Session Summaries for SOFE05

Monday Morning - 8:00 AM - 12:15 PM - Salon ABC
Welcome and Introductions
Plenary - The ITER Era

Monday Afternoon 1:30 - 3:00 PM
Poster Session I.a - Salon DE
Experimental Devices and New Device Design
Plasma Facing Materials / Plasma Materials Interactions
Targets, Chambers, Vacuum Vessels and Pumping

Poster Session I.a. Experimental Devices and New Device Design
Session Chair - Mike Cole (ORNL)

Gentile		Vacuum Pumping System for a Large IFE Target Chamber		A-1
Ju Chang		Design and Numerical Stress Analysis of Silicon Membrane Hibachi Windows		A-2
Madhukar		Conductor R&D for QPS		A-4
Bykov		Strategy of Structural Analysis of W7-X Magnet System		A-5
Heinemann		Design of Narrow Support Elements for Non Planar Coils of Wendelstein-7X		A-6
Williamson		Challenges in Designing the Modular Coils for the National Compact Stellarator Experiment (NCSX)		A-7
Fogarty		Development of Fusion Design Concepts Using Stereolithography		A-8
Yang		Recent Progress of the KSTAR Tokamak Assembly		A-9
Kessel		Simulation and Analysis of the ITER Hybrid Operating Mode		A-10
Cucchiaro		Ignitor Plasma Chamber, First Wall and Remote Handling Maintenance		A-11
Cucchiaro		The Ignitor Load Assembly Structural Analysis and Toroidal Field Coil		A-12
Teodorescu		Supersonically Rotating Plasmas for Magnetic Fusion: the Maryland Centrifugal Experiment		A-13
Ogawa		Simultaneous Neutron and Proton Measurements of D-D and D-3He Fusion Reaction in an Inertial Electrostatic Confinement Fusion Device		A-15

Takamatsu		Improvement of Inertial Electrostatic Confinement Device by Magnetron-Discharge-Based Built-in Ion Sources		A-16
Noborio		The Potential Profile and its Influence on the Neutron Yield of Inertial Electrostatic Confinement Fusion Device		A-17

15 posters were presented by authors Gentile, Ju Chang, Madhukar, Bykov, Heinemann, Williamson, Fogarty, Yang, Kessel, Cucchiaro, Cucchiaro, Teodorescu, Ogawa, Takamatsu, Noborio (Posters A[1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17] according to the program). This session saw the presentations on several different machines 3 on Inertial Electrostatic Confinement, 2 on W7-X, 2 on NCSX ,2 on Ignitor , 1 each on IFE, DIII-D, QPS, KSTAR, and ITER. Several of the posters presented issues of new machines and the challenges and problems associated with these machines. Examples included NCSX[Williamson] and QPS[Fogarty/ Madhukar] where complex geometry created challenges and opportunities for innovative techniques in modeling and analysis. Both QPS and NCSX have used stereo lithography techniques to aid in visualization and fabrication. Several posters described assembly methods used during the construction of KSTAR[Yang] and W7-X[Heinemann]. The poster on KSTAR presented the assembly steps for the assembly to date. The techniques used to control the distortion of the vacuum vessel during assembly by taking real time measurements of displacement during the welding process and adjusting the welding positions based on the results of these measurements was very challenging. The analysis method used on W7-X of using two independent teams using two different analysis programs (ANSYS and ADIMA) to solve the displacement, force, and stress analysis was very interesting.

Monday Afternoon 1:30 - 3:00 PM
Poster Session I.b - Center BC
Power Plant Studies
Blanket, and Shield

Poster Session 1.b: Blanket, and Shield
Session Chair - Roger Stoller (ORNL)

Sviatoslavsky	First Wall Thermal Analysis of the US- ITER Dual Coolant Pb-17Li Liquid (DCLL) Test Blanket Module Design	B-10
Yamauchi	Shielding Design of ITER Pressure Suppression Line	B-11
Meyder	Tritium Analysis for the European HCPB TBM Module in ITER	B-12
Sawan	Neutronics Assessment of Blanket Options for the HAPL Laser Inertial Fusion Energy Chamber	B-14
Sawan	Neutronics Features of a Dual Coolant Lithium Lead Test Blanket Module for ITER	B-15
Luo	Numerical Study on Splash Conditions of an Integrated Droplet-type Divertor	B-16
Brenner	Hydrogen Absorption in Liquid Lithium Exposed to Hydrogen	B-17

	Plasma	
De Groot	Modeling Shrapnel Formation in a Z-Pinch Power Plant	B-18

A total of 8 eight posters were presented, by authors Sviatoslavsky, Yamauchi, Meyder, Sawan, Luo, Brenner, De Groot (Posters B[10,11,12,14,15,16,17,18] according to the program). Four of the posters dealt specifically with ITER-related issues, two with inertial confinement systems, and two with generic issues related to the use of flowing liquids to protect the first wall of a fusion device. The imminence of ITER seems to be bringing an increased focus on what can be called practical issues related to its use. For example, the neutronics behavior related to neutron streaming and activation of components that may require maintenance (Yamauchi, et al.), and more detailed neutronic and thermomechanical calculations of tritium breeding and behavior in ITER blanket modules (Meyder, et al. and Sawan, et al.). Similarly, a more detailed thermal analysis of a dual-coolant ITER blanket module involving counter-flowing He demonstrated the trade-off between engineering complexity and unexpectedly-improved thermal performance (Sviatoslavsky, et al.). In a more realistic look at potential tritium uptake in a liquid lithium film, exposure to energetic deuterons led to much higher hydrogen retention than exposure to static deuterium (Brenner, et, al).

Monday Afternoon 3:00 - 5:20 PM (3 Parallel Sessions)
Oral I.c - Power Plant Studies - Salon C
Oral I.d - Magnet System Technology - Salon AB
Oral I.e - Diagnostics and Data Acquisition - Sequoyah 3

Oral Session I.d Magnet System Technology
Session Chair - Joseph Minervini (MIT)

The Magnet System Technology oral session consisted of 6 papers which presented a range of magnet technology topics including presently operating resistive fusion devices, construction of superconducting fusion devices, designs for future machines and development of advanced components for superconducting magnet systems.

The first paper was presented by Joel Schultz of the MIT Plasma Science and Fusion Center and gave an overview of the design of the superconducting Central Solenoid for ITER. This is one of the components which could be a potential US contribution-in-kind to the ITER project. The magnet system weighs over 840 metric tons, has a maximum operating current of 45 kA and generates a peak magnetic field of 13 Tesla. It is comprised of 6 identical coil modules. The vertical segmentation allows for separate control of coil currents and is advantageous for plasma shaping and control. Initial development activities have been started to prepare industry to produce very large quantities of superconducting high performance Nb_3Sn wire and to establish the manufacturing QA program. Schultz also addressed the technical issues surrounding the choice of jacket material for the conductor. The ITER Team has selected a new Japanese alloy called JK2LB whose composition is still being iterated. The US believes the alloy composition is not suitable for this application and proposes using Incoloy Alloy 908.

Dr. T. Ando from the Japanese Atomic Energy Research Institute presented a conceptual design for a tokamak fusion power reactor (VECTOR) which uses high temperature superconductor tape made from YBCO for the toroidal field magnets. The coils would operate at 33K and use 3 conductor grades to limit the flux jumping magnetic field. The 3 grades are placed in slots in the TF coil, using 4-in-hand tapes each grade, and have peak fields of 6.7 T, 13.4 T and 20 T, respectively at the windings. The grades would operate with separate power supplies. Other issues considered in the design study are AC losses, stability, and joints. A small test coil has been fabricated from a 250 m length of YBCO tape and generated a 0.72 T field at 66K.

The next talk returned us to the present operation of the NSTX machine. Here R. Woolley of Princeton Plasma Physics Laboratory presented an analysis of the voltage measurements from the 72 TF radial flag joints. From a series of laboratory measurements and results of structural analysis it was possible to calibrate the voltage readings into joint forces and ultimately to torque on the joints. These results showed that the structural support scheme for the joints was inadequate. It relied on an injected epoxy/glass mixture which turned out to have many large voids. The joints potting was redone to reduce or eliminate the large void area and this resulted in significantly improved joint performance. Lately a slow drift up in joint resistance has been seen. Bolt loosening doesn't explain it, so further investigation is needed.

C. Baxi of General Atomics continued on the line of presently operating machines with a presentation of a thermal analysis of the DIII-D coils for long pulse operation. Here the issue was how to limit the temperature rise of the magnets when the machine is operated for longer times at higher currents when the machine returns to operations in 2006. The 230 meter length flow paths limit the maximum pressure drop allowed for increased coolant flow rate. A detailed analysis indicated that the longer pulse times at higher current could be achieved only by lowering the coolant inlet temperature and taking longer to recool the magnets between shots.

A new development of high temperature superconducting current leads for use with the ITER magnets was reported by W. Fietz of Forschungszentrum Karlsruhe. The purpose of the development was to determine the technical feasibility of using this new technology and by analysis, to determine if the use of HTS leads could reduce the capital investment in the refrigeration system as well as the operating costs. The development was done in cooperation with American Superconductor Corp. who provided the HTS elements (BSCCO-2223/AgAu tape). The nominal TF operating current is 68 kA, but the current lead was successfully tested with overcurrent and with a loss of coolant test. Design inlet temperature was 50K, but it was also tested stably up to 80K. Other tests were done in both helium gas cooling and with liquid nitrogen. Results indicate that it might be possible to operate the leads in ITER with liquid nitrogen at substantial reduction in operating costs and, potentially with one less refrigeration module.

The final paper was presented by C. Damiani of the Wendelstein 7-X Team and gave a detailed report of the complex structural support elements for the 70 superconducting coils (50 non-planar and 20 planar coils) of the device. A unique feature of the support system are the Narrow Support Elements which are assembled with a gap which only gets closed and loaded when the magnet system is cold and energized. These elements provide for sliding and tilting of the coils, but must maintain the coil current positions to very tight constraints to achieve field errors of less than 1 part in 10^{-4}. Another interesting structural feature is the Central Support Element. This is a bolted structure that uses 10^4 jack bolts which must be precisely adjusted during assembly. Many of the coils have been fabricated, some have already been cold tested and a few are on site to be readied for assembly.

Tuesday Morning - 8:00 - 10:00 AM - Salon ABC
Oral II.a - Fusion Development and Experimental Devices 1

Tuesday Morning - 10:15 - 12:15 PM - Salon ABC
Oral II.b - Fusion Development and Experimental Devices 2

Tuesday Afternoon 1:30 - 3:45 PM (3 Parallel Sessions)
Oral II.c - IFE Chamber Technology - Salon C
Oral II.d - Materials Technology - Salon AB
Oral II.e - Plasma Science and Technology - Sequoyah 3

Oral session II.c IFE Chamber Technology
Session Chair – John DeGroot (U.C. Davis)

Zoran Dragojlovic and Farrokh Najmabadi
Paper given by Najmabadi
'Hydrodynamic Evolution of IFE Chanber with Different Protective Gases and Pre-Ignition Conditions'
The SPARTAN 2d Navier Stokes simulation code was used to investigate IFE chamber evolution with protective gas. Simulations were performed of the dynamic evolution of a 6.5-m-radius chamber filled with either Xe, D, or He at different initial pressures. Xenon has been proposed previously as a protective gas. Initial conditions for SPARTAN are taken from solutions of BUCKY 1-D rad-hydro code. The gas properties are dependent on local density and temperature. The ideal gas law is used as the equation of state. The chamber wall is assumed to have a constant temperature of 700ºC.
The results indicate that radiation of background plasma has a major impact on the evolution of the chamber environment. The background plasma exists due to compressive heating from the initial shockwave generated from the target blast. This shockwave reflects from the chamber wall and converges back to the center of the chamber, generating a hot core. Radiation removes the heat from this region. At 50mTorr, Xe gas heats up to 3500ºC, whereas D or He gas only heat to ~ 1500ºC. Clearly, D or He should be used as the protective gas.

M. H. Anderson, J. G. Oakley, R. Bonazza, V. Vigil, and S. Rodriquez
Paper given by V. Virgil
'Shock Mitigation Studies of Solid Foams for Z-Pinch Chamber Protection"
A highly instrumented shock tube is used to study the deformation and shock history for different porosity foams (AL-6061 Foam). A Mach 6 shock was formed. Pore sizes of 10, 20, and 40 pores per inch were used. The 40 ppi foam was crushed by a factor of two. Smaller cell size gives more deformation. The shock impulse is reduced by 1/2.

V.Vigil and S Rodriguez
Paper given by V. Virgil
"Foamed Liquid Metal Shock Attenuation Analysis for Z-IFE"

Foamed liquid metal is being considered as a shock mitigation material. Two-D Alegra simulations were performed with a 1m x1m square containing 50% liquid and 50% gas with a pressure pulse of 500 GPa. The gas regions were modeled as an ideal gas and the Mie -Gruneisen equation of state was used for the liquid. The key result was that increasing the gas regions from 9 to 100 for a 50%-50% mixture reduced the pressure at the wall from 28 GPa to 2 GPa.

T. A. Heltemes, E. Marriott, G. A. Moses, and R. R. Peterson
Paper given by T. A. Heltemes
"Z-Pinch (LIF) 2-BEF2 (Flibe) Preliminary Vaporization Estimation Using the Bucky 1-D Radiation Hydrodynamics Code"
The one-D Bucky computer code was used to model the material; vaporization and shock characteristics of the proposed z-pinch power plant design. Calculations were performed for +z, -z and r directions(the fusion source is at the origin.) The heating was due to the x-rays, neutrons were not included. The +z direction calculations showed that the FLIBE foam was vaporized to a distance of 63 cm, which compares favorably to an analytic estimate of 79 cm. In the -z direction, the FLIBE was vaporized to a distance of 108 cm compared to an analytical estimate of 103 cm. Finally, in the r direction, the FLIBE was vaporized to a distance of 84 cm compared to an analytical estimate of 78 cm.

T. J. Renk, P. P. Provencio, T. J. Tanaka, and C. L. Olson.
Paper given by T Renk
"Use of RHEPP-1 for Long-Term Materials Exposure for IFE and MFE"
In future laser fusion power plants, MeV ions will impinge on the chamber wall at a high fluence (up to 20 J/cm2) and at rates up to 10 Hz. The effects on proposed chamber materials subjected to long-term pulsed ion beam exposure (up to 2000 Pulses) are investegated using the RHEPP-1 facility. It appears that (powder metallurgy) tungsten exposed below 1 Jcm2(nitrogen beam) remains unaffected by up to 1220 pulses. SEM imaging at 15,000 magnification shows no evidence of micro-cracking. Above 1 J/cm2 tungsten evolves surface relief rapidly with pulse number, although evidence of a saturation mechanism after about 1000 pulses is clearly seen. Alloying of the tungsten, or heating to beyond the brittle -ductile transition temperature, is observed to reduce but not eliminate these effects. Other metals studied (Ti, Cu, Al) also appear to undergo complex surface development, an evolution that takes hundreds of pulses to occur. In addition, the results were compared to materials response predictions from simulation codes.

Tuesday Afternoon 3:45 - 5:45 PM
Poster Session II.a - Salon DE
Diagnostics, Data Acquisition, and Plasma Control Systems
Applications
Power Systems

Poster session II.a Diagnostics, Data Acquisition, and Plasma Control Systems
Session Chair - Dennis Mueller (PPPL)

Poster session II.a included 24 posters. Fourteen posters primarily covered various diagnostic systems, seven posters primarily concerned control of a plasma effect or diagnostic and three were primarily about data acquisition systems.

Some diagnostics posters were concerned with the engineering aspects of new diagnostics on existing experimental devices with an eye on their potential application on ITER. The use of polycrystalline CVD diamond films for neutron detection, the design of the last alpha array for JET and the ELM simulating plasma are examples of posters whose application to ITER are especially intriguing. Several diagnostic posters were concerned with the engineering issues involved for diagnostics on either existing or new machines, this group included posters on the heavy ion beam on the TVC tokamak, the He beam for Inertial Electrostatic Confinement, the long-pulse DNB on Alcator C-Mod, the NSTX high-k scattering, the design study of the KSTAR Thomson scattering system, the layout of sight-lines for diagnostics on QPS, the development of quasi-optical technology for ECE measurements on LHD, and the use of ECE to measure toroidal mode number and observe asymmetry during the collapse of discharges in the electron temperature on JT-60. One diagnostic, concerned with inertial confinement fusion, was a method to measure the response of the cold target capsule to the warm walls in a fusion reaction chamber. One poster estimated the effect of nuclear elastic scattering on the thermal distribution of plasma heated by MeV neutral beams and concluded that a significant effect exists for beams above 1 MeV.

Posters on control can be grouped loosely into two broad categories, first feedback systems to control plasmas or diagnostics and second the engineering involved new or novel plasma actuators beyond the usual heating or coil systems. Control systems included a circuit design to stabilize the reflectometer local oscillator signals in DIII-D, real-time control of the two antennas used for MHD control in Alcator C-Mod at frequencies from a few kHz to 1 MHz, and poster on the use of a decentralized feedback control system to control cooperative robots. Other control posters were concerned with the engineering issues and characterization of new actuators for plasma and diagnostic control or mitigation of plasma effects. One poster discussed the issues in implementing a cryopump on Alcator C-Mod to provide pumping and density control. Another covered the characterization of the saddle coil system for RFX-Mod and use of the saddle coil system has been successful in doubling the pulse length in RFX. A novel control system was the use of massive gas injection for disruption mitigation on DIII-D, the results indicate that enough gas could be injected to stop runaways in large tokamaks if the right location can be utilized.

The three posters on data acquisition included one on the issue of how data from long pulse (thousands of seconds) can be acquired seamlessly without data loss. That poster proposed that a client/server PXI bus based system-making use of LabView, and Labwindows can handle the large amount of data without loss. Two posters from NSTX discussed improvements to the NSTX acquisition system. One covered the development of a new-networked timer that would serve to replace the old CAMAC based system. The other was on the use of a computer-based high-speed digitizer to replace a CAMAC based digitizer that was unable to handle the required data rate. The new digitizer could record samples up to 1.2 s at 100 megasamples/s.

Poster Session II.a – Applications and Power Systems
Session Chair – Tim Bigelow (ORNL)

H. Kimura	Hydrogen Production from Biomass using Nuclear Fusion Energy	A-26

Y. Takeuchi	Numerical Analysis of Endothermic Quantity in Hydrogen Production from Biomass Using Nuclear Thermal Energy	A-27
P. Fu	The Control System of Poloidal Field Power supply for EAST Superconducting Tokamak	A-28
T. Matsukawa	Synchronous AC/DC Converter Using Advanced Unipolar Power Electronics Devices	A-29
S. Ramakrishnan	Power Supply for NSTX Resistive Wall Mode Coils	A-30
A. Coletti	The Pulsed Power Supply System for IGNITOR	A-31
B. Lewicki	Programmable Coil Power Systems for Pegasus Experiment	A-32
T. Isobe	Fusion Power Supplies Using Magnetic Energy Recovery Switch	A-33

A total of 6 posters were presented by authors Kimura, Matsukawa, Ramakrishnan, Coletti, Lewicki, and Isobe. Two posters were not presented (A-27 and A-28).

The poster by Kimura (A-26) was in the Application category and covered the use of fusion power heat output to drive thermal reactions needed to produce hydrogen from various precursors but principally cellulose from biomass. A small-scale study was performed which indicated that a reaction temperature of 1000C was 34% efficient in converting cellulose to H2 gas plus CO without the use of a catalyst.

The remaining 5 posters were in the Power System category and dealt with research into high power electronics and power supplies for fusion energy applications.

The posters by Lewicki and Ramakrishnan (A-30 and A-32) presented designs and results for high power systems to drive coils on existing fusion experiments. These power systems utilized IGBT and IGCT devices in "H-bridge" configurations to drive magnet coils with fast bipolar waveforms for plasma position control and resistive wall mode experiments.

Coletti (poster A-31) presented a system overall design strategy for the entire pulsed power needs of the IGNITOR experiment. Thyristor (SCR) based power supplies will be utilized to power the IGNITOR coils which will require > 1 GW to be drawn from the 400 kV European power grid during a plasma shot.

The remaining two posters (A-29 and A-33) were presentations on research into improved configurations for high power supplies for fusion applications. Matsukawa (A-33) discussed the use of power mosfets as active rectifiers in AC to DC conversion. The low on-state resistance on the power mosfet compared to a ~ 0.6V junction voltage in silicon diode offers improved power supply efficiency in high current applications. The poster by Isobe (A-33) described the use of a capacitor and power devices in an H-bridge configuration that would recover and utilize magnet energy recovery from a magnet coil during portions of a charging cycle to reduce the overall voltage requirements or boost the current capability for a particular size power system.

Tuesday Afternoon 3:45 - 5:45 PM
Poster Session II.b - Center BC
Safety and Environment
Plasma Fueling
IFE Drivers and Related Technologies

Poster Session II.b Safety and Environment
Session Chair - Lee C Cadwallader (INL)

The Safety and Environment session had several interesting papers. Alex Klix from the Technical University of Dresden had a paper showing the results of bombarding Flibe molten salt with 14 MeV neutrons to 1 MW/m2; short-term radiation was dominated by Na-22 and long-term radiation by Al-26. Sandro Sandri from ENEA presented results of a study of first wall break and heat exchanger leakage repairs in ITER; replacing three FW modules would generate 1.43 person-mSv and heat exchanger tube plugging would generate 0.249 person-mSv. Lee Cadwallader from INL gave some reliability data analysis results for DIII-D magnet power supplies that compared well to JET power supply data, between 1E-02 and 3E-02/hour. Charlie Gentile of PPPL presented the results of adapting a miniature integrated nuclear detection system used to sense tritium contamination on TFTR tiles for new uses in homeland security to detect low energy radionuclides in areas with high background radiation. Margaret Lumia of PPPL presented some test results that demonstrated the effectiveness of cured, removable thin films at removing lead oxide surface dust and beryllium dust from a variety of surfaces. Mohamed Sawan from the University of Wisconsin-Madison gave the results of a neutronics study of an ITER dual cooled lithium-lead test blanket module, including tritium breeding (2.4 g/year), nuclear heating (1.357 MW, including surface heating), radiation damage (5.7 dpa), and radiation shielding requirements (~1 m-thick shield plug to allow personnel access).

Wednesday Morning - 8:00 - 10:00 AM - Salon ABC
Oral III.a - Fusion Development and Experimental Devices 3

Wednesday Morning - 10:15 - 12:15 PM - Salon ABC
Oral III.b - Fusion Development and Experimental Devices 4

Wednesday Afternoon 1:30 - 3:00 PM
Poster Session III.a - Salon DE
Heating and Current Drive
Materials Technology and Fabrication
Tritium

Wednesday Afternoon 1:30 - 3:00 PM
Poster Session III.b - Center BC
Magnet Engineering

Poster Session III.b Magnet Engineering
Session Chair - Joel H. Schultz (MIT)

Three papers were presented on the magnet fabrication of Wendelstein VII-X (WVII-X).

F.H. Hurd presented a paper on the assembly of the WVII-X stellarator. The assembly is unusually complex, because 70 planar and nonplanar magnets must be threaded individually over the vacuum vessel. A ProEngineering animation was used to prove the feasibility of assembly. Full-scale mockups of the cryostat and of coil bolting to the central ring were needed. Full-scale welds were needed on the mockups to establish the relative shrinkage of coils and cases.
A. Cardella presented a paper on the preload experiments on the superconducting coils attachment system for WVII-X. Superbolts are needed to connect the coils to the central support. Because of substantial relaxation in the walls, Lorentz load had to be simulated by hydraulic jacks.
M. Sauer presented a paper on the design and construction of the superconducting bus system for WVII-X. The bus is a cable-in-conduit with higher copper fraction than the coil conductors and an aluminum alloy conduit. The bus is heavily insulated with three glass-araldite and two kapton layers.

Seven papers were presented on the magnet system for the National Compact Stellarator Experiment (NCSX).

J. Chrzanowski presented a paper on the manufacturing development of the NCSX modular windings. These complex coils were prototyped with a 1/3 scale Twisted Racetrack Coil with the same topology. Excess conductor keystoning was addressed by eliminating kapton tape and reducing the conductor size.
M. Kalish presented a paper on the NCSX Toroidal Field coil design. 18 coils use hollow conductor and and VPIed epoxy. Detailed design analysis led to the addition of a kapton slip plane and lengthening of lead spurs.
G. Gettelfinger's paper on the test facility for NCSX field coils was not presented.
C.C. Tsai presented a paper on the development of dynamic strain and temperature measurements of the NCSX coils. Conventional sensors were supplemented by an interferometric fiber optic strain and temperature sensor with a displacement-sensitive gap between fibers.
T.A. Kozub presented a paper on the measurement of NCSX modular coil composite conductor material properties. The conductor is an epoxy-filled fine gauge copper cable. A twisting fixture was designed to measure conductor shear modulus. Special racetrack and tensile test fixtures measured conductor fatigue to 3.5 million cycles at 1.5 times design load.
P. Fogarty presented a paper on the manufacturing development of the modular coil windings for NCSX. CAD models with all components were used to generate fabrication steps. Uncertainties in "soft" component modulus led to iterations on clamping force on models.

Five papers were presented on the Quasi-Poloidal Stellarator (QPS) magnets, one with direct application to NCSX, as well.
P. Fogarty presented a paper on the QPS modular coil winding and assembly. A 1/3 scale prototype, including the hardest bend configuration was wound, VPIed and cooled. Field flux measurements established the accuracy of the fabrication technique.

A. Lumsdaine presented a paper on the structural integrity of the QPS magnetic coils. Structural analysis was calibrated against experimental welds of the coil can to the steel casting. Thermal analysis showed no damage to insulation from weld distortions.
J. Lyon presented a paper on winding pack position determination and field error correction, applied to stellarator magnet systems, such as NCSX and QPS. Error minimization techniques were used to calculate actual coil center trajectories from magnetic measurements. These can be used to alter coil positions or relative currents to reduce field errors, particularly to eliminate magnetic islands.
K.D. Freudenberg presented a paper on the cooling design and analysis of the QPS modular coil winding packs. Three internal and one externally-cooled concept were analysed. Internal cooling had lower temperature rise, but the 40 C rise with external cooling and a 10 minute dwell appears acceptable.

One paper apiece was presented on the tokamak experiments ITER, KSTAR, and SST-1, and the National Spherical Torus Experiment (NSTX).

P. H. Titus presented a paper on the analysis of the ITER Central Solenoid (CS) by the U.S. Participant Team. The relative motion of the CS coil and inner straps led to high stress in the leads. The unsupported lead length will be reduced. A lower spider was added to reduce seismic displacements. Upper gravity supports were stiffened to reduce rotation of the TF-mounted structure.
Y.K. Oh presented a paper on the status of manufacture and testing of the KSTAR magnets. A complete summary of the magnet system was given. All of the TF coils have been manufactured and eight assembled along with TF structure. Four PF coils are complete and two CS coils have been heat treated.
B. Doshi presented a paper on the structural analysis of the cold mass support structure of the Steady-State Superconducting Tokamak (SST-1). The structure, a ring on pedestals with 16 cantilevers, supports the TF system. Tests showed that a 0.05 friction factor with MoS_2 could reduce stress to 118 MPa by allowing radial motion.
C. Neumeyer presented a paper on operational experience with the NSTX demountable TF joint. A novel voltage sensor on the TF flags showed growing resistance in the joint, while fast camera imaging showed curved radial motion. Voids in the potted structure were attributed to inadequate pot life. The flags were repotted successfully with araldite.

Wednesday Afternoon 3:00 - 5:20 PM (3 Parallel Sessions)

Oral III.c - Blanket Technology - Salon C
Oral III.d - Alternates - ST - Salon AB
Oral III.e - MFE Engineering, NCSX, EAST - Sequoyah 3

ORAL Session III.c Blanket Technology

Session Chair – Mohamed Sawan (University of Wisconsin)

The oral session on Blanket Technology included six presentations; two invited and four contributed. The first invited paper was presented by Clement Wong and gave an extensive overview of the US ITER dual coolant lead lithium test blanket module. The steel structure is cooled by helium and SiC flow channel inserts are used for MHD and thermal insulation in the lead lithium channels. The presentation described the design including the ancillary equipment, testing strategy and corresponding test plan, and required R&D. The second invited paper was presented by V. Heinzel. He reviewed the designs of the helium cooled high and medium flux test modules for the International-Fusion-Material-Irradiation-Facility (IFMIF). A Medium-Flux-Test-Module (MFTM) is dedicated to in situ creep-fatigue tests. In the HFTM material specimens are installed in capsules that are cooled at the outer side by helium. The neutronics and thermal hydraulics calculations were presented.

Z. An presented results of thermo-mechanical analysis for the helium cooled pebble bed ITER test unit cells under pulsed operation. 3-D finite element analysis simulations with edge-on configuration showed that after each pulse cycle, the temperature inside the breeder pebble beds is increasing and the stresses at the front part increased. Stress-strain behaviors of pebble bed should include material creep mechanism and moveable characteristic of pebble bed. E. Cheng investigated the nuclear energy option with a combination of fusion and fission concepts where fusion neutrons are used to drive subcritical fission assemblies. The concept has attractive applications, including destruction of transuranium nuclear waste produced from fission reactors, and energy extraction from fissionable materials. Blanket concepts with solid zirconium actinide mixture, similar to that used in the liquid metal fast breeder reactor concept, have been studied.

M. Narula explored the use of fast flowing lithium streams protection of the divertor surface for effective particle pumping and surface heat removal. The divertor magnetic field environment tends to create strong flow disrupting MHD forces, which pose a major challenge in establishing a smooth and controllable flow. R. Sunyk examined the material design limits for a test blanket module under ITER operating conditions. Existing structural design criteria (SDC) are based on the material data, which do not consider a possible change of material properties after a cyclic loading. A comparison of the lifetime assessment results obtained by an application of the SDC to results of a linear-elastic simulation allowed a verification of the SDC.

Thursday Morning - 8:30 - 11:00 AM - Salon ABC

Oral IV.a - ITER Project, Space & Gen-IV Reactors, and Waste Separation