSFER AND FLUID FLOW SERVICE, UK, 1990, PP.49-58
035196 1990 ** EXTENDEDSURF CONDENSATION

KEDZIERSKI;M.A. WEBB;R.L.
"EXPERIMENTAL MEASUREMENTS OF CONDENSATION ON VERTICAL PLATES WITH ENHANCED FINS"
BOILING AND CONDENSATION IN HEAT TRANSFER EQUIPMENT, HTD-VOL.85, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1987, PP.87-95
035217 1987 ASME EXTENDEDSURF CONDENSATION

KEDZIERSKI;M.A. WEBB;R.L.
"PRACTICAL FIN SHAPES FOR SURFACE-TENSION-DRAINED CONDENSATION"
JOURNAL OF HEAT TRANSFER, VOL.112, 1990, PP.479-485
035151 1990 JHT EXTENDEDSURF CONDENSATION

KHANPARA;J.C. BERGLES;A.E. PATE;M.B.
"AUGMENTATION OF R-113 IN-TUBE CONDENSATION WITH MICRO-FIN TUBES"
HEAT TRANSFER IN AIR CONDITIONING AND REFRIGERATION EQUIPMENT, HTD-VOL.65, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1986, PP.21-32
035205 1986 ASME EXTENDEDSURF CONDENSATION

KHARKHU;V.A. BOROVKOV;V.P.
"THE EFFECT OF TWIST IN A FLUID STREAM ON THE INTENSIFICATION OF HEAT TRANSFER IN A CIRULAR CYLINDRICAL TUBE"
AD-729 750, 1971
035027 1971 ** EXTENDEDSURF CONDENSATION

KIKKAWA;K KAWAI;S. MACHUZAMA;T.
"SOME TRIALS ON THE IMPROVEMENTS OF CONDENSING HEAT TRANSFER COEFFICIENTS OF FINNED-TUBE"
BULLETIN OF SCIENCE AND ENGINEERING RESEARCH LABORATORY, WASEDA UNIVERSITY, JAPAN, VOL.78, 1977, PP.62-65.
035045 1977 ** EXTENDEDSURF CONDENSATION

KONDEPUDI;S.N. O'NEAL;D.L.
"MODELING TUBE-FIN HEAT EXCHANGERS UNDER FROSTING CONDITIONS"
PROCEEDINGS OF THE XVIII INTERNATIONAL CONGRESS OF REFRIGERATION, VOL.3, INTERNATIONAL INSTITUTE OF REFRIGERATION, PARIS, FRANCE, 1991, PP.1289-1293
035246 1991 ** EXTENDEDSURF CONDENSATION

KOYAMA;S. MIYARA;A. TAKAMATSU;H.
FUJII;T.
"CONDENSATION HEAT TRANSFER OF BINARY REFRIGERANT MIXTURES OF R22 AND R114 INSIDE A HORIZONTAL TUBE WITH INTERNAL SPIRAL GROOVES"
INTERNATIONAL JOURNAL OF REFRIGERATION, VOL.13, 1990, PP.256-263
035268 1990 IJR EXTENDEDSURF CONDENSATION NHC

KROEGER;D.G.
"LAMINAR CONDENSATION HEAT TRANSFER INSIDE INCLINED TUBES"
AMERICAN INSTITUTE OF CHEMICAL ENGINEERS SYMPOSIUM SERIES NO.164, VOL.73, 1977, PP.256-260
035043 1976 AICHE EXTENDEDSURF CONDENSATION

KROEGER;D.G.
"DEVELOPMENT OF HIGH PERFORMANCE AIR-COOLED REFRIGERANT CONDENSERS"
I.I.R.-COMMISSIONS B1, B2, E1, BEOGRAD, YUGOSLAVIA, 1977
035083 1977 ** EXTENDEDSURF CONDENSATION

LEWIS;L.G. SATHER;N.F.
"OTEC PERFORMANCE TESTS OF THE CARNEGIE-MELLON UNIVERSITY VERTICAL FLUTED-TUBE CONDENSER"
ARGONNE NATIONAL LABORATORY, OCEAN THERMAL ENERGY CONVERSION
PROGRAM, REPORT NO. ANL/OTEC-PS-4, MAY 1979.
032262 1979 ANL EXTENDEDSURF 1FORCECONV CONDENSATION

LUU;M. BERGLES;A.E.
"ENHANCEMENT OF HORIZONTAL IN-TUBE CONDENSATION OF R-113"
ASHRAE TRANSACTIONS, VOL.85, PART 2, 1979, PP.293-312.
025031 1979 ASHRAET ROUGHSURF CONDENSATION EXTENDEDSURF SWIRLFLO

LUU;M. BERGLES;A.E.
"AUGMENTATION OF IN-TUBE CONDENSATION OF R-113"
HEAT TRANSFER LABORATORY REPORT NO. HTL-23, ISU-ERI-AMES-80175, IOWA STATE UNIVERSITY,1980.
025035 1979 ISU ROUGHSURF EXTENDEDSURF CONDENSATION SWIRLFLO

MARKOWITZ;A. MIKIC;B.B. BERGLES;A.E.
"CONDENSATION ON A DOWNWARD FACING, HORIZONTAL RIPPLED SURFACE"
JOURNAL OF HEAT TRANSFER, VOL.94, 1972, PP.315-320
035008 1972 JHT EXTENDEDSURF CONDENSATION

MARTO;P.J.
"HEAT TRANSFER AND TWO-PHASE FLOW DURING SHELL-SIDE CONDENSATION"
HEAT TRANSFER ENGINEERING, VOL.5, NOS.1-2, 1984, PP.31-
000174 1984 HTE LITSURVEY

CONDENSATION EXTENDEDSURF

MARTO;P.J.
"RECENT PROGRESS IN ENHANCING FILM CONDENSATION HEAT TRANSFER ON HORIZONTAL TUBES"
HEAT TRANSFER 1986, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, 1986, VOL.1, PP.161-170
000147 1986 VIIIIHTC LITSURVEY
CONDENSATION EXTENDEDSURF ROUGHSURF TREATSURF

MARTO;P.J.
"RECENT PROGRESS IN ENHANCING FILM CONDENSATION HEAT TRANSFER ON HORIZONTAL TUBES"
HEAT TRANSFER ENGINEERING, VOL.7, NOS.3-4, 1986, PP.53-
000175 1986 HTE LITSURVEY
CONDENSATION EXTENDEDSURF ROUGHSURF

MARTO;P.J. ZEBROWSKI;D. WANNIARACHCHI;A.S. ROSE;J.W.
"FILM CONDENSATION OF R-113 ON HORIZONTAL FINNED TUBES"
ASME PROCEEDINGS OF THE 1988 NATIONAL HEAT TRANSFER CONFERENCE, HTD-96, VOL.2, ASME, NEW YORK, 1988, PP.583-592
035267 1988 ASME EXTENDEDSURF
CONDENSATION

MARTO;P.J. ZEBROWSKI;D. WANNIARACHCHI;A.S. ROSE;J.W.
"AN EXPERIMENTAL STUDY OF R-113 FILM CONDENSATION ON HORIZONTAL INTEGRAL-FIN TUBES"
JOURNAL OF HEAT TRANSFER, VOL.112, 1990, PP.758-767
035234 1990 JHT EXTENDEDSURF
CONDENSATION

MC GOWAN;J.G. HERONEMUS;W.E. BRAREN;R.
"DEVELOPMENT OF COMPACT HEAT EXCHANGERS FOR OCEAN THERMAL ENERGY CONVERSION (OTEC) SYSTEMS"
AMERICAN SOCIETY OF MECHANICAL ENGINEERS PAPER NO.78-WA/HT-34, 1978
034019 1978 ASME EXTENDEDSURF
FLOBOIL CONDENSATION

MC NAUGHT;J.M. COTCHIN;C.D.
"HEAT TRANSFER AND PRESSURE DROP IN A SHELL AND TUBE CONDENSER WITH PLAIN AND LOW-FIN TUBE BUNDLES"
SECOND UK NATIONAL CONFERENCE ON HEAT TRANSFER, GLASGOW, VOL.2, 1988, PP.1125-1135
035228 1988 IIUKNHTC EXTENDEDSURF
CONDENSATION

MICHEL;J.W.
"ANALYTICAL AND EXPERIMENTAL STUDIES OF OTEC HEAT TRANSFER PROBLEMS AT OAK RIDGE NATIONAL LABORATORY"
PROCEEDINGS FOURTH ANNUAL CONFERENCE ON OCEAN THERMAL ENERGY
CONVERSION, MARCH 1977, PP. VI-15 - VI-26.
035098 1977 ** EXTENDEDSURF
CONDENSATION

MICHEL;J.W.
"ENHANCEMENT ON VERTICAL FLUTED SURFACES"
POWER CONDENSER HEAT TRANSFER TECHNOLOGY, HEMISPHERE PUBLISHING CORPORATION, 1981, PP.325-344
035116 1981 ** EXTENDEDSURF
CONDENSATION

MICHAEL;A.G. MARTO;P.J. WANNIARACHCHI;A.S. ROSE;J.W.
"EFFECT OF VAPOR VELOCITY DURING CONDENSATION ON HORIZONTAL SMOOTH AND FINNED TUBES"
HEAT TRANSFER WITH PHASE CHANGE, HTD VOL.114, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1989, PP.1-10
035226 1989 ASME EXTENDEDSURF
CONDENSATION

MICHAEL;A.G. MARTO;P.J. WANNIARACHCHI;A.S. ROSE;J.W.
"FILMWISE CONDENSATION OF R-113 ON HORIZONTAL INTEGRAL-FIN TUBES OF DIFFERENT DIAMETERS"
HEAT TRANSFER 1990, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, VOL.2, 1990, PP.15-20
035177 1990 IXIHTC EXTENDEDSURF
CONDENSATION

MITSUDA;M. KANZAKI;N. YAMAMOTO;M. SONOI;H.
"PERFORMANCE OF A COMPACT HEAT EXCHANGER AS THE CONDENSER OF BINARY REFRIGERANTS WORKING IN A HEAT PUMP"
PROCEEDINGS OF THE SECOND INTERNATIONAL SYMPOSIUM ON CONDENSERS AND CONDENSATION, UNIVERSITY OF BATH, UK, HEAT TRANSFER AND FLUID FLOW SERVICE, UK, 1990, PP.357-366
035197 1990 ** EXTENDEDSURF
CONDENSATION

MORI;Y. HIJIKATA;K. HIRASAWA;S.
"OPTIMIZED PERFORMANCE OF CONDENSERS WITH OUTSIDE CONDENSING SURFACE"
JOURNAL OF HEAT TRANSFER, VOL. 103, NO. 1, 1981, PP. 96-102
035084 1981 JHT EXTENDEDSURF
CONDENSATION

MORI;Y. WEI;P. HIJIKATA;K.
"NONCONDENSABLE GAS EFFECT ON HIGH PERFORMANCE VERTICAL CONDENSING SURFACE WITH PARALLEL LOW FINS"
ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE PROCEEDINGS, HONOLULU, HAWAII, MARCH 1983, VOL.3, PP.297-303
035135 1983 ** EXTENDEDSURF
CONDENSATION

MORI;Y. HIJIKATA;K. KONDOU;T. HIRASAWA;S.
"FUNDAMENTAL STUDY OF CONDENSATION HEAT TRANSFER TO VERTICAL TUBES WITH LONGITUDINALLY SMALL FINS (EFFECTS OF SUPERHEAT, VAPOR VELOCITY AND TUBE ARRANGEMENT)"
ABSTRACTED IN BULLETIN OF BJSME, VOL.28, 1985, PP.1802-1803
035257 1985 BJSME EXTENDEDSURF
CONDENSATION

MOSKVICHEVA;V.N. GOGONIN;I.I. DOROKHOV;A.R.
"HEAT EXCHANGE IN R-21 BOILING AND CONDENSATION"
HEAT EXCHANGE IN REFRIGERATING SYSTEMS, INTERNATIONAL INSTITUTE OF REFRIGERATION, PARIS, FRANCE, 1970, PP.259-268
034092 1970 ** EXTENDEDSURF
FLOBOIL CONDENSATION

MURATA;K. ABE;N. HASHIZUME;K.
"CONDENSATION HEAT TRANSFER IN A BUNDLE OF HORIZONTAL INTEGRAL-FIN TUBES"
HEAT TRANSFER 1990, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, VOL.4, 1990, PP.259-264
035179 1990 IXIHTC EXTENDEDSURF
CONDENSATION

MURATA;K. HASHIZUME;K.
"PREDICTION OF CONDENSATION HEAT TRANSFER COEFFICIENT IN HORIZONTAL INTEGRAL-FIN TUBE BUNDLES"
EXPERIMENTAL HEAT TRANSFER, VOL.5, 1992, PP.115-130
035245 1992 EHT EXTENDEDSURF
CONDENSATION

MURPHY;R.W. MICHEL;J.W.
"ENHANCEMENT OF REFRIGERANT CONDENSATION"
ASHRAE TRANSACTIONS, VOL.90, PART 1B, 1984, PP.72-79
035165 1984 ASHRAE EXTENDEDSURF
CONDENSATION ROUGHSURF

MURPHY;R.W. CHEN;F.C. HWANG;B.C.
"CONDENSING HEAT TRANSFER FOR R114/R12 MIXTURES ON HORIZONTAL FINNED TUBES"
INTERNATIONAL JOURNAL OF REFRIGERATION, VOL.11, 1988, PP.361-366
035243 1988 IJR EXTENDEDSURF
CONDENSATION

NAKAYAMA;W. TAKAHASHI;K. SENSHU;T. YOSHIDA;H.
"HEAT TRANSFER ANALYSIS OF SHELL-AND-TUBE CONDENSERS WITH SHELL-SIDE ENHANCEMENT"
ASHRAE TRANSACTIONS, VOL.90, PART 1B, 1984, PP.60-71
035164 1984 ASHRAE EXTENDEDSURF
CONDENSATION

NAKAOKA;T. UEHARA;H.

"PERFORMANCE TEST OF A SHELL-AND-PLATE-TYPE CONDENSER FOR OTEC"
EXPERIMENTAL THERMAL AND FLUID SCIENCE, VOL.1, 1988, PP.275-281
145006 1988 ETFS COMPOUNDTECH
CONDENSATION EXTENDEDSURF ROUGHSURF 1FORCECONV

NOZU;S. HONDA;H.
"EFFECTS OF BUNDLE DEPTH AND WORKING FLUID ON THE OPTIMIZED FIN GEOMETRY OF A HORIZONTAL LOW-FINNED CONDENSER TUBE"
HEAT TRANSFER - JAPANESE RESEARCH, VOL.20, NO.5, 1991, PP.441-457
035239 1991 HTJR EXTENDEDSURF
CONDENSATION

NOZU;S. OZAKI;K. INABA;H. HONDA;H.
"CONDENSATION OF NON-AZEOTROPIC REFRIGERANT MIXTURE OF R114/R113 IN THE ANNULI WITH AN ENHANCED INNER TUBE"
PROCEEDINGS OF THE 1991 ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE, VOL.2, JSME, TOKYO, AND ASME, NEW YORK, 1991, PP.471-478
035254 1991 ASME-JSME EXTENDEDSURF
CONDENSATION

PANCHAL;C.B. HILLIS;D.L. LORENZ;J.J. YUNG;D.T.
"OTEC PERFORMANCE TESTS OF THE TRANE PLATE-FIN HEAT EXCHANGER"
ARGONNE NATIONAL LABORATORY, REPORT NO. ANL/OTEC-PS-7, APRIL 1981.
150053 1981 ANL PERFORMANCE
EXTENDEDSURF POOLBOIL CONDENSATION

PANCHAL;C.B. FRANCE;D.M. BELL;K.J.
"EXPERIMENTAL INVESTIGATION OF SINGLE-PHASE, CONDENSATION, AND FLOW BOILING HEAT TRANSFER FOR A SPIRALLY FLUTED TUBE"
HEAT TRANSFER ENGINEERING, VOL.13, NO.1, 1992, PP.42-52
035238 1992 HTE EXTENDEDSURF
CONDENSATION FLOBOIL

PANDAY;P.K. BILEK;A.
"CONDENSATION OF PURE VAPOUR ON LONGITUDINALLY GROOVED VERTICAL CYLINDERS"
NUMERICAL METHODS IN THERMAL PROBLEMS, PART 1, PINERIDGE PRESS, SWANSEA, UK, 1985, PP.218-228
035250 1985 ** EXTENDEDSURF
CONDENSATION

PANDOLFINI;P.P. KEIRSEY;J.L. FUNK;J.A. CUSICK;R.T.
"TESTS OF THE APJ/H6 FOLDED-TUBE, OTEC HEAT EXCHANGER CORE UNIT"
HEAT TRANSFER IN OCEAN THERMAL ENERGY (OTEC) SYSTEMS, HTD-VOL. 12, ASME, NEW YORK 1980, PP. 9-15.
034033 1980 ** EXTENDEDSURF
FLOBOIL CONDENSATION

PATE;M.B.
"DESIGN CONSIDERATIONS FOR AIR-CONDITIONING EVAPORATOR AND CONDENSER COILS"
TWO-PHASE FLOW HEAT EXCHANGERS: THERMAL-HYDRAULIC FUNDAMENTALS AND DESIGN, KLUWER ACADEMIC PUBLISHERS, DORDRECHT, THE NETHERLANDS, 1988, PP.849-884
034059 1988 ** EXTENDEDSURF
FLOBOIL CONDENSATION SWIRLFLO MASSTRAN

PATE;M.B.
"RECENT DEVELOPMENTS IN CONDENSERS AND CONDENSATION FOR REFRIGERATION AND AIR-CONDITIONING APPLICATIONS"
PROCEEDINGS OF THE SECOND INTERNATIONAL SYMPOSIUM ON CONDENSERS AND CONDENSATION, UNIVERSITY OF BATH, UK, HEAT TRANSFER AND FLUID FLOW SERVICE, UK, 1990, PP.1-25
000166 1990 ** LITSURVEY
CONDENSATION EXTENDEDSURF TREATSURF

PEARSON;J.F. WITHERS;J.G.
"NEW FINNED TUBE CONFIGURATION IMPROVES REFRIGERANT CONDENSING"
ASHRAE JOURNAL, JUNE 1969, PP.77-82
035076 1969 ASHRAE EXTENDEDSURF
CONDENSATION

POVOLOTSKIY;V.M. MANKOVSKIY;O.N. PIVOVAROV;M.A.
"HEAT TRANSFER WITH VAPOR CONDENSATION ON A LONGITUDINALLY FINNED VERTICAL SURFACE"
HEAT TRANSFER-SOVIET RESEARCH, VOL.21, NO.1, 1989, PP.11-
035209 1989 HTSR EXTENDEDSURF
CONDENSATION

REISBIG;R.L.
"CONDENSING HEAT TRANSFER AUGMENTATION INSIDE SPLINED TUBES"
ASME PAPER NO.74-HT-7 PRESENTED AT AIAA/ASME THERMOPHYSICS AND HEAT TRANSFER CONFERENCE, BOSTON, JULY 1974
035060 1974 ASME EXTENDEDSURF
CONDENSATION

RIFERT;V.G. LEONT'YEV;G.G. CHAPLINSKIY;S.I. YEFREMOV;A.A.
"AUGMENTATION OF HEAT TRANSFER FROM REFRIGERENTS CONDENSING ON VERTICAL TUBES"
HEAT TRANSFER - SOVIET RESEARCH, VOL.8, NO.6, 1976, PP.120-126
035078 1976 HTSR EXTENDEDSURF
CONDENSATION

RIFERT;V.G. BARABASH;P.A. GOLUBEV;A.B. LEONT'YEV;G.G. CHAPLINSKIY;S.I.
"INVESTIGATION OF FILM CONDENSATION ENHANCED BY SURFACE FORCES"
HEAT TRANSFER - SOVIET RESEARCH, VOL.9, NO.2, 1977, PP.23-27
035040 1977 HTSR EXTENDEDSURF
CONDENSATION

RIFERT;V.G.
"A NEW METHOD FOR CALCULATING RATES OF CONDENSATION ON FINNED TUBES"
HEAT TRANSFER - SOVIET RESEARCH, VOL.12, NO.3, 1980, PP. 142-147
035118 1980 HTSR EXTENDEDSURF
CONDENSATION

RIFERT;V.G. TROKOZ;YA.YE. ZADIRAKA;V.YU.
"ENHANCEMENT OF HEAT TRANSFER IN CONDENSATION OF AMMONIA VAPOR ON A BUNDLE OF WIRE-FINNED TUBES"
HEAT TRANSFER-SOVIET RESEARCH, VOL.16, NO.1, 1984, PP.36-
035206 1984 HTSR EXTENDEDSURF
CONDENSATION

ROTHFUS;R.R. NEUMAN;C.P.
"THE OTEC PROGRAM AT CARNEGIE-MELLON UNIVERSITY HEAT TRANSFER RESEARCH AND POWER CYCLE TRANSIENT MODELING"
PROCEEDINGS OF THE FOURTH ANNUAL CONFERENCE ON OCEAN THERMAL ENERGY CONVERSION, NEW ORLEANS, LOUISIANA, MARCH 1977, PP.VI-55 - VI-70
033039 1977 ** EXTENDEDSURF
CONDENSATION POOLBOIL

RUDY;T.M. WEBB;R.L.
"CONDENSATE RETENTION OF HORIZONTAL INTEGRAL-FIN TUBING"
ADVANCES IN ENHANCED HEAT TRANSFER-1981, HTD VOL. 18, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1981, PP. 35-41
035097 1981 ASME EXTENDEDSURF
CONDENSATION

RUDY;T.M. WEBB;R.L.
"AN ANALTYICAL MODEL TO PREDICT CONDENSATE RETENTION ON HORIZONTAL, INTEGRAL-FIN TUBES"
ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE PROCEEDINGS, HONOLULU, HAWAII, MARCH 1980, VOL.1, PP.373-378
035137 1983 ** EXTENDEDSURF
CONDENSATION

RUDY;T.M. WEBB;R.L.
"THEORETICAL MODEL FOR CONDENSATION ON HORIZONTAL, INTEGRAL-FIN TUBES"
AMERICAN INSTITUTE OF CHEMICAL ENGINEERS SYMPOSIUM SERIES, NO.225, VOL.79, 1983, PP.11-18
035139 1983 AICHESS EXTENDEDSURF

CONDENSATION

RUDY;T.M. WEBB;R.L.
"AN ANALYTICAL MODEL TO PREDICT CONDENSATE RETENTION ON HORIZONTAL INTEGRAL-FIN TUBES"
JOURNAL OF HEAT TRANSFER, VOL.107, 1985, PP.361-368
035158 1985 JHT EXTENDEDSURF CONDENSATION

SAMI;S.M. SCHNOTALE;J.
"PREDICTION OF TWO PHASE FLOW CONDENSATION OF PURE AND REFRIGERANT MIXTURES ON ENHANCED SURFACE TUBING"
INTERNATIONAL COMMUNICATIONS IN HEAT AND MASS TRANSFER, VOL.19, 1992, PP.191-202
035241 1992 ICHMT EXTENDEDSURF CONDENSATION

SARTOR;W.E.
"EXTENDED AND ENHANCED TUBE SURFACES TO IMPROVE HEAT TRANSFER"
PROCEEDINGS OF THE SECOND SYMPOSIUM ON SHELL AND TUBE HEAT EXCHANGERS, HOUSTON, TEXAS, SEPTEMBER 1981, PP. 411-418, 1982
025042 1982 ** ROUGHSURF CONDENSATION EXTENDEDSURF

SAUER,JR.;H.J. WILLIAMS;P.E.
"CONDENSATION OF REFRIGERANT-OIL MIXTURES ON LOW-PROFILE FINNED TUBING"
HEAT TRANSFER 1982, VOL.5, HEMISPHERE PUBLISHING COMPANY, WASHINGTON, D.C., 1982, PP.147-152
035121 1978 VIIIHTC EXTENDEDSURF CONDENSATION

SCHLAGER;L.M. PATE;M.B. BERGLES;A.E.
"EVAPORATION AND CONDENSATION OF REFRIGERANT-OIL MIXTURES IN A LOW-FIN TUBE"
ASHRAE TRANSACTIONS, VOL.94, PART 2, 1988, PP.1176-1194
034054 1988 ASHRAE EXTENDEDSURF FLOBOIL CONDENSATION

SCHLAGER;L.M. PATE;M.B. BERGLES;A.E.
"EVAPORATION AND CONDENSATION HEAT TRANSFER AND PRESSURE DROP IN HORIZONTAL, 12.7-MM MICRO-FIN TUBES WITH REFRIGERANT 22"
HEAT TRANSFER EQUIPMENT FUNDAMENTALS, DESIGN APPLICATIONS, AND OPERATING PROBLEMS, HTD-VOL.108, ASME, NEW YORK, 1989, PP.205-213
034067 1989 ASME EXTENDEDSURF FLOBOIL CONDENSATION

SCHLAGER;L.M. PATE;M.B. BERGLES;A.E.
"HEAT TRANSFER AND PRESSURE DROP PERFORMANCE OF SMOOTH AND INTERNALLY FINNED TUBES WITH OIL AND REFRIGERANT 22 MIXTURES"
ASHRAE TRANSACTIONS, VOL.95, PART 2, 1989, PP.375-385
150081 1989 ASHRAE PERFORMANCE EXTENDEDSURF FLOBOIL CONDENSATION

SCHLAGER;L.M. PATE;M.B. BERGLES;A.E.
"CONDENSATION OF REFRIGERANT-OIL MIXTURES IN SMOOTH AND AUGMENTED TUBES"
PROCEEDINGS OF THE SECOND INTERNATIONAL SYMPOSIUM ON CONDENSERS AND CONDENSATION, UNIVERSITY OF BATH, UK, HEAT TRANSFER AND FLUID FLOW SERVICE, UK, 1990, PP.451-460
035204 1990 ** EXTENDEDSURF CONDENSATION

SCHLAGER;L.M. PATE;M.B. BERGLES;A.E.
"EVAPORATION AND CONDENSATION HEAT TRANSFER AND PRESSURE DROP IN HORIZONTAL, 12.7-MM MICROFIN TUBES WITH REFRIGERANT 22"
JOURNAL OF HEAT TRANSFER, VOL.112, 1990, PP.1041-1047
035235 1990 JHT EXTENDEDSURF CONDENSATION FLOBOIL

SCHLAGER;L.M. PATE;M.B. BERGLES;A.E.
"OIL QUANTITY MEASUREMENTS IN SMOOTH AND MICRO-FIN TUBES DURING EVAPORATION AND CONDENSATION OF REFRIGERANT-OIL MIXTURES"
ASHRAE TRANSACTIONS, VOL.96, PART 2, 1990, PP.465-469
035252 1990 ASHRAE EXTENDEDSURF CONDENSATION FLOBOIL

SCHNABEL;G.
"ANALYSIS OF LOCAL AND OVERALL HEAT TRANSFER ENHANCEMENT BY DOUBLE FLUTED CONDENSER/EVAPORATOR TUBES"
HEAT EXCHANGERS: THEORY AND PRACTICE, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, AND MC GRAW-HILL BOOK COMPANY, NEW YORK, 1983, PP.205-220
033062 1983 ** EXTENDEDSURF POOLBOIL CONDENSATION

SENSHU;T. SEGA;H.
"HEAT TRANSFER COEFFICIENT FOR CONDENSATION OF R22 AND PERFORMANCE OF CONDENSERS"
HEAT TRANSFER - JAPANESE RESEARCH, VOL.4, 1975, PP.50-60
035044 1975 HTJR EXTENDEDSURF CONDENSATION

SHEKARRIZ;A. PLUMB;O.A.
"ENHANCEMENT OF FILM CONDENSATION USING POROUS FINS"
JOURNAL OF THERMOPHYSICS AND HEAT TRANSFER, VOL.3, NO.3, 1989, PP.309-314
145004 1989 JTHT COMPOUNDTECH CONDENSATION TREATSURF EXTENDEDSURF

SHINOHARA;Y. TOBE;M.
"DEVELOPMENT OF AN IMPROVED 'THERMOFIN TUBE'"
HITACHI CABLE REVIEW, NO.4, AUGUST 1985, PP.47-50
034068 1985 ** EXTENDEDSURF FLOBOIL CONDENSATION

SHOHTANI;H.
"THE EXPERIMENTAL RESEARCH ON CONDENSATION OF THE PLATE-FIN HEAT EXCHANGERS, USING NON-AZEOTROPIC REFRIGERANT MIXTURES"
PROCEEDINGS OF THE SECOND INTERNATIONAL SYMPOSIUM ON CONDENSERS AND CONDENSATION, UNIVERSITY OF BATH, UK, HEAT TRANSFER AND FLUID FLOW SERVICE, UK, 1990, PP.367-376
035198 1990 ** EXTENDEDSURF CONDENSATION

SMIRNOV;G.F. LUKANOV;I.I.
"STUDY OF HEAT TRANSFER FROM FREON-11 CONDENSING ON A BUNDLE OF FINNED TUBES"
HEAT TRANSFER-SOVIET RESEARCH, VOL.4,NO.3,1972,PP.51-56
035063 1972 HTSR EXTENDEDSURF CONDENSATION

SMIRNOV;G.F.
"HEAT TRANSFER IN CONDENSATION OF BINARY MIXTURES ON FINNED SURFACES"
HEAT TRANSFER - SOVIET RESEARCH, VOL.8, NO.1, 1976, PP.45-50
035081 1976 HTSR EXTENDEDSURF CONDENSATION

STAJIC;Z. MARKOSKI;M. HRNJAK;P.
"EXPERIMENTAL STUDY OF HEAT TRANSFER BETWEEN INSIDE EVAPORATING AND OUTSIDE CONDENSING R12 ON LOW EXTERNAL SPIRALLY FINNED TUBES"
PROCEEDINGS OF THE XVIII INTERNATIONAL CONGRESS OF REFRIGERATION, VOL.3, INTERNATIONAL INSTITUTE OF REFRIGERATION, PARIS, FRANCE, 1991, PP.1312-1315
035248 1991 ** EXTENDEDSURF CONDENSATION FLOBOIL

SUKHATME;S.P. JAGADISH;B.S. PRABHAKARAN;P.
"FILM CONDENSATION OF R-11 VAPOR ON SINGLE HORIZONTAL ENHANCED CONDENSER TUBES"
JOURNAL OF HEAT TRANSFER, VOL.112, 1990, PP.229-234
035152 1990 JHT EXTENDEDSURF CONDENSATION

SUKHATME;S.P.
"CONDENSATION ON ENHANCED SURFACE HORIZONTAL TUBES"
HEAT TRANSFER 1990, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, VOL.1, 1990, PP.305-328
000155 1990 IXIHTC LITSURVEY CONDENSATION EXTENDEDSURF

SUR;B. AZER;N.Z.

"CONDENSATION HEAT TRANSFER AND PRESSURE DROP OF OIL-REFRIGERANT MIXTURES INSIDE SMOOTH AND INTERNALLY FINNED TUBES"
HEAT TRANSFER 1990, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, VOL.5, 1990, PP.33-38
035180 1990 IXIHTC EXTENDEDSURF CONDENSATION

SUR;B. AZER;N.Z.
"EFFECT OF OIL ON HEAT TRANSFER AND PRESSURE DROP DURING CONDENSATION OF REFRIGERANT-113 INSIDE SMOOTH AND INTERNALLY FINNED TUBES"
ASHRAE TRANSACTIONS, VOL.97, PART 1, 1991, PP.365-373
035242 1991 ASHRAE EXTENDEDSURF CONDENSATION

TAKAZAWA;H. NISHIYAMA;K. KAJIKAWA;T.
"CONDENSING HEAT TRANSFER ENHANCEMENT ON VERTICAL SPIRAL DOUBLE FIN TUBES WITH DRAINAGE GUTTERS"
ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE PROCEEDINGS, HONOLULU, HAWAII, MARCH 1983, VOL.2, PP.269-275
035136 1983 ** EXTENDEDSURF CONDENSATION

TAN;Y.-K. ZHU;D.-S.
"AN EXPERIMENTAL INVESTIGATION OF HEAT TRANSFER IN CONVECTIVE CONDENSATION OF IMMISCIBLE MIXTURES"
PROCEEDINGS OF THE SECOND INTERNATIONAL SYMPOSIUM ON CONDENSERS AND CONDENSATION, UNIVERSITY OF BATH, UK, HEAT TRANSFER AND FLUID FLOW SERVICE, UK, 1990, PP.39-47
035195 1990 ** EXTENDEDSURF CONDENSATION

TORIKOSHI;K. KAWABATA;K. EBISU;T. SAKON;Y.
"HEAT TRANSFER AUGMENTATION OF CONDENSATION ON A HORIZONTAL TUBE"
PROCEEDINGS OF THE SECOND INTERNATIONAL SYMPOSIUM ON CONDENSERS AND CONDENSATION, UNIVERSITY OF BATH, UK, HEAT TRANSFER AND FLUID FLOW SERVICE, UK, 1990, PP.441-450
035203 1990 ** EXTENDEDSURF CONDENSATION

UEHARA;H. KUSUDA;H. MIYOSHI;M. SUMITOMO;H.
"PLATE TYPE EVAPORATOR AND CONDENSER FOR OCEAN THERMAL ENERGY CONVERSION PLANT"
PROCEEDINGS OF THE FIFTH OCEAN THERMAL ENERGY CONVERSION CONFERENCE, MIAMI BEACH, FLORIDA, FEBRUARY, 1978, PP.VI/261-VI287
033031 1978 OTEC EXTENDEDSURF POOLBOIL CONDENSATION

UEHARA;J. NAKAOKA;T. TAKESUE;H.
"CONDENSATION ON A DOUBLE SWIRL TUBE"
PROCEEDINGS OF THE SECOND INTERNATIONAL SYMPOSIUM ON CONDENSERS AND CONDENSATION, UNIVERSITY OF BATH, UK, HEAT TRANSFER AND FLUID FLOW SERVICE, UK, 1990, PP.431-440
035202 1990 ** EXTENDEDSURF CONDENSATION

VENKATESH;K.S. AZER;N.Z.
"ENHANCEMENT OF CONDENSATION HEAT TRANSFER OF R-11 BY INTERNALLY FINNED TUBES"
ASHRAE TRANSACTIONS, VOL.91, PART 2A, 1985, PP.128-144
035166 1985 ASHRAE EXTENDEDSURF CONDENSATION

VRABLE;D.L. YANG;W.J. CLARK;A.
"CONDENSATION OF REFRIGERANT-12 INSIDE HORIZONTAL TUBES WITH INTERNAL AXIAL FINS"
HEAT TRANSFER 1974, VOL.III, 1974, THE JAPAN SOCIETY OF MECHANICAL ENGINEERS, TOKYO, PP.250-254
035013 1974 VIHTC EXTENDEDSURF CONDENSATION

VRABLE;D.L.
"CONDENSATION HEAT TRANSFER INSIDE HORIZONTAL TUBES WITH INTERNAL AXIAL FINS"
PH.D. DISSERTATION, UNIVERSITY OF MICHIGAN, 1974
035047 1974 ** EXTENDEDSURF CONDENSATION

WANG;J.C.Y. TURAGA;M. LIN;S. FAZIO;P.
"EFFECTS OF REFRIGERANT-OIL MIXTURES ON CONDENSATION HEAT TRANSFER ON THE EXTERNAL SURFACE OF HORIZONTAL TUBES IN WATER-COOLED SHELL-AND-TUBE CONDENSERS"
ASHRAE TRANSACTIONS, VOL.90, PART 1B, 1984, PP.26-38
035162 1984 ASHRAE EXTENDEDSURF CONDENSATION

WANG;J.C.Y. LIN;S. FAZIO;P. JIANG;Z.
"EXPERIMENTAL STUDY ON CONDENSATION OF REFRIGERANT-OIL MIXTURES, PART III: R-12 AND R-22 ON THE EXTERNAL SURFACE OF SINGLE AND MULTIPLE HORIZONTAL FINNED TUBES"
ASHRAE TRANSACTIONS, VOL.95, PART 2, 1989, PP.386-392
035170 1989 ASHRAE EXTENDEDSURF CONDENSATION

WANG;S. LIN;P. WEI;H.
"INVESTIGATION ON PERFORMANCE OF FREON CONDENSER WITH BOTH-SIDE ENHANCED TUBES"
HEAT TRANSFER ENHANCEMENT AND ENERGY CONSERVATION, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, 1990, PP.319-326
035174 1990 ** EXTENDEDSURF CONDENSATION

WANG;S.P. HIJIKATA;K. DENG;S.J.
"EXPERIMENTAL STUDY OF CONDENSATION HEAT TRANSFER ENHANCEMENT BY VARIOUS KINDS OF INTEGRAL FINNED TUBES"
PROCEEDINGS OF THE SECOND INTERNATIONAL SYMPOSIUM ON CONDENSERS AND CONDENSATION, UNIVERSITY OF BATH, UK, HEAT TRANSFER AND FLUID FLOW SERVICE, UK, 1990, PP.397-406
035199 1990 ** EXTENDEDSURF CONDENSATION

WEBB;R.L. GEE;D.L.
"ANALYTICAL PREDICTIONS FOR A NEW CONCEPT SPINE-FIN SURFACE GEOMETRIES"
ASHRAE TRANSACTIONS, VOL. 85, PART 2, 1979, PP. 274-283
035088 1979 ASHRAET EXTENDEDSURF CONDENSATION

WEBB;R.L.
"SHELL-SIDE CONDENSATION IN REFRIGERANT CONDENSER"
ASHRAE TRANSACTIONS, VOL.90, PART 1B, 1984, PP.5-25
000134 1984 ASHRAE LITSURVEY ROUGHSURF EXTENDEDSURF CONDENSATION

WEBB;R.L.
"THE EFFECTS OF VAPOR VELOCITY AND TUBE BUNDLE GEOMETRY ON CONDENSATION IN SHELL-SIDE REFRIGERATION CONDENSERS"
ASHRAE TRANSACTIONS, VOL.90, PART 1B, 1984, PP.39-59
035163 1984 ASHRAE EXTENDEDSURF CONDENSATION

WEBB;R.L. RUDY;T.M. KEDZIERSKI;M.A.
"PREDICTION OF THE CONDENSATION COEFFICIENT ON HORIZONTAL INTEGRAL-FIN TUBES"
JOURNAL OF HEAT TRANSFER, VOL.107, 1985, PP.369-376
035159 1985 JHT EXTENDEDSURF CONDENSATION

WEBB;R.L.
"ENHANCEMENT OF FILM CONDENSATION"
INTERNATIONAL COMMUNICATIONS IN HEAT AND MASS TRANSFER, VOL.15, 1988, PP.475-507
000171 1988 ICHMT LITSURVEY CONDENSATION EXTENDEDSURF

WEBB;R.L. MURAWSKI;C.G.
"ROW EFFECT FOR R-11 CONDENSATION ON ENHANCED TUBES"
JOURNAL OF HEAT TRANSFER, VOL.112, 1990, PP.768-776
035233 1990 JHT EXTENDEDSURF CONDENSATION

WEBB;R.L. MENZE;K.W. APPARAO;T.V.V.R.
"COMPARISON OF ENHANCED AND STANDARD FINNED TUBES: FIELD TEST OF 250-TON CENTRIFUGAL WATER CHILLERS"

HEAT TRANSFER ENGINEERING, VOL.11, NO.2, 1990, PP.19-28
150099 1990 HTE PERFORMANCE
EXTENDEDSURF CONDENSATION

WEI;B.T. YUN;X.Y.
"LAMINAR FILM CONDENSATION OF FREON-AIR MIXTURE ON HIGH PERFORMANCE VERTICAL CONDENSING SURFACE WITH PARALLEL LOW FINS"
SECOND INTERNATIONAL SYMPOSIUM ON MULTIPHASE FLOW AND HEAT TRANSFER, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, VOL.1, 1989, PP.782-789
035265 1989 ** EXTENDEDSURF
CONDENSATION

WITTE;L.C.
"CONDENSATION HEAT TRANSFER"
HEAT TRANSFER IN HIGH TECHNOLOGY AND POWER ENGINEERING, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, 1987, PP.239-254
000181 1987 ** LITSURVEY
CONDENSATION EXTENDEDSURF TREATSURF

XIULING;Y. JINHU;L. ZAIVING;Z.
ZHIMING;C. RUIQI;Z.
"EXPERIMENTAL STUDY OF HEAT TRANSFER ENHANCEMENT FOR CONDENSATION ON RECTANGULAR VERTICAL FLUTED TUBE"
PROCEEDINGS OF THE XVIII INTERNATIONAL CONGRESS OF REFRIGERATION, VOL.3, INTERNATIONAL INSTITUTE OF REFRIGERATION, PARIS, FRANCE, 1991, PP.1307-1311
035247 1991 ** EXTENDEDSURF
CONDENSATION

YANG;W.-J.
"EQUIVALENT F AND J FACTORS FOR CONDENSATION INSIDE HORIZONTAL SMOOTH AND FINNED TUBES"
LETTERS IN HEAT AND MASS TRANSFER,VOL.1,1974,PP.127-130
035048 1974 LHMT EXTENDEDSURF
CONDENSATION

YAU;K.K. COOPER;J.R. ROSE;J.W.
"EFFECTS OF DRAINAGE STRIPS AND FIN SPACING ON HEAT TRANSFER AND CONDENSATE RETENTION FOR HORIZONTAL FINNED AND PLAIN CONDENSER TUBES"
FUNDAMENTALS OF PHASE CHANGE: BOILING AND CONDENSATION, HTD-VOL.38, AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, 1984, PP.151-156
035193 1984 ASME EXTENDEDSURF
CONDENSATION

YAU;K.K. COOPER;J.R. ROSE;J.W.
"HORIZONTAL PLAIN AND LOW-FINNED CONDENSER TUBES - EFFECT OF FIN SPACING AND DRAINAGE STRIPS ON HEAT TRANSFER AND CONDENSATION RETENTION"
JOURNAL OF HEAT TRANSFER, VOL.108, 1986, PP.946-950
035156 1986 JHT EXTENDEDSURF
CONDENSATION

YUNG;D. LORENZ;J.J. PANCHAL;C.
"CONVECTIVE VAPORIZATION AND CONDENSATION IN SERRATED-FIN CHANNELS"
HEAT TRANSFER IN OCEAN THERMAL ENERGY (OTEC) SYSTEMS, HTD-VOL. 12, ASME, NEW YORK, 1980, PP. 29-37.
034034 1980 ** EXTENDEDSURF
FLOBOIL CONDENSATION

YUNG;D.T. HILLIS;D.L. LORENZ;J.L.
SATHER;N.F.
"OTEC PERFORMANCE TESTS OF THE UNION CARBIDE ENHANCED-TUBE CONDENSER"
ARGONNE NATIONAL LABORATORY, OCEAN THERMAL ENERGY CONVERSION
PROGRAM, REPORT NO. ANL/OTEC-PS-2, MAY 1979.
035095 1979 ANL EXTENDEDSURF
CONDENSATION 1FORCECONV

ZENER;C.
"THE POSITIVE SIDE OF USING AMMONIA FOR A SEA THERMAL POWER PLANT"
COMBUSTION, JANUARY 1977, PP.41-42
035066 1977 COMB EXTENDEDSURF
CONDENSATION

ZHOU;X.Q. TAN;Y.K. LU;Y.S.
LIN;P.S.
"AUGMENTATION OF CONDENSATION IN INTERNAL SPIRAL-FINNED TUBES"
SECOND INTERNATIONAL SYMPOSIUM ON MULTIPHASE FLOW AND HEAT TRANSFER, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, VOL.1, 1989, PP.576-584
035266 1989 ** EXTENDEDSURF
CONDENSATION

ZOZULYA;N.V. KARKHU;V.A. BOROVKOV;V.P.
"AN ANALYTIC AND EXPERIMENTAL STUDY OF HEAT TRANSFER CONDENSATION OF VAPOR ON FINNED SURFACES"
HEAT TRANSFER - SOVIET RESEARCH, VOL.9, NO.2, 1977, PP.18-22
035026 1977 HTSR EXTENDEDSURF
CONDENSATION

DISPLACED ENHANCEMENT DEVICES - CONDENSATION

AZER;N.Z. FAN;L.T. LIN;S.T.
"AUGMENTATION OF CONDENSATION HEAT TRANSFER WITH IN-LINE STATIC MIXERS"
PROCEEDINGS OF THE 1976 HEAT TRANSFER AND FLUID MECHANICS INSTITUTE,STANFORD UNIVERSITY PRESS,1976,PP.512-526
045001 1976 ** DISPENHDEVICE
CONDENSATION

FAN;L.T. LIN;S.T. AZER;N.Z.
"SURFACE RENEWAL MODEL OF CONDENSATION HEAT TRANSFER IN TUBES WITH IN-LINE STATIC MIXERS"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.21, 1978, PP.849-854
045004 1978 IJHMT DISPENHDEVICE
CONDENSATION

FAYNZILBERG;S.N. KOLOSKOVA;N.Y. SEMENA;M.G.
"CORRELATION OF EXPERIMENTAL DATA ON THE MAXIMUM HEAT FLUXES IN TWO-PHASE THERMOSYPHONS"
HEAT TRANSFER - SOVIET RESEARCH, VOL.11, NO.2, 1979, PP.119-122
045005 1979 HTSR DISPENHDEVICE
CONDENSATION

LIN;S.T.
"AUGMENTATION OF CONDENSATION HEAT TRANSFER WITH IN-LINE STATIC MIXERS"
M.S. THESIS, KANSAS STATE UNIVERSITY, 1975
045002 1975 ** DISPENHDEVICE
CONDENSATION NHC

LIN;S.
"AUGMENTATION OF TWO PHASE HEAT TRANSFER WITH IN-LINE STATIC MIXERS"
PH.D. DISSERTATION, KANSAS STATE UNIVERSITY, 1979.
044004 1979 ** DISPENHDEVICE
FLOBOIL 1FORCECONV CONDENSATION NHC

LIN;S.T. AZER;N.Z. FAN;L.T.
"HEAT TRANSFER AND PRESSURE DROP DURING CONDENSATION INSIDE HORIZONTAL TUBES WITH STATIC MIXER INSERTS"
ASHRAE TRANSACTIONS, VOL.86, PART 2, 1980, PP.649-661
045003 1980 ASHRAET DISPENHDEVICE
CONDENSATION

LIU;Z.-Q TAN;Y.-K. CUI;N.-Y.
"THE ENHANCEMENT OF R-113 CONDENSATION INSIDE HORIZONTAL TUBES WITH NOVEL TUBE INSERTS"
ADVANCES IN PHASE CHANGE HEAT TRANSFER, INTERNATIONAL ACADEMIC PUBLISHERS, CHONGQING, CHINA, AND PERGAMON PRESS, NEW YORK, 1988, PP.448-453
045007 1988 ** DISPENHDEVICE
CONDENSATION

SWIRL FLOW DEVICES - CONDENSATION

AZER;N.Z. SAID;S.A.
"AUGMENTATION OF CONDENSATION HEAT TRANSFER BY INTERNALLY FINNED TUBES AND TWISTED TAPE INSERTS"
DEPARTMENT OF MECHANICAL ENGINEERING, KANSAS STATE UNIVERSITY FINAL TECHNICAL REPORT, JUNE 1981
035112 1981 ** EXTENDEDSURF
CONDENSATION SWIRLFLO

CAREY;V.P. SHAH;R.K.
"DESIGN OF COMPACT AND ENHANCED HEAT EXCHANGERS FOR LIQUID-VAPOR PHASE-CHANGE APPLICATIONS"
TWO-PHASE FLOW HEAT EXCHANGERS: THERMAL-HYDRAULIC FUNDAMENTALS AND DESIGN, KLUWER ACADEMIC PUBLISHERS, DORDRECHT, THE NETHERLANDS, 1988, PP.909-968
034060 1988 ** EXTENDEDSURF
FLOBOIL CONDENSATION SWIRLFLO

LUU;M. BERGLES;A.E.
"ENHANCEMENT OF HORIZONTAL IN-TUBE CONDENSATION OF R-113"
ASHRAE TRANSACTIONS, VOL.85, PART 2, 1979, PP.293-312.
025031 1979 ASHRAET ROUGHSURF
CONDENSATION EXTENDEDSURF SWIRLFLO

LUU;M. BERGLES;A.E.
"AUGMENTATION OF IN-TUBE CONDENSATION OF R-113"
HEAT TRANSFER LABORATORY REPORT NO. HTL-23, ISU-ERI-AMES-80175, IOWA STATE UNIVERSITY,1980.
025035 1979 ISU ROUGHSURF
EXTENDEDSURF CONDENSATION SWIRLFLO

LUU;M. BERGLES;A.E.
"ENHANCEMENT OF HORIZONTAL IN-TUBE CONDENSATION OF R-113"
ASHRAE TRANSACTIONS, VOL.86, PART 1, 1980, PP.293-311
055010 1980 ASHRAE SWIRLFLO
CONDENSATION EXTENDEDSURF

PATE;M.B.
"DESIGN CONSIDERATIONS FOR AIR-CONDITIONING EVAPORATOR AND CONDENSER COILS"
TWO-PHASE FLOW HEAT EXCHANGERS: THERMAL-HYDRAULIC FUNDAMENTALS AND DESIGN, KLUWER ACADEMIC PUBLISHERS, DORDRECHT, THE NETHERLANDS, 1988, PP.849-884
034059 1988 ** EXTENDEDSURF
FLOBOIL CONDENSATION SWIRLFLO MASSTRAN

SAID;S.A. AZER;N.Z.
"HEAT TRANSFER AND PRESSURE DROP DURING CONDENSATION INSIDE HORIZONTAL TUBES WITH TWISTED-TAPE INSERTS"
ASHRAE TRANSACTIONS, VOL.89, PT.1, 1983, PP.96-113
055009 1983 ASHRAET SWIRLFLO
CONDENSATION

TRAVISS;D.P. ROHSENOW;W.M.
"THE INFLUENCE OF RETURN BENDS ON THE DOWNSTREAM PRESSURE DROP AND CONDENSATION HEAT TRANSFER IN TUBES"
ASHRAE TRANSACTIONS, VOL.79,PART1,1973,PP.129-137
055006 1973 ASHRAE SWIRLFLO
CONDENSATION

COILED TUBES - CONDENSATION

ANAND;G. CHRISTENSEN;R.N. RICHARDS;D.E.
"FORCED CONVECTION CONDENSATION OF AMMONIA INSIDE COILED FLUTED TUBES"
ASHRAE TRANSACTIONS, VOL.94, PART 2, 1988, PP.1132-1158
145005 1988 ASHRAE COMPOUNDTECH
CONDENSATION ROUGHSURF COILEDTUBE

BOKHA1OVSKIY;Y.G.
"HEAT TRANSFER FROM FREON-12, FREON-22 AND THEIR MIXTURES IN A COILED-TUBE CONDENSER"
HEAT TRANSFER-SOVIET RESEARCH, VOL. 12, NO. 4, 1980, PP. 43-45.
165006 1980 HTSR COILEDTUBE
CONDENSATION

IVASHCHENKO;N.I. KREKTUNOV;O.P. LEBEDEVA;L.V.
"HEAT TRANSFER AND HYDRAULIC RESISTANCE OF VAPOR CONDENSING IN TUBES AND COILS"
HEAT TRANSFER - SOVIET RESEARCH, VOL.23, NO.1, 1991, PP.1-13
165009 1991 HTSR COILEDTUBE
CONDENSATION

PANCHAL;C.B. YAMPOLSKY;J. BUYCO;E.H.
BELL;K.J.
"A SPIRALLY FLUTED TUBE HEAT EXCHANGER AS A CONDENSER AND EVAPORATOR"
HEAT TRANSFER 1986, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, 1986, VOL.6, PP.2787-2972
165007 1986 VIIIIHTC COILEDTUBE
CONDENSATION FLOBOIL

YAMASHITA;T.
"HEAT TRANSFER OF SHELL-AND-COIL CONDENSER"
HEAT TRANSFER - JAPANESE RESEARCH, VOL. 1, NO. 3, 1972, PP. 8-18
165003 1972 HTJR COILEDTUBE
CONDENSATION

SURFACE TENSION DEVICES - CONDENSATION

HIJIKATA;K. SIMODA;K. MORI;Y.
"CONDENSATION HEAT TRANSFER ENHANCEMENT ON A DOWNWARD FACING SURFACE BY THE GRAVITY"
PROCEEDINGS OF THE 1987 ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE, VOL.4, JSME, TOKYO, AND ASME, NEW YORK, 1987, PP.393-400
145009 1987 ASME-JSME COMPOUNDTECH
CONDENSATION EXTENDEDSURF SURFTENSION

PLUMB;O.A. BURNETT;D.B. SHEKARRIZ;A.
"FILM CONDENSATION ON A VERTICAL FLAT PLATE IN A PACKED BED"
JOURNAL OF HEAT TRANSFER, VOL.112, 1990, PP.235-239
065002 1990 JHT SURFTENSION
CONDENSATION

SOZEN;M. VAFAI;K.
"ANALYSIS OF THE NON-THERMAL EQUILIBRIUM CONDENSING FLOW OF A GAS THROUGH A PACKED BED"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.33, 1990, PP.1247-1261
065003 1990 IJHMT SURFTENSION
CONDENSATION

ADDITIVES FOR LIQUIDS - FLOW BOILING

CAWTE;H.
"EFFECT OF LUBRICATING OIL CONTAMINATION ON CONDENSATION IN REFRIGERANT R22"
INTERNATIONAL JOURNAL OF ENERGY RESEARCH, VOL.16, 1992, PP.327-340
074037 1992 IJER ADDFORLIQUIDS
FLOBOIL CONDENSATION

FUKUSHIMA;T. KUDOU;M.
"HEAT TRANSFER COEFFICIENTS AND PRESSURE DROP FOR FORCED CONVECTION BOILING AND CONDENSATION OF HFC 134A"
PROCEEDINGS OF THE USNC/IIR-PURDUE REFRIGERATION CONFERENCE, PURDUE UNIVERSITY, PURDUE, 1990, PP.196-204
074035 1990 ** ADDFORLIQUIDS
FLOBOIL CONDENSATION

MECHANICAL AIDS - CONDENSATION

DANIELS;T.C. WILLIAMS;R.J.
"THE EFFECT OF EXTERNAL BOUNDARY CONDITIONS ON CONDENSATION HEAT TRANSFER IN ROTATING PIPES"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.22, 1979, PP.1237-1241
095017 1979 IJHMT MECHAID
CONDENSATION

FUTAGAMI;K. IKEDA;J. OHHIRA;K.
AOYAMA;Y. MIZUKAMI;K.
"CONDENSATION HEAT TRANSFER IN A ROTATING HORIZONTAL CYLINDER WITH A SCRAPER"
EXPERIMENTAL HEAT TRANSFER, FLUID MECHANICS, AND THERMODYNAMICS 1988, ELSEVIER SCIENCE PUBLISHING, NEW YORK, 1988, PP.1061-1068
095021 1988 IWCEHTFMT MECHAID
CONDENSATION

FUTAGAMI;K. IKEDA;J. OHHIRA;K.
AOYAMA;Y. MIZUKAMI;K.
"CONDENSATION HEAT TRANSFER IN A ROTATING HORIZONTAL CYLINDER WITH A SCRAPER"
EXPERIMENTAL THERMAL AND FLUID SCIENCE, VOL.2, 1989, PP.384-391
095020 1989 ETFS MECHAID
CONDENSATION

MAEDA;H. IZUMI;R. YAMASHITA;H.
KAGA;S.
"STUDY ON A ROTATING CONDENSER WITH A SCRAPER (3RD REPORT, EXPERIMENT OF CONDENSATION ON OUTER SURFACE OF VERTICAL AND HORIZONTAL CYLINDERS)"
BULLETIN OF JSME, VOL.28, NO.235, 1985, PP.94-100
095023 1985 BJSME MECHAID
CONDENSATION

NANDAPURKAR;S.S. BEATTY JR.;K.O.
"CONDENSATION ON A HORIZONTAL ROTATING DISK"
CHEMICAL ENGINEERING PROGRESS SYMPOSIUM SERIES, VOL.56, NO.30, 1960, PP.129-137
095003 1960 CEPSS MECHAID
CONDENSATION

YAMASHITA;H. IZUMI;R. MAEDA;H.
SUGIURA;Y.
"STUDY ON A ROTATING CONDENSER WITH A SCRAPER (1ST REPORT, ANALYSIS OF CONDENSATION ON OUTER SURFACE OF VERTICAL CYLINDER)"
BULLETIN OF JSME, VOL.28, NO.239, 1985, PP.860-867
095024 1985 BJSME MECHAID
CONDENSATION

YAMASHITA;H. IZUMI;R. MAEDA;H.
SUGIURA;Y.
"STUDY ON A ROTATING CONDENSER WITH A SCRAPER (2ND REPORT, ANALYSIS OF CONDENSATION ON OUTER SURFACE OF HORIZONTAL CYLINDER)"
BULLETIN OF JSME, VOL.28, NO.239, 1985, PP.868-875
095025 1985 BJSME MECHAID
CONDENSATION

SURFACE VIBRATION - CONDENSATION

NISHIYAMA;K. MURATA;A. KAJIKAWA;T.
"THE STUDY OF CONDENSATION HEAT TRANSFER PERFORMANCE DUE TO PERIODIC MOTION OF A VERTICAL TUBE"
HEAT TRANSFER - JAPANESE RESEARCH, VOL.15, NO.6, 1986, PP.32-43
105008 1986 HTJR SURFVIB
CONDENSATION

NISHIYAMA;K. MURATA;A. KAJIKAWA;T.
"THE STUDY OF HEAT TRANSFER PERFORMANCE FOR A PERIODIC MOVING CONDENSER"
ABSTRACTED IN BULLETIN OF JSME, VOL.29, 1986, PP.642-643
105010 1986 BJSME SURFVIB
CONDENSATION

NISHIYAMA;K.
"STUDY OF HEAT TRANSFER PERFORMANCE OF A PERIODIC MOVING CONDENSER"
HEAT TRANSFER - JAPANESE RESEARCH, VOL.17, NO.5, 1988, PP.32-42
105009 1988 HTJR SURFVIB
CONDENSATION

ELECTRIC OR MAGNETIC FIELDS - CONDENSATION

ALLEN;P.H.G.
"HEAT TRANSFER ENHANCEMENT BY DIELECTROPHORESIS"
SECOND UK NATIONAL CONFERENCE ON HEAT TRANSFER, GLASGOW, VOL.1, 1988, PP.861-870
000194 1988 IIUKNHTC LITSURVEY ELECTROFIELD CONDENSATION POOLBOIL

ALLEN;P.H.G. KARAYIANNIS;T.G.
"ELECTROHYDRODYNAMIC ENHANCEMENT OF BOILING AND CONDENSATION
OF DIELECTRIC FLUIDS"
ADVANCES IN POOL BOILING HEAT TRANSFER, EUROTHERM NO.8, PADERBORN, GERMANY, 1989, PP.98-110
125023 1989 ** ELECTROFIELD CONDENSATION

ARAJS;S. LEGVOLD;S.
"ELECTROCONVECTIONAL HEAT TRANSFER IN GASES"
JOURNAL OF CHEMICAL PHYSICS, VOL.29, NO.3, 1958, PP.531-536
121006 1958 ** ELECTROFIELD POOLBOIL CONDENSATION 1FORCECONV

BOLOGA;M.K. DIDKOVSKIY;A.B.
"ENHANCEMENT OF HEAT TRANSFER IN FILM CONDENSATION OF VAPORS OF DIELECTRIC LIQUIDS BY SUPERPOSITION OF ELECTRIC FIELDS"
HEAT TRANSFER - SOVIET RESEARCH, VOL.9, NO.1, 1977, PP.147-151
125011 1977 HTSR ELECTROFIELD CONDENSATION

BOLOGA;M.K. VASILIEV;L.L. KOZUHAR;I.A. SKILEV;V.D.
"EFFECTS OF ELECTRIC FIELDS ON HEAT-PIPE CHARACTERISTICS"
JOURNAL OF ENGINEERING PHYSICS, VOL.36, 1979, PP.748-756
125017 1979 JEP ELECTROFIELD CONDENSATION FLOBOIL

BOLOGA;M.K. SAVIN;I.K. DIDKOVSKY;A.B.
"ELECTRIC-FIELD-INDUCED ENHANCEMENT OF VAPOUR CONDENSATION HEAT TRANSFER IN THE PRESENCE OF A NON-CONDENSABLE GAS"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL.30, NO.8, 1987, PP.1577-1585
125019 1987 IJHMT ELECTROFIELD CONDENSATION

CHOI;H.Y.
"ELECTRODYNAMIC CONDENSATION HEAT TRANSFER"
JOURNAL OF HEAT TRANSFER, VOL.90, 1968, PP.98-102
125003 1967 ASME ELECTROFIELD CONDENSATION

COOPER;P. ALLEN;P.H.G.
"THE POTENTIAL OF ELECTRICALLY ENHANCED CONDENSERS"
SECOND INTERNATIONAL SYMPOSIUM ON THE LARGE SCALE APPLICATIONS OF HEAT PUMPS, YORK, ENGLAND, 1984, PP.295-309
145010 1984 ** COMPOUNDTECH ELECTROFIELD EXTENDEDSURF CONDENSATION

DAMIANIDIS;C. COLLINS;M.W. KARAYIANNIS;T.G. ALLEN;P.H.G.
"EHD EFFECTS IN CONDENSATION OF DIELECTRIC FLUIDS"
PROCEEDINGS OF THE SECOND INTERNATIONAL SYMPOSIUM ON CONDENSERS AND CONDENSATION, UNIVERSITY OF BATH, UK, HEAT TRANSFER AND FLUID FLOW SERVICE, UK, 1990, PP.505-
125022 1990 ** ELECTROFIELD CONDENSATION

DIDKOVSKII;A.B. BOLOGA;M.K.
"INTENSIFICATION OF HEAT EXCHANGE UPON CONDENSATION OF A VAPOR IN AN ELECTRIC FIELD"
HIGH TEMPERATURE, VOL.16, NO.3, PP.490-496.
125012 1978 ** ELECTROFIELD CONDENSATION

DIDKOVSKY;A.B. BOLOGA;M.K.
"VAPOUR FILM CONDENSATION HEAT TRANSFER AND HYDRODYNAMICS UNDER THE INFLUENCE OF AN ELECTRIC FIELD"
INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER, VOL. 24, 1981, PP. 811-819.
125013 1981 IJHMT ELECTROFIELD CONDENSATION

DYAKOWSKI;T. TROMMELMANS;J. BERGHMANS;J.
"THEORETICAL INVESTIGATION OF THE EFFECT OF AN ELECTRIC FIELD UPON VERTICAL PLATE CONDENSATION HEAT TRANSFER"
HEAT TRANSFER 1982, VOL.5, HEMISPHERE PUBLISHING COMPANY, WASHINGTON, D.C., 1982, PP.65-70
125016 1982 VIIIHTC ELECTROFIELD CONDENSATION

HOLMES;R.E. CHAPMAN;A.J.
"CONDENSATION OF FREON-114 IN THE PRESENCE OF A STRONG, NON-UNIFORM ALTERNATING ELECTRIC FIELD
JOURNAL OF HEAT TRANSFER, VOL.92, 1970, PP.616-620
125004 1970 JHT ELECTROFIELD CONDENSATION

ISHIGURO;H. NAGATA;S. YABE;A. NARIAI;H.
"AUGMENTATION OF FORCED-CONVECTION HEAT TRANSFER BY APPLYING ELECTRIC FIELDS TO DISTURB FLOW NEAR A WALL"
PROCEEDINGS OF THE 1991 ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE, VOL.3, JSME, TOKYO, AND ASME, NEW YORK, 1991, PP.25-31
125026 1991 ASME-JSME ELECTROFIELD CONDENSATION

JONES;T.B.
"AN ELECTROHYDRODYNAMIC HEAT PIPE"
AMERICAN SOCIETY OF MECHANICAL ENGINEERS PAPER NO. 72-WA/HT-35, 1972
125006 1972 ASME ELECTROFIELD CONDENSATION POOLBOIL

POULTER;R. ALLEN;P.H.G.
"ELECTROHYDRODYNAMICALLY AUGMENTED HEAT AND MASS TRANSFER IN THE SHELL/TUBE HEAT EXCHANGER"
HEAT TRANSFER 1986, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, 1986, VOL.6, PP.2963-2968
122053 1986 VIIIIHTC ELECTROFIELD 1FORCECONV FLOBOIL CONDENSATION

SATO;M. YABE;A. TAKETANI;T.
"HEAT TRANSFER ENHANCEMENT BY APPLYING AN ELECTRO-HYDRODYNAMIC PUMP UTILIZING DIELECTROPHORETIC FORCE"
PROCEEDINGS OF THE 1991 ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE, VOL.3, JSME, TOKYO, AND ASME, NEW YORK, 1991, PP.3-8
125024 1991 ASME-JSME ELECTROFIELD CONDENSATION

SETH;A.K. LEE;L.
"THE EFFECT OF AN ELECTRIC FIELD IN THE PRESENCE OF NONCONDENSABLE GAS ON FILM CONDENSATION HEAT TRANSFER"
JOURNAL OF HEAT TRANSFER, VOL.96, 1974, PP.257-258
125007 1974 JHT ELECTROFIELD CONDENSATION

SUNADA;K. YABE;A. TAKETANI;T. YOSHIZAWA;Y.
"EXPERIMENTAL STUDY OF EHD PSEUDO-DROPWISE CONDENSATION"
PROCEEDINGS OF THE 1991 ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE, VOL.3, JSME, TOKYO, AND ASME, NEW YORK, 1991, PP.47-53
125025 1991 ASME-JSME ELECTROFIELD CONDENSATION

TROMMELMANS;J. BERGHMANS;J.
"INFLUENCE OF ELECTRICAL FIELDS ON CONDENSATION HEAT TRANSFER ON A HORIZONTAL TUBE"
AMERICAN SOCIETY OF MECHANIAL ENGINEERS PAPER NO. 82-WA/HT-19, 1982
125018 1982 ASME ELECTROFIELD CONDENSATION

TROMMELMANS;J. BERGHMANS;J.
"INFLUENCE OF ELECTRIC FIELDS ON CONDENSATION HEAT TRANSFER OF NONCONDUCTING FLUIDS ON HORIZONTAL TUBES"
HEAT TRANSFER 1986, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, 1986, VOL.6, PP.2969-2976
125021 1986 VIIIIHTC ELECTROFIELD

CONDENSATION

VELKOFF;H.R. MILLER;J.H.
"CONDENSATION OF VAPOR ON A VERTICAL PLATE WITH A TRANSVERSE ELECTROSTATIC FIELD"
JOURNAL OF HEAT TRANSFER, VOL.87, 1965, PP.197-201
125002 1965 JHT ELECTROFIELD CONDENSATION

YABE;A. KIKUCHI;K. TAKETANI;T.
MORI;Y. HIJIKATA;K.
"AUGMENTATION OF CONDENSATION HEAT TRANSFER BY APPLYING NON-UNIFORM ELECTRIC FIELDS"
HEAT TRANSFER 1982, VOL.5, HEMISPHERE PUBLISHING COMPANY, WASHINGTON, D.C., 1982, PP.189-194
125015 1982 VIIIHTC ELECTROFIELD CONDENSATION

YABE;A. KIKUCHI;K. YAMANISHI;T.
MORI;Y. HIJIKATA;K.
"AUGMENTATION OF CONDENSATION HEAT TRANSFER BY APPLYING NON-UNIFORM ELECTRIC FIELDS"
ABSTRACTED IN BULLETIN OF JSME, VOL.26, 1983, PP.1265
125028 1983 BJSME ELECTROFIELD CONDENSATION

YABE;A. TAKETANI;T. KIKUCHI;K.
MORI;Y. MAKI;H.
"AUGMENTATION OF CONDENSATION HEAT TRANSFER BY APPLYING ELECTRO-HYDRO-DYNAMICAL PSEUDO-DROPWISE CONDENSATION"
HEAT TRANSFER 1986, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, 1986, VOL.6, PP.2957-2962
125020 1986 VIIIIHTC ELECTROFIELD CONDENSATION

YABE;A. MORI;Y. HIJIKATA;K.
"HEAT TRANSFER ENHANCEMENT TECHNIQUES UTILIZING ELECTRIC FIELDS"
HEAT TRANSFER IN HIGH TECHNOLOGY AND POWER ENGINEERING, HEMISPHERE PUBLISHING CORPORATION, NEW YORK, 1987, PP.394-405
000183 1987 ** LITSURVEY ELECTROFIELD 1FORCECONV CONDENSATION

YAMASHITA;K. KUMAGAI;M. SEKITA;S.
YABE;A. TAKETANI;T. KIKUCHI;K.
"HEAT TRANSFER CHARACTERISTICS OF AN EHD CONDENSER"
PROCEEDINGS OF THE 1991 ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE, VOL.3, JSME, TOKYO, AND ASME, NEW YORK, 1991, PP.61-67
125027 1991 ASME-JSME ELECTROFIELD CONDENSATION

INJECTION OR SUCTION - CONDENSATION

FAGHRI;A. CHOW;L.C.
"FORCED CONDENSATION IN A TUBE WITH SUCTION AT THE WALL FOR MICROGRAVITATIONAL APPLICATIONS"
INTERNATIONAL SYMPOSIUM ON THERMAL PROBLEMS IN SPACE-BASED SYSTEMS, HTD-VOL.83, ASME, NEW YORK, 1987, PP.71-76
135007 1987 ASME INJECTORSUCT CONDENSATION

LIENHARD;J. DHIR;V.
"A SIMPLE ANALYSIS OF LAMINAR FILM CONDENSATION WITH SUCTION"
JOURNAL OF HEAT TRANSFER, VOL.94, 1972, PP.334-336
135005 1972 JHT INJECTORSUCT CONDENSATION

COMPOUND ENHANCEMENT - CONDENSATION

ANAND;G. CHRISTENSEN;R.N. RICHARDS;D.E.
"FORCED CONVECTION CONDENSATION OF AMMONIA INSIDE COILED FLUTED TUBES"
ASHRAE TRANSACTIONS, VOL.94, PART 2, 1988, PP.1132-1158
145005 1988 ASHRAE COMPOUNDTECH
CONDENSATION ROUGHSURF COILEDTUBE

COOPER;P. ALLEN;P.H.G.
"THE POTENTIAL OF ELECTRICALLY ENHANCED CONDENSERS"
SECOND INTERNATIONAL SYMPOSIUM ON THE LARGE SCALE APPLICATIONS OF HEAT PUMPS, YORK, ENGLAND, 1984, PP.295-309
145010 1984 ** COMPOUNDTECH
ELECTROFIELD EXTENDEDSURF CONDENSATION

HIJIKATA;K. SIMODA;K. MORI;Y.
"CONDENSATION HEAT TRANSFER ENHANCEMENT ON A DOWNWARD FACING SURFACE BY THE GRAVITY"
PROCEEDINGS OF THE 1987 ASME-JSME THERMAL ENGINEERING JOINT CONFERENCE, VOL.4, JSME, TOKYO, AND ASME, NEW YORK, 1987, PP.393-400
145009 1987 ASME-JSME COMPOUNDTECH
CONDENSATION EXTENDEDSURF SURFTENSION

HONDA;H. NOZU;S. MATSUOKA;Y.
AOYAMA;T. NAKATA;H.
"CONDENSATION OF REFRIGERANTS R-11 AND R-113 IN HORIZONTAL ANNULI WITH AN ENHANCED INNER TUBE"
EXPERIMENTAL HEAT TRANSFER, FLUID MECHANICS, AND THERMODYNAMICS 1988, ELSEVIER SCIENCE PUBLISHING, NEW YORK, 1988, PP.1069-1076
025044 1988 IWCEHTFMT ROUGHSURF
CONDENSATION COMPOUNDTECH

HONDA;H. NOZU;S. MATSUOKA;Y.
AOYAMA;T. NAKATA;H.
"CONDENSATION OF REFRIGERANTS R-11 AND R-113 IN THE ANNULI OF HORIZONTAL DOUBLE-TUBE CONDENSERS WITH AN ENHANCED INNER TUBE"
EXPERIMENTAL THERMAL AND FLUID SCIENCE, VOL.2, 1989, PP.173-182
145007 1989 ETFS COMPOUNDTECH
CONDENSATION EXTENDEDSURF ROUGHSURF

NAKAOKA;T. UEHARA;H.
"PERFORMANCE TEST OF A SHELL-AND-PLATE-TYPE CONDENSER FOR OTEC"
EXPERIMENTAL THERMAL AND FLUID SCIENCE, VOL.1, 1988, PP.275-281
145006 1988 ETFS COMPOUNDTECH
CONDENSATION EXTENDEDSURF ROUGHSURF 1FORCECONV

SHEKARRIZ;A. PLUMB;O.A.
"ENHANCEMENT OF FILM CONDENSATION USING POROUS FINS"
JOURNAL OF THERMOPHYSICS AND HEAT TRANSFER, VOL.3, NO.3, 1989, PP.309-314
145004 1989 JTHT COMPOUNDTECH
CONDENSATION TREATSURF EXTENDEDSURF

VASIL'EV;L.L. KALITA;V. KHROLENOK;V.V.
"INTENSIFICATION OF HEAT EXCHANGE IN THE CONDENSATION ZONE OF CENTRIFUGAL HEAT PIPES"
JOURNAL OF ENGINEERING PHYSICS, VOL.46, 1984, PP.382-387
145008 1984 JEP COMPOUNDTECH
CONDENSATION

PERFORMANCE EVALUATION - CONDENSATION

GU;N. ZHANG;Z.X.
"A NEW METHOD TO EVALUATE AUGMENTATIVE HEAT TRANSFER TECHNIQUE"
SECOND INTERNATIONAL SYMPOSIUM ON MULTIPHASE FLOW AND HEAT TRANSFER, HEMISPHERE PUBLISHING CORPORATION, WASHINGTON, DC, VOL.1, 1989, PP.764-773
150108 1989 ** PERFORMANCE
1FORCECONV FLOBOIL CONDENSATION

HORAZAK;D.A. RABAS;T.J.
"CAPITOL COST SYSTEM OPTIMIZATION OF OTEC POWER MODULES"
ENERGY TECHNOLOGY CONFERENCE, HOUSTON, TEXAS, NOVEMBER 1978
150064 1978 ** PERFORMANCE
TREATSURF ROUGHSURF EXTENDEDSURF CONDENSATION

LORENZ;J.J. YUNG;D.
"AN EVALUATION OF THE COST-EFFECTIVENESS OF SURFACE ENHANCEMENTS FOR OTEC HEAT EXCHANGERS"
PROCEEDINGS OF THE SEVENTH OCEAN ENERGY CONFERENCE, CONF-800633, VOL.2, 1980, PP.12.3-1 - 12.3-8
150057 1980 ** PERFORMANCE
POOLBOIL CONDENSATION

NISHIYAMA;K.
"THE STUDY OF HEAT TRANSFER PERFORMANCE FOR A PERIODIC MOVING CONDENSER (FOR THE CASE OF A VERTICAL FLUTED TUBE CONDENSER)"
ABSTRACTED IN JSME INTERNATIONAL JOURNAL, VOL.30, 1987, PP.1181
150100 1987 BJSME PERFORMANCE
CONDENSATION

PANCHAL;C.B. HILLIS;D.L. LORENZ;J.J.
YUNG;D.T.
"OTEC PERFORMANCE TESTS OF THE TRANE PLATE-FIN HEAT EXCHANGER"
ARGONNE NATIONAL LABORATORY, REPORT NO. ANL/OTEC-PS-7, APRIL 1981.
150053 1981 ANL PERFORMANCE
EXTENDEDSURF POOLBOIL CONDENSATION

WEBB;R.L. MENZE;K.W. APPARAO;T.V.V.R.
"COMPARISON OF ENHANCED AND STANDARD FINNED TUBES: FIELD TEST OF 250-TON CENTRIFUGAL WATER CHILLERS"
HEAT TRANSFER ENGINEERING, VOL.11, NO.2, 1990, PP.19-28
150099 1990 HTE PERFORMANCE
EXTENDEDSURF CONDENSATION

APPENDIX 2

POOL BOILING PATENTS

BECKMAN;J.H.
"COOLER"
1,708,600 1929 APR.9 153F

BAILEY;E.G.
"LIQUID VAPORIZING TUBE"
2,279,548 1942 APR. 14 122/235 023A

GAUGLER;R.S.
"REFRIGERATING APPARATUS"
2,517,654 1950 AUG. 8 261/99 073F
083F

GAUGLER;R.S.
"REFRIGERATING APPARATUS"
2,565,221 1951 AUG. 21 261/104 023A

PROTZE;C.
"HEAT EXCHANGER FOR ELECTRIC DISCHARGE TUBE"
2,873,954 1959 FEB. 17 257/250 033F

BEURTHERET;C.A.E.
"VAPOR COOLING APPARATUS FOR ELECTRIC DISCHARGE DEVICES"
2,935,306 1960 MAY 3 257/250 043F

CORNELISON;B. WOLFF;E.A. JR.
"COOLING ARRANGEMENT FOR TRANSISTORS"
2,958.021 1960 OCT. 25 317/234 043A

HINDE;J.N.
"INTERFINNED HEAT TRANSFER TUBES"
2,960,114 1960 NOV. 15 138/38 043A

BEURTHERET;C.A.E.
"ELECTRIC DISCHARGE DEVICE COOLING SYSTEMS"
2,969,957 1961 JAN. 31 257/250 043F

POHL;W.J.
"ELECTRIC DISCHARGE TUBE"
3,045,138 1962 JUL. 17 313/21 023C

BEURTHERET;C.A.E.
"HIGH FREQUENCY ENERGY INTERCHANGE DEVICE"
3,046,428 1962 JUL. 24 313/12 043F

BEURTHERET;C.A.E.
"HIGH FREQUENCY ENERGY INTERCHANGE DEVICE"
3,046,429 1962 JUL. 24 313/12 043F

BEURTHERET;C.A.E.
"HEAT EXCHANGERS"
3,055,643 1962 SEP. 25 257/250 073A

KOCH;P.H. PIRSH;E.A. SWENSON;H.S.
"RIBBED VAPOR GENERATING TUBES"
3,089,494 1963 MAY 7 138/37 043A

HEBELER;H.K.
"HYPERSONIC COOLING SYSTEM"
3,089,318 1963 MAY 14 62/467 043F

WYATT;T.
"SATELLITE TEMPERATURE STABILIZATION SYSTEM"
3,152,774 1964 OCT. 13 244/1 083F
085F

HUMMEL;R.L.
"MEANS FOR INCREASING THE H.T. COEFFICIENT BETWEEN A WALL AND ETC."
3,207,209 1965 SEP. 21 165/1 013F

GROVER;G.M.
"EVAPORATION-CONDENSATION HEAT TRANSFER DEVICE"
3,229,759 1966 JAN. 18 165/105 083F
015F 085F

BEURTHERET;C.A.E.
"HEAT DISSIPATING STRUCTURE"
3,235,004 1966 FEB. 15 165/185 043F

ALLEN;B.F.
"STATIONARY INDUCTION APPARATUS COOLING SYSTEM"
3,261,905 1966 JUL. 19 174/15 153F

BEURTHERET;C.A.E.
"DEVICE FOR EVAPORATIVE COOLING OF BODIES AND POWER VACUUM ETC."
3,299,949 1967 JAN. 24 165/185 043C

BEURTHERET;C.A.E.
"ELECTRON DISCHARGE TUBE HAVING IMPROVED COOLING MEANS THEREFOR"
3,306,350 1967 FEB. 28 165/105 043F

WARE;C.D.
"HEAT TRANSFER SURFACE"
3,326,283 1967 JUN. 29 165/181 043C

MCGURTY;J.A. NECKER;W.C.
"HEAT EXCHANGER UTILIZING VORTEX FLOW"
3,339,631 1967 SEP. 5 165/109 043A

BEURTHERET;C.A.E.
"ANISOTHERM EVAPORATION HEAT-TRANSFER STRUCTURE"
3,367,415 1968 FEB. 6 165/185 043F

KARTLUKE;H. BOYD;C.A.
"SUPERHEATING PREVENTION AND BOILING CONTROL"
3,368,610 1968 FEB. 13 165/1 133F

BEURTHERET;C.A.E.
"NON-ISOTHERMAL EVAPORATIVE TYPE HEAT TRANSFER APPARATUS"
3,384,160 1968 MAY 21 165/74 043F

BEURTHERET;C.A.E.
"TWO-STAGE COOLING SYSTEM FOR HEAT MACHINE COMPONENTS"
3,390,667 1968 JUL. 2 123/8 043F

ZUBER;N. LUSTENADER;E.L.
"VAPORIZING HEAT TRANSFER DEVICE"
3,392,781 1968 JUL.16 165/135 023A

KUN;L.C. CZIKK;A.M.
"SURFACE FOR BOILING LIQUIDS"
3,454,081 1969 JUL. 8 165/133 023A

BEURTHERET;C.A.E.
"HEAT EXCHANGER"
3,455,376 1969 JUL. 15 165/1 043E

THEOPHILOS;N.P. WANG;D.I.J.
"MULTIPLE PASSAGE HEAT EXCHANGER UTILIZING NUCLEATE BOILING"
3,457,990 1969 JUL. 29 165/133 023A
045A

BEUTHERET;C.A.E. DOUGUET;E.J.
"HEAT EXCHANGE STRUCTURE AND ELECTRON TUBE INCLUDING SUCH EXCHANGE STRUCTURE"
3,521,705 1970 JUL. 28 165/74 023C

WEBB;R.L.
"HEAT TRANSFER SURFACE WHICH PROMOTES NUCLEATE EBULLITION"
3,521,708 1970 JUL. 28 165/186 043C

SZUMIGALA;F.T.
"MANUFACTURING METHOD FOR BOILING SURFACES"
3,566,514 1971 MAR. 2 29/558 023F

MOORE;R.D. JR.
"HEAT TRANSFER SURFACE STRUCTURE"
3,598,180 1971 AUG. 10 165/133 083C

KLUG;W.A. WARE;C.D.
"SIMULTANEOUS FINNING AND REFORMING OF TUBULAR HEAT TRANSFER SURFACE"
3,602,027 1971 AUG. 31 72/98 023B
042C

KESSLER;S.W. JR. HESS;J.L.
"FLEXIBLE HEAT PIPE"
3,604,504 1971 SEP. 14 165/105 083A

WERNER;R.W. ALEXANDER;E.E. COMSTOCK;I.J.
"METHOD OF FABRICATING A HEAT PIPE"
3,665,573 1972 MAY 30 29/157.3 083A

RAGI;E.G.
"COMPOSITE STRUCTURE FORE BOILING LIQUIDS AND ITS FORMATION"
3,684,007 1972 AUG. 15 165/133 033C

DYSKIN;E.M.
"HOLLOW TYRE OF ROTARY FURNACES & METHOD OF EQUALIZING TYRE TEMP."
3,687,434 1972 AUG. 29 266/24 113A

WEBB;R.L.
"HEAT TRANSFER SURFACE HAVING A HIGH BOILING H.T. COEFFICIENT"
3,696,861 1972 OCT. 10 165/133 043C

ZATELL;V.A.
"METHOD OF MODIFYING A FINNED TUBE FOR BOILING ENHANCEMENT"
3,768,290 1973 OCT. 30 72/68 043C

BYKOV;A.V.
"HEAT EXCHANGE APPARATUS"
3,871,407 1975 MAR. 18 138/38 043A

THORNE;J.K.
"METHOD FOR MAKING INTEGRAL FINNED TUBES FOR SUBMERGED BOILING"
3,881,342 1975 MAY 6 72/68 043C

STAUB;F.W. KOSKY;P.G.
"EVAPORATIVE COOLING SYST. EMPLOYING LIQUID FILM EVAPORATION ETC."
3,887,759 1975 JUN. 3 174/15R 023F

NELSON;B.E.
"HEAT PIPE LOBAR WICKING ARRANGEMENT"
3,892,273 1975 JUL. 1 165/105 083A

KAKIZAKI;K. SUZUMURA;T.
"METHOD FOR FORMING HEAT TRANSMISSIVE WALL SURFACE"
3,906,604 1975 SEP. 23 29/157.3A 023F

DAHL;M.M. ERB;L.D.
"LIQUID HEAT EXCHANGER INTERFACE AND METHOD"
3,990,862 1976 NOV. 9 29/191.2 013F

CAMPBELL;B.J. RIEGER;K.R.
"FINNED TUBE HAVING ENHANCED NUCLEATE BOILING SURFACE"
4,040,479 1977 AUG. 9 165/133 043C

FUJIE;K.
"HEAT TRANSFER PIPE"
4,044,797 1977 AUG. 30 138/38 023A

CHU;R.C. MORAN;K.P.
"METHOD FOR CUSTOMIZING NUCLEATE BOILING H.T. FROM ELECTRONIC ETC."
4,050,507 1977 SEP. 27 165/1 023F

THORNE;J.K.
"INTEGRAL FINNED TUBE FOR SUBMERGED BOILING APPLICATIONS ETC."
4,059,147 1977 NOV. 22 165/133 043C

FUJIE;K.
"HEAT TRANSFER WALL FOR BOILING LIQUIDS"
4,060,125 1977 NOV. 29 165/133 013C

SCHMITTLE;K.V. STARNER;K.E.
"HEAT TRANSFER IN POOL BOILING"
4,074,753 1978 FEB. 21 165/184 043C

DAHL;M.M. ERB;L.D.
"METHOD FOR MAKING A LIQUID HEAT EXCHANGER COATING"
4,093,755 1978 JUN. 6 427/299 013B

LORD;R.G BUSSJAGER;R.C. GEARY;D.F.
"HIGH PERFORMANCE HEAT EXCHANGER"
4,118,944 1978 OCT. 10 62/98 043A

KUSUDA;H. UEHARA;H.
"PLATE TYPE EVAPORATOR"
4,156,459 1979 MAY 29 165/167 033D

ANDERSON;J.H.
"PLATE-FIN HEAT EXCHANGER WITH CONTROLS THEREFOR"
4,159,735 1979 JUL. 3 165/40 043D/E

BROTHERS;W.S. KALLFELZ;A.J.
"HEAT TRANSFER SURFACE AND METHOD OF MANUFACTURE"
4,159,739 1979 JUL. 3 165/133 043C

SAIER;M. KASTNER;H.-W. KLOCKLER;R.
"Y AND T-FINNED TUBES AND METHODS AND APPARATUS FOR THEIR MAKING"
4,179,911 1979 DEC. 25 72/78 023B

SHUM;M.S.
"FINNED HEAT TRANSFER TUBE WITH POROUS BOILING SURFACE AND METHOD FOR PRODUCING SAME"
4,182,412 1980 JAN. 8 165/133 023B

ALBERTSON;C.E. NICHOLS;G.M. RASMUSSEN;N.
"BOILING HEAT TRANSFER SURFACE, METHOD OF PREPARING SAME AND METHOD OF BOILING"
4,186,063 1980 JAN. 29 204/29 013B

ITOH;M. TAKASUNA;T. ISHIKAWA;Y.
KIMURA;H. MUSOH;M.
"METHOD OF MAKING FIN ELEMENTS FOR HEAT EXCHANGER"
4,211,276 1980 JUL. 8 165/1 013E

SUMITOMO;H.
"PLATE TYPE EVAPORATOR"
4,216,825 1980 AUG. 12 165/109R 013D

FUJIKAKE;J.
"HEAT TRANSFER TUBE FOR USE IN BOILING TYPE HEAT EXCHANGERS AND METHOD OF PRODUCING THE SAME"
4,216,826 1980 AUG. 12 165/133 023C

WITHERS;J.G. JR.
"HEAT TRANSFER SURFACE FOR NUCLEATE BOILING"
4,219,078 1980 AUG. 26 165/133 013F

HILAL;M.A.
"HEAT TRANSFER IN BOILING LIQUIFIED GAS"
4,223,723 1980 SEP. 23 165/133 063F

ALBERTSON;C.E. NICHOLS;G.M. RASMUSSEN;J.N.
"BOILING HEAT TRANSFER SURFACE, METHOD OF PREPARING SAME AND METHOD OF BOILING"
4,258,783 1981 MAR. 31 165/133 023C

WITHERS;J.G. JR.
"METHOD OF PRODUCING A NUCLEATE BOILING SURFACE ONlend> A HEAT TRANSFER MEMBER"
4,288,897 1981 SEP. 15 29/157.4 013C

FUJII;M. OGAWA;Y. MORIHIRO;Y.
"PREPARATION OF BOILING HEAT TRANSFER SURFACE"
4,291,758 1981 SEP. 29 165/133 013C

FUJIKAKE;J.
"METHOD OF PRODUCING HEAT TRANSFER TUBE FOR USE IN BOILING TYPE HEAT EXCHANGERS"
4,313,248 1982 FEB. 2 29/157.3 A 023C

EASTMAN;G.Y.
"MECHANICALLY ASSISTED EVAPORATOR SURFACE"
4,352,392 1982 OCT. 5 165/104.25 013F

MODAHL;R.J. LUCKEROTH;V.C.
"HEAT TRANSFER SURFACE FOR EFFICIENT BOILING OF LIQUID R-11 AND EQUIVALENTS"

4,354,550 1982 OCT. 19 165/133 013C

SANBORN;D.F. HOLMAN;J.L.M. WARE;C.D.
"HEAT EXCHANGE SURFACE WITH POROUS COATING AND SUBSURFACE CAVITIES"
4,359,086 1982 NOV. 16 165/133 013C

ALORIO;J.P. BROWN;R.F. KOSSON;R.L.
"MONOGROOVE HEAT PIPE DESIGN: INSULATED LIQUID CHANNEL WITH BRIDGING WICK"
4,515,207 1985 MAY 7 165/1 083A

MAIDANIK;J.F. VERSHININ;S.V. KHOLODOV;V.F.
DOLGIREV;J.E.
"HEAT TRANSFER APPARATUS"
4,515,209 1985 MAY 7 165/104.22 083A

NAKAJIMA;T. NAKAYAMA;W. DAIKOKU;T.
"FALLING FILM EVAPORATION TYPE HEAT EXCHANGER"
4,520,866 1985 JUN. 4 165/115 013C

KUWAHARA;H. TAKAHASHI;K. YAMAGIDA;T.
NAKAYAMA;W. SUGIMOTO;S. NAKAYAMA;Y.
YOSHIDA;H. OISUMI;K. SASAKI;T.
FUKUDA;S.
"METHOD FOR PRODUCING A HEAT TRANSFER WALL FOR VAPORIZING LIQUIDS"
4,653,163 1987 MAR. 31 29/157.3R 043C

BOLMSTEDT;U. LUNDBLAD;B.
"HEAT EXCHANGER OF FALLING FILM TYPE"
4,706,741 1987 NOV. 17 165/115 023C

CHU;R.C. SIMONS;R.E.
"HEAT TRANSFER ELEMENT WITH NUCLEATE BOILING SURFACE AND BIMETALLIC FIN FORMED FROM ELEMENT"
4,709,754 1987 DEC. 1 165/133 013C

PORTER;J.E. RAMSHAW;C.
"EVAPORATOR"
4,731,159 1988 MAR. 15 159/6.1 163F

BERGLES;A.E. FANG;C.M.
"GAS JET IMPINGEMENT MEANS AND METHOD"
4,741,385 1988 MAY 3 165/1 153F

BEDUX;C. SCURLOCK;R.G.
"HEAT EXCHANGERS"
4,747,448 1988 MAY 31 165/133 023A

ZOHLER;S.R.
"APPARATUS FOR MANUFACTURING ENHANCED HEAT TRANSFER SURFACE"
4,765,058 1988 AUG. 23 29/727 043C

SHATTES;W.J. BANDYOPADHYAY;N. KRUEGER;P.C.
"PROCESS OF FORMING ENHANCED HEAT TRANSFER SURFACES"
4,767,497 1988 AUG. 30 156/665 013E

GROTE;M.G. STARK;J.A. TEFFT;E.C. III
"ENHANCED EVAPORATOR SURFACE"
4,819,719 1989 APR. 11 165/104.26 083A

SHATTES;W.J. BANDYOPADHYAY;N. KRUGER;P.C.
"ENHANCED HEAT TRANSFER SURFACES"
4,846,267 1989 JUL. 11 165/133 013C

O'NEILL;P.S.
"AMMONIA PRODUCTION PROCESS UTILIZING ENHANCED BOILING SURFACE IN REFRIGERATION ZONE"
4,869,888 1989 SEP. 26 423/359 013A

FLOW BOILING PATENTS

PHILIPP;L.A.
"REFRIGERATING SYSTEM"
1,931,268 1933 OCT. 17 62/126 054A

GAMBILL;W.R. GREENE;N.D.
"HEAT TRANSFER METHOD"
2,950,604 1960 AUG. 30 62/5 074A

SEPHTON;H.H.
"VORTEX FLOW FILM DISTILLATION PROCESS"
3,423,294 1969 JUN. 21 203/10 074A

HEDSTROM;B.
"METHOD OF IMPROVING THE H.T. IN A TUBE OF AN EVAPORATOR ETC."
3,621,905 1971 NOV. 23 165/1 094A

SEPHTON;H.H.
"VORTEX FLOW FOR ENHANCING INTERFACIAL SURFACE AND HEAT AND MASS TRANSFER"
3,648,754 1972 MAR. 14 153/13A 074A

NAKAMURA;H. TANAKA;M.
"CROSS-RIFLED VAPOR GENERATING TUBES"
3,734,140 1973 MAY 22 138/177 024A

NEWSON;I.H. HODGSON;T.D.
"HEAT TRANSFER MEMBERS"
3,762,468 1973 OCT. 2 165/177 084B
085B

WITHERS;J.G. DEAN;H.R. ROSS;S.T.
"ADVANTAGEOUS CONFIGURATION OF TUBING FOR INTERNAL BOILING"
3,826,304 1974 JUL. 30 165/1 024A

FISCHER;W. GAMMEL;G.
"HEAT PIPE WITH A SINTERED CAPILLARY STRUCTURE"
3,840,069 1974 OCT. 8 165/105 084A

HORNER;I.M.
"HEAT TRANSFER METHOD"
4,123,837 1978 NOV. 7 29/157.3R 014C

FENNER;G.W. RAGI;E.G.
"ENHANCED TUBE INNER SURFACE HEAT TRANSFER DEVICE AND METHOD"
4,154,293 1979 MAY 15 165/133 014A
015A

TSELUIKO;J.I. KUTSYKOVICH;D.B. SHABELNIKOVA;L.A.
KHOLOPOV;V. SCHEKIN;N.G. GRITSUK;L.D.
KATSENELENBOGEN;L.B.
"TUBULAR COOLED MEMEBERS OF METALLURGICAL FURNACE"
4,186,798 1980 FEB. 5 165/147 054A

GIANNI;S.J. SEELEY;W.M.
"CONCENTRIC TUBE HEAT EXCHANGE ASSEMBLY WITH IMPROVED INTERNAL FIN STRUCTURE"
4,284,133 1981 AUG. 18 165/133 044A

HACKETT;C.D.
"RIB DESIGN FOR BOILER TUBES"
4,314,587 1982 FEB. 9 138/38 024A

COURY;G.E.
"METHOD FOR IMPROVED HEAT TRANSFER"
4,349,068 1982 SEP. 14 165/1 154A

KLASCHKA;J.T. DAVIES;M.J.
"HEAT PIPES AND THERMAL SIPHONS"
4,353,415 1982 OCT. 12 165/104.21 084A

ASAMI;T.
"HEAT TRANSFER TUBING FOR NATURAL GAS EVAPORATOR"
4,367,791 1983 JAN. 11 165/109 044A/B

MORANNE;J.-P.
"TUBE FOR TUBE-PLATE HEAT EXCHANGERS"
4,369,837 1983 JAN. 25 165/175 024B

TATSUMI;A.
"MACHINE FOR FORMING SPIRAL GROOVES IN METAL PIPE INNER SURFACE"
4,373,366 1983 FEB. 15 72/75 024A
025A

NISHIGUCHI;A. USUI;S. OOUCHI;T.
IWAI;K.
"VAPOR GENERATOR"
4,499,859 1985 FEB. 19 122/18 044A

SHINOHARA;Y. OIZUMI;K. ITOH;Y.
HORI;M.
"HEAT-TRANSFER TUBES WITH GROOVED INNER SURFACE"
4,658,892 1987 APR. 21 165/133 044A
045A

CUNNINGHAM;J.L. CAMPBELL;B.J.
"HEAT TRANSFER TUBE HAVING INTERNAL RIDGES, AND METHOD OF MAKING SAME"
4,660,630 1987 APR. 28 165/133 044A
045A

CUNNINGHAM;J.L. CAMPBELL;B.J.
"METHOD OF MAKING HEAT TRANSFER TUBE WITH IMPROVED OUTSIDE SURFACE FOR NUCLEATE BOILING"
4,729,155 1988 MAR. 8 29/157.3AH 044A
045A

SATO;Y.
"HEAT TRANSFER PIPE"
4,733,698 1988 MAR. 29 138/38 024A
025A

ACKER;R.M. EGBERT;L.
"PLATE FOR EVAPORATIVE HEAT EXCHANGER AND EVAPORATIVE HEAT EXCHANGER"
4,758,385 1988 JUL. 19 261/153 024D

HALLSTROM;B. OLSSON;O. BOLMSTEDT;U.
JOHANNSON;B.-O.
"PLATE TYPE EVAPORATOR"
4,762,171 1988 AUG. 9 165/147 044D

HESSE;W.
"HEAT EXCHANGER, PARTICULARLY A COOLANT EVAPORATOR"
4,775,006 1988 OCT. 4 165/150 034D

MURAYAMA;K.
"LAMINATE TYPE EVAPORATOR WITH EXPANSION VALVE"
4,809,518 1989 MAR. 7 62/225 044D

YOSHIDA;T. FUJII;M. SAKUMA;K.
"HEAT EXCHANGER TUBE FOR EVAPORATION OR CONDENSATION"
4,880,054 1989 NOV. 14 165/133 044A
045A

ZOHLER;S.R.
"HIGH PERFORMANCE HEAT TRANSFER TUBE FOR HEAT EXCHANGERS"
4,938,282 1990 JUL. 3 165/133 044A

KURODA;K. HAYASHI;C. NAKASUJI;K.
"METHOD OF MANUFACTURING METALLIC TUBE WITH SPIRAL FIN"
4,959,985 1990 OCT. 2 72/97 044C
045C

HUGHES;G.C. LARRABEE;S.
"SERPENTINE FIN, ROUND TUBE HEAT EXCHANGER"
4,966,230 1990 OCT. 30 165/150 044E
045E 042E

KHATTAR;M.K.
"HEAT TUBE DEVICE"
4,971,139 1990 NOV. 20 165/86 164A

NOGUCHI;I.
"LAMINATED EVAPORATOR"
4,974,670 1990 DEC. 4 165/153 054D

SHIMOYA;M. NAKABOU;T. YAMAUCHI;Y.
"PLATE-TYPE REFRIGERANT EVAPORATOR"

5,137,082	1992 AUG. 11	165/110	044D

SHIMOYA;M. NAKABOU;T. YAMAUCHI;Y.
"PLATE-TYPE REFRIGERANT EVAPORATOR"

5,172,759	1992 DEC. 22	165/110	044D

CONDENSATION PATENTS

TOWNSEND;A.J.
"HEAT EXCHANGER AND METHOD OF MAKING SAME"
2,181,927 1939 DEC. 5 29/157.3 165A

LEA;E.S.
"FINNED CONDENSER TUBE"
2,241,209 1941 MAY 6 257/236 045C

KUENHOLD;O.J. SR.
"EVAPORATOR"
2,394,698 1946 FEB. 12 261/104 015F

FENGER;C.
"CROSS FLOW HEAT EXCHANGERS"
2,813,701 1957 NOV. 19 257/245 045E

VAALER;L.E.
"IMPREGNATED POROUS CONDENSER SURFACE"
2,919,115 1959 DEC. 29 257/58 015F

BUCKINGHAM;W.T.
"METHOD OF APPLYING A PLASTIC COATING"
2,923,640 1960 FEB. 2 117/49 015B

BLOEM;A.T.
"H-X FOR SEPARATING OUT CONSTITUENTS FROM A GAS BY COOLING"
2,947,152 1960 AUG. 2 62/40 045F

VAN LUIK;F.W. JR.
"VAPOR-LIQUID PHASE CONVERSION"
2,962,265 1960 NOV. 29 257/43 145B/C

BERGSON;G.
"CONDENSING FILTER"
2,970,669 1961 FEB. 7 183/2 085A

CASWELL;H.E.
"HEAT TRANSFER DEVICE WITH CONDENSATE DRAINAGE MEANS"
2,983,115 1961 MAY 9 62/285 045C

WYATT;T.
"SATELLITE TEMPERATURE STABILIZATION SYSTEM"
3,152,774 1964 OCT. 13 244/1 085F
083F

LYNCH;P.J. TAYLOR;P.L.
"PROMOTION OF DROPWISE CONDENSATION"
3,167,927 1965 FEB. 2 62/56 015F

KASSAT;H.
"AIR COOLED CONDENSER FOR DISTILLING APPARATUS"
3,175,960 1965 MAR. 30 202/189 045B

RICH;D.G.
"REFRIGERATION SYSTEM"
3,196,634 1965 JUL. 27 62/394 015C

NEUGEBAUER;F.J. LUSTENADER;E.L.
"DROPWISE CONDENSATION DISTILLATION APPARATUS"
3,206,381 1965 SEP. 14 202/185 015F

RODGERS;J.S.
"STEAM CONDENSER OF THE WATER TUBE TYPE"
3,217,799 1965 NOV. 16 165/179 025A

WARTENBERG;K.
"AIR COOLED HEAT EXCHANGER FOR COOLING LIQUID MEDIA"
3,225,824 1965 DEC. 28 165/122 045E

GROVER;G.M.
"EVAPORATION-CONDENSATION HEAT TRANSFER DEVICE"
3,229,759 1966 JAN. 18 165/105 015F
085F 083F

WOODWORTH;L.R.
"CONDENSER"
3,232,341 1966 FEB. 1 165/111 075A

ROGERS;F.A.
"DISTILLATION APPARATUS FOR TREATING SEA WATER TO PRODUCE ETC."
3,240,683 1966 MAR. 15 202/173 065D

DIEDRICH;G.E.
"FLUTED TUBULAR DISTILLATION APPARATUS"
3,244,601 1966 APR. 5 202/236 025C

HEEREN;H.
"INTERNALLY FINNED CONDENSER TUBE"
3,273,599 1966 SEP. 20 138/38 045A
042A

STAUB;F.W.
"CONDENSING HEAT TRANSFER DEVICE"
3,289,752 1966 DEC. 6 165/110 035D

ERB;R.A.
"METHOD AND APPARATUS FOR DROPWISE CONDENSATION"
3,298,427 1967 JAN. 17 165/1 015F

GAERTNER;R.F.
"METHOD AND MEANS FOR INCREASING THE H.T. COEFFICIENT ETC."
3,301,314 1967 JAN. 31 165/1 015F

THOMAS;D.G.
"CONDENSER TUBE"
3,358,750 1967 DEC. 19 165/177 035C

ROSENBLAD;C.F.
"FALLING FILM PLATE HEAT EXCHANGER"
3,371,709 1968 MAR. 5 165/115 065D

MILTON;R.M.
"HEAT EXCHANGER SYSTEM"
3,384,154 1968 MAY 21 165/1 015C

TIMSON;W.J.
"BOILING HEAT TRANSFER SYSTEM"
3,433,294 1969 MAR. 18 165/1 015F

WOLFE JR.;W.
"CORRUGATED TUBING"
3,450,193 1969 JUN. 17 165/1 045C

THEOPHILOUS;N.P. WANG;D.I.J.
"MULTIPLE PASSAGE HEAT EXCHANGER UTILIZING NUCLEATE BOILING"
3,457,990 1969 JUL. 29 165/133 045A
023A

ERB;R.A.
"METHOD FOR IMPROVING HEAT TRANSFER IN CONDENSERS"
3,466,189 1969 SEP. 9 117/132 015F

WITHERS;J.G. JR.
"CONFIGURATION OF H.T. TUBING FOR VAPOUR CONDENSATION ETC."
3,481,394 1965 DEC. 2 165/179 045C

ROE;R.C.
"CONDENSER TUBES"
3,508,608 1970 APR. 28 165/179 085C

MILTON;R.M.
"HEAT EXCHANGE SYSTEM"
3,523,577 1970 AUG. 11 165/110 015C

LEVEDAHL;W.J.
"HEAT PIPE FOR LOW THERMAL CONDUCTIVITY WORKING FLUIDS"
3,528,494 1970 SEP. 15 165/105 045A

EISSENBERG;D.M.
"METHOD FOR PROMOTING DROPWISE CONDENSATION ON COPPER ETC."
3,547,185 1970 DEC. 15 165/1 105C

WITHER;J.G. JR.
"METHOD AND APPARATUS FOR MAKING HEAT TRANSFER TUBING"
3,559,437 1971 FEB. 2 72/96 045C

022A

MILTON;R.M.
"HEAT EXCHANGE SYSYTEM WITH POROUS BOILING LAYER"
3,587,730 1971 JUN. 28 165/110 015C

BROWN;C.E.
"APPARATUS FOR OBTAINING HIGH HEAT TRANSFER IN FALLING WATER FILM"
3,613,779 1971 OCT. 19 165/133 085C

BISTOW;R.E.
"HIGH EFFICIENCY VAPOR CONDENSER AND METHOD"
3,675,710 1972 JUL. 11 165/1 075A
155A

SLAASTED;R.S. DUDLEY;J.C.
"METHOD OF COOLING A GAS AND REMOVING MOISTURE THEREFROM"
3,759,050 1973 SEP. 18 62/93 065D

NEWSON;I.H. HODGSON;T.D.
"HEAT TRANSFER MEMBERS"
3,762,468 1973 OCT. 2 165/177 085B
084B

FORD;J.A.
"PROCESS FOR IMPROVING H.T. EFFICIENCY AND IMPROVED H.T. SYSTEM"
3,789,915 1974 FEB. 5 165/1 025C

PAUL;R.S. WEILER;D.W.
"ROTARY HEAT EXCHANGER AND APPARATUS"
3,797,559 1974 MAR. 19 165/1 165A

GRANT;A.C.
"POROUS METALLIC LAYER FORMATION"
3,821,018 1974 JUN. 28 117/94 015C

INOUE;K.
"HEAT EXCHANGER"
3,825,064 1974 JUL. 23 165/179 015C

NEWTON;A.B.
"VERTICAL SURFACE VAPOR CONDENSERS"
3,837,396 1974 SEP. 24 165/111 085A

SEPHTON;H.H.
"INTERFACE ENHANCEMENT APPLIED TO EVAPORATION OF LIQUIDS"
3,846,254 1974 NOV. 5 203/11 085A
042A

NEWSON;I.H. HODGSON;T.D.
"TUBULAR HEAT TRANSFER MEMBERS"
3,875,997 1975 APR. 8 165/110 025A

DERONZIER;J.C.
"METHOD FOR CAUSING CONDENSATION IN DROPS ON H-X TUBES"
3,878,885, 1975 APR. 22 165/1 105A/B

NEWTON;A.B.
"CONDENSATE GUIDING APPARATUS FOR VERTICAL CONDENSING TUBES ETC."
3,903,962 1975 SEP. 9 165/110 085A

NEWTON;A.B.
"CONDENSER INSERTS"
3,989,104 1976 NOV. 2 165/111 085A

NOTARO;F.
"ENHANCED CONDENSATION HEAT TRANSFER DEVICE AND METHOD"
4,154,294 1979 MAY 15 165/133 015C

ALBERTSON;C.E.
"BOILING HEAT TRANSFER SURFACE AND METHOD"
4,018,264 1977 APR. 19 165/1 015C

GRANT;A.C.
"POROUS METALLIC LAYER AND FORMATION"
4,064,914 1977 DEC. 27 138/142 015C

HONDA;I. TAKASU;S. ONUKI;Y.
"HEAT PIPES, PROCESS AND APPARATUS FOR MANUFACTURING SAME"
4,109,709 1978 AUG. 29 165/105 085F

JANOWSKI;K.R. SHUM;M.S. BRADLEY;S.A.
"HEAT TRANSFER SURFACE"
4,129,181 1978 DEC. 12 165/133 015C

ANDERSON;J.H.
"PLATE FIN HEAT EXCHANGER"
4,139,054 1979 FEB. 13 165/76 065D

WOODHULL;I.D. JR. LIEDEL;T.H.
"CONDENSER HEADER CONSTRUCTION"
4,141,409 1979 FEB. 27 165/110 045F

FENNER;G.W. RAGI;E.G.
"ENHANCED TUBE INNER SURFACE HEAT TRANSFER DEVICE AND METHOD"
4,154,293 1979 MAY 15 165/133 015A
014A

FUJIE;K.
"VAPOR-CONDENSING, HEAT-TRANSFER WALL"
4,166,498 1979 SEP. 4 165/133 045B

SUMIMOTO;H.
"PLATE TYPE CONDENSER"
4,180,129 1979 DEC. 25 165/110 065D

YOSHIDA;K. KOBAYASHI;K. SUMIMOTO;H.
"PLATE TYPE CONDENSER"
4,182,410 1980 JAN. 8 165/110 065D

SUMIMOTO;H. FUKAMI;K. KOBAYASHI;K.
DOI;M. KAWANISHI;K. YOSHIDA;K.
"PLATE TYPE CONDENSER"
4,182,411 1980 JAN. 8 165/110 065D

FUJIE;K. NAKAYAMA;W. KUWAHARA;H.
DAIKOKU;T. KAKIZAKI;K.
"HEAT-TRANSFER WALL FOR CONDENSATION AND METHOD OF MANUFACTURING THE SAME"
4,195,688 1980 APR. 1 165/133 025B

SUMIMOTO;H.
"PLATE USED IN CONDENSER"
4,228,850 1980 OCT. 21 165/110 065D

UEHARA;H. MIYOSHI;M.
"PLATE TYPE CONDENSERS"
4,230,179 1980 OCT. 28 165/113 065D

FENNER;G.W. RAGI;E.G.
"METHOD FOR ENHANCED HEAT TRANSFER"
4,232,728 1980 NOV. 11 165/1 025A
022A

UEHARA;H. MIYOSHI;M.
"PLATE TYPE CONDENSERS"
4,237,970 1980 DEC. 9 165/110 085D

FUJIKAKE;J.
"HEAT TRANSFER TUBE FOR CONDENSATION AND METHOD FOR MANUFACTURING SAME"
4,245,695 1981 JAN. 20 165/133 025C

KUN;L.C. RAGI;E.G.
"ENHANCEMENT FOR FILM CONDENSATION APPARATUS"
4,253,519 1981 MAR. 3 165/110 035B

MASUTANI;K. HORIGUCHI;A. SUMIMOTO;H.
"STRUCTURE OF FLUID CONDENSING AND HEAT CONDUCTING SURFACE OF CONDENSER"
4,285,395 1981 AUG. 25 165/110 065D

YAMPOLSKY;J.S.
"HEAT TRANSFER TUBE"

4,305,460 1981 DEC. 15 165/179 085C
042A

SUMIMOTO;H. DOI;M. KOBAYASHI;K.
FUKAMI;K. KAWANISHI;K.
"CONDENSER"
4,314,605 1982 FEB. 9 165/110 085D

SATOH;Y. HIGO;T.
"CONSTRUCTION OF A HEAT TRANSFER WALL AND HEAT TRANSFER PIPE AND METHOD OF PRODUCING HEAT TRANSFER PIPE"
4,330,036 1982 MAY 18 165/179 045C

MUELLEJANS;H.
"PROCESS FOR THE PREPARATION OF A SURFACE OF A METAL WALL FOR THE TRANSFER OF HEAT"
4,360,058 1982 NOV. 23 165/104.21 025A

TATSUMI;A.
"MACHINE FOR FORMING SPIRAL GROOVES IN METAL PIPE INNER SURFACE"
4,373,366 1983 FEB. 15 72/75 025A
024A

HULL;F.R.
"CONDENSING GAS-TO-GAS HEAT EXCHANGER"
4,548,262 1985 OCT. 22 165/111 085A

ALLEN;P.H.G. COOPER;P.
"HEAT EXCHANGER WITH ELECTROHYDRODYNAMIC EFFECT"
4,651,806 1987 MAR. 24 165/1 145C

UEHARA;H. NAKAOKA;T.
"ROTARY BLADE TYPE FLUID CONDENSER"
4,658,890 1987 APR. 21 165/92 115C

SHINOHARA;Y. OIZUMI;K. ITOH;Y.
HORI;M.
"HEAT-TRANSFER TUBES WITH GROOVED INNER SURFACE"
4,658,892 1987 APR. 21 165/133 045A
044A

CUNNINGHAM;J.L. CAMPBELL;B.J.
"HEAT TRANSFER TUBE HAVING INTERNAL RIDGES, AND METHOD OF MAKING SAME"
4,660,630 1987 APR. 28 165/133 045A
044A

ZOGG;R.A. ROBERTSON;G.F.
"INTERNALLY ENHANCED TUBES"
4,705,103 1987 NOV. 10 165/110 045A

CUNNINGHAM;J.L. CAMPBELL;B.J.
"METHOD OF MAKING HEAT TRANSFER TUBE WITH IMPROVED OUTSIDE SURFACE FOR NUCLEATE BOILING"
4,729,155 1988 MAR. 8 29/157.3AH 045A
044A

SATO;Y.
"HEAT TRANSFER PIPE"
4,733,698 1988 MAR. 29 138/38 025A
024A

NAKAMURA;Y. MORI;K. OKUMURA;M.
MOCHIDA;Y. MIYAZAKI;M.
"HEAT TRANSFER PROMOTERS AND METHOD OF USING THE SAME"
4,801,394 1989 JAN. 31 252/75 015C

KADLE;D.S.
"CONDENSER WITH IMPROVED FLOW PATH"
4,831,844 1989 MAY 23 62/507 045B

ZOHLER;S.R.
"METHOD OF MAKING A HIGH PERFORMANCE, UNIFORM FIN HEAT TRANSFER TUBE"
4,866,830 1989 SEP. 19 29/157.3A 045C

YOSHIDA;T. FUJII;M. SAKUMA;K.
"HEAT EXCHANGER TUBE FOR EVAPORATION OR CONDENSATION"
4,880,054 1989 NOV. 14 165/133 045A
044A

ZOHLER;S.R.
"HIGH PERFORMANCE HEAT TRANSFER TUBE AND METHOD OF MAKING SAME"
4,921,042 1990 MAY 1 165/179 045C

MIZOGUCHI;M. INOUE;S. OTSUKA;T.
ISOYAMA;E.
"ALUMINUM HEAT EXCHANGER PROVIDED WITH FINS HAVING HYDROPHILIC COATING"
4,957,159 1990 SEP. 18 165/133 015C

KURODA;K. HAYASHI;C. NAKASUJI;K.
"METHOD OF MANUFACTURING METALLIC TUBE WITH SPIRAL FIN"
4,959,985 1990 OCT. 2 72/97 045C
044C

HUGHES;G.C. LARRABEE;S.
"SERPENTINE FIN, ROUND TUBE HEAT EXCHANGER"
4,966,230 1990 OCT. 30 165/150 045E
044E 042E

ROBERTSON;G.F. MOYER;R.A. MCMANUS;J.R.
"METHOD AND APPARATUS FOR INTERNALLY ENHANCING HEAT EXCHANGER TUBING"
4,995,252 1991 FEB. 26 72/194 025A

INTERNAL DISTRIBUTION

1.	V. D. Baxter	15.	V. C. Mei
2.	J. B. Cannon	16.	W. A. Miller
3.	R. S. Carlsmith	17.	R. W. Murphy
4.	F. C. Chen	18.	C. K. Rice
5-7.	J. C. Conklin	19.	R. B. Shelton
8.	G. E. Courville	20.	T. J. Wilbanks
9.	P. D. Fairchild	21.	P. P. Wolff
10.	S. K. Fischer	22.	ORNL Patent Office
11.	W. Fulkerson	23.	Central Research Library
12.	J. O. Kolb	24.	Document Reference Section
13.	M. A. Kuliasha	25-27.	Laboratory Records
14.	H. A. McLain	28.	Laboratory Records

EXTERNAL DISTRIBUTION

29. Mr. Manfred Ahle, Vice President, Engineering, Honeywell, Inc., 1985 Douglas Drive, MN10-2400, Golden Valley, MN 55422-3992
30. Mr. Warren L. Beeton, Director, Design Technology and Test, Unitary Products Group, The Trane Company, 6200 Troup Highway, Tyler, TX 75711-9010
31. Mr. Jeffrey Berge, Manager, Component Development, Thermo King Corporation, 314 West 90th Street, Bloomington, MN 55420
32. Dr. Douglas R. Bohi, Director, Energy and Natural Resources Division, Resources for the Future, 1616 P Street, N.W., Washington, DC 20036
33. Mr. Wilson E. Bradley, Chairman of the Board, EVAPCO, Inc., P.O. Box 1300, Westminster, MD 21158
34. Dr. Charles E. Bullock, Principal Staff Engineer, Corporate Advanced Systems, Carrier Corporation, Carrier Parkway, A&R Building, P.O. Box 4808, Syracuse, NY 13221
35. Mr. Lee W. Burgett, Vice President, Engineering and Technology, The Trane Company, Commercial Systems Group, 3600 Pammel Creek Road, La Crosse, WI 54601-7599
36-38. Mr. James M. Calm, P.E., Engineering Consultant, 10887 Woodleaf Lane, Great Falls, VA 22066
39. Mr. Bradley J. Campbell, Vice President, Engineering, Climate Master, Inc., Environmental Group, LSB Industries, 7300 SW 44th Street, Oklahoma City, OK 73179
40. Mr. Daniel J. Canclini, Vice President, Product Development and Research Engineering, Rheem Manufacturing Company, 5600 Old Greenwood Road (72903) P.O. Box 17010, Fort Smith, AR 72917-7010
41. Dr. Robert Chiang, Project Leader, Refrigerant Side Heat Transfer, Corporate Engineering Operations, Carrier Corporation, P.O. Box 4808, Carrier Parkway, Syracuse, NY 13221
42. Mr. Gary W. Cole, Quality Assurance Manager, Matsushita Compressor Corp. of America, One Panasonic Way, P.O. Box 1418, Morresville, NC 28115
43. Mr. Jimmy L. Cox, Engineering Manager, Rheem Air-Conditioning Division, Rheem Manufacturing Company, 5600 Old Greenwood Road, P.O. Box 17010, Fort Smith, AR 72917-7010

44. Mr. Piyush J. Desai, Packless Industries, Director of Marketing and Product Engineering, A/C & Refrigeration Components, P.O. Box 20668, Waco, TX 76702
45. Dr. David A. Didion, Thermal Machinery Group, Building Environment Division, NIST Building 226, Room B114, Gaithersburg, MD 20899
46. Mr. Warren H. Dillenbeck, Manager, International Technology Liaison, Commercial Products Division, Dunham-Bush, Inc., 101 Burgess Road, Harrisonburg, VA 22801
47. Dr. Thomas E. Drabek, Professor, Department of Sociology, University of Denver, Denver, CO 80208-0209
48. Mr. Richard E. Ertinger, Director, Centrifugal and Absorption, Chiller Engineering, Carrier Corporation, Carrier Parkway, Bldg., TR-4, P.O. Box 4808, Syracuse, NY 13221
49. Mr. Jack L. Esformes, Director of Heat Transfer, Corporate Engineering Operations, Carrier Corporation, P.O. Box 4808, Carrier Parkway, Syracuse, NY 13221
50. Mr. Paul R. Glamm, Engineering Manager, Thermal Systems Technology, Commercial Systems Group, The Trane Company, 3600 Pammel Creek Road, La Crosse, WI 54601-7599
51. Mr. Dieter E. Grether, Executive Vice President, Technology, The Environmental Group, LSB Industries, Inc., P.O. Box 1535, Oklahoma City, OK 73101
52. Mr. Mike Heidenreich, Director of Engineering, Heatcraft, Inc., Highway 51 South, P.O. Box 948, Grenada, MS 38901
53. Mr. Todd W. Herrick, President and CEO, Tecumseh Products Company, 100 East Patterson Street, Tecumseh, MI 49286
54. Dr. Kenneth E. Hickman, Vice President, Applied Systems Engineering, York International Corporation, 631 South Richland Avenue, P.O. Box 1592, Mail Code 191A, York, PA 17405-1592
55. Dr. William D. Hill, Director, R&D Fluorochemicals, Du Pont Fluoroproducts (B13242) Fluorochemicals Division, E.I. du Pont de Nemours and Company, Inc., 1007 Market Street, B13237, Wilmington, DE 19898
56-58. Mr. Glenn C. Hourahan, Research Manager, Air-Conditioning and Refrigeration Technology Institute, Inc. 4301 North Fairfax Drive, Suite 425, Arlington, VA 22203
59. Mr. H. Michael Hughes, Manager Refrigerant Technology, Buffalo Research Laboratory, Allied-Signal Inc., 20 Peabody Street, Buffalo, NY 14210
60. Dr. Ronald O. Hultgren, Deputy Assistant Manager, Energy Research and Development, Department of Energy, Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, TN 37831-6269
61. Mr. Joseph R. Humphrey, Vice President, Engineering, Tyler Refrigeration Corporation, 1329 Lake Street, Niles, MI 49120
62. Mr. Robert L. Jenkins, President and Chief Operating Officer, Heatcraft, Inc., Highway 51 South, P.O. Box 948, Grenada, MS 38901
63-64. M. K. Jensen, Rensselaer Polytechnic Institute, Department of Mechanical Engineering, Aeronautical Engineering and Mechanics, Troy, NY 12180-3590
65. Dr. M. A. Kedzierski, Thermal Machinery Group, Building Environment Division, NIST Building 226, Room B114, Gaithersburg, MD 20899
66. Mr. John C. Knopp, Design Engineer, Commercial Products Group, SnyderGeneral Corporation, P.O. Box 2510, Staunton, VA 24401-1420
67. Mr. John E. Lebo, President, Doucette Industries, Inc., P.O. Box 2337, York, PA 17405
68. Mr. Peter W. Likes, Vice President, Government & Trade Relations, Hussmann Corporation, 12999 St. Charles Rock Rd., Bridgeton, MO 63044
69. Mr. Alexander T. Lim, Director of Technology, Inter-City Products Corporation, 1136 Heil-Quaker Boulevard, Lavergne, TN 37086-1985
70. Ms. Karen M. Lindsay, Manager, Components and Parts, North American Trading Company, Dunham-Bush, 101 Burgess Road, Harrisonburg, VA 22801

71. Mr. Calvin D. MacCracken, President, Calmac Manufacturing Corporation, 101 West Sheffield Avenue, P.O. Box 710, Englewood, NJ 07631
72. Mr. Thomas A. Mahoney, Editor-at-large, Business News Publishing Co., P.O. Box 2600, Troy, MI 48007
73. Mr. Earl B. Muir, Senior Vice President, Engineering and Research, Copeland Corporation, 1675 West Campbell Road, Sidney, OH 45635-0699
74. Mr. W. E. Noel, U.S. Department of Energy, EE-422, 5H-048/FORS, 1000 Independence Avenue SW, Washington DC 20585
75-76. Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831
77. Mr. L. Michael O'Keeffe, Vice President, Engineering, Copeland Corporation, 1675 West Campbell Road, Sidney, OH 45365-0669
78. Dr. Keshav S. Sanvordenker, Assistant Director, Research Laboratory, Tecumseh Products Company, 3869 Research Park Drive, Ann Arbor, MI 48108
79. Mr. Fred Scheideman, Director of Engineering, Standard Refrigeration Company, 2050 North Ruby Street, Melrose Park, IL 60160
80-81. B. Shome, Rensselaer Polytechnic Institute, Department of Mechanical Engineering, Aeronautical Engineering and Mechanics, Troy, NY 12180-3590
82. Ms. Jacqueline B. Shrago, Director, Office of Technology Transfer, 405 Kirkland Hall, Vanderbilt University, Nashville, TN 37240
83. Mr. Howard W. Sibley, Program Manager, Refrigerant Technology, Carrier Corporation, Carrier Parkway, A&R Building, P.O. Box 4808, Syracuse, NY 13221
84. Mr. George F. Sowers, P.E., Senior Vice President, Law Companies Group, Inc., 114 Townpark Drive, Suite 250, Kennesaw, GA 30144-5599
85. Mr. Mark W. Spatz, Research Engineer, Genetron Refrigerant Applications, Allied-Signal Inc., Fluorine Products Division, 20 Peabody Street, Buffalo, NY 14210
86. Mr. Keith E. Starner, Engineering Manager, Heat Transfer, Applied Systems Engineering, York International Corporation, 631 South Richland Avenue, York, PA 17405-1592
87. Mr. Robert S. Strandberg, Engineering Manager, SnyderGeneral Corporation, P.O. Box 1551, Minneapolis, MN 55440
88. Mr. Petur Thors, Manager of Product Development, Wolverine Tube, Inc., 2100 Market Street, N.E., P.O. Box 2202, Decatur, AL 35601
89. Mr. David W. Treadwell, Vice President, Research, Lennox Industries, Inc., P.O. Box 877, Carrollton, TX 75011-0877
90. Mr. John H. Vana, Vice President, Engineering, Hill Refrigeration Corporation, 360 Pennington Avenue, Trenton, NJ 08601
91. Dr. C. Michael Walton, Ernest H. Cockrell Centennial Chair in Engineering and Chairman, Department of Civil Engineering, University of Texas at Austin, Austin, TX 78712-1076
92. Mr. Thomas E. Watson, P.E., Manager Staunton Engineering, Commercial Products Group, SnyderGeneral Corporation, P.O. Box 2510, Staunton, VA 24002-2510
93. Mr. Gary B. Wetzel, Manager, Engineering Services, Commercial Products Group, SnyderGeneral Corporation, 13600 Industrial Park Boulevard, P.O. Box 1551, Minneapolis, MN 55440
94. Mr. Jack Wileczka, Sales Manager, Turbotec Products, Inc., 651 Day Hill Road, Windsor, CT 06095
95. Mr. David L. Wilkerson, President, Recold, 550 West Mercury Lane, Brea, CA 92621