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SURFACE FINISH SPECIFICATIONS
AT
OAK RIDGE NATIONAL LABORATORY

J. J. Wallace
F. Ring, Jr.

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BY

J. J. Wallace and F. Ring, Jr.

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SURFACE FINISH SPECIFICATIONS
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Surface finish control is important from the standpoint of performance, appearance and cost. In many cases the degree of finish has been left entirely up to the craftsman, who makes the part. At times, only the method of finishing has been specified by the designer.

The designer is most familiar with the performance and appearance required and to a large extent responsible for cost. It is therefore in order that he should control and specify finish degree.

This brings up the necessity of having available the same concept of finish degree in both the design and shop organizations.

The literature on this subject has been studied. Available scales and gages have been checked over. ASA Standard B46.1-1947 has been selected as our guide and General Electric Surface Scales, Cat. Nos. 342X60 and 342X61 are being used. These same scales are on hand in both our design and shop organizations.

Each member of our design organization has been supplied with the following instructions. He is also supplied with a compilation of related information and recommendations taken from various technical publications (see bibliography) dealing with surface finishes and their application. This is expected to serve as a guide to his selection of surface finish.

INSTRUCTIONS

1. The symbol used should be that described in ASA Standard B46.1-1947. (Use only applicable parts of the symbol shown on page 6.)

2. Place these notes near the title block on each drawing.

   a. Finish symbols are in accordance with ASA Standard B46.1-1947.

   b. Roughness height values are the maximum arithmetical average deviation from the mean surface, expressed in microinches.

   c. For surfaces not otherwise indicated, roughness height values shall not exceed *______________.

3. Avoid specifying waviness height, lay and roughness width except where it is known that malfunctioning will result from uncontrolled values of these variables. (In every case, it is necessary to decrease the depth of cut and feed in order to obtain a smoother finish, and as a result of this the waviness height and roughness width will decrease in proportion.)

4. Always specify roughness when specifying any other surface property such as lay, waviness and/or roughness width.

5. It is understood that when only one figure is used to specify a surface property that figure is the maximum value and any lesser value is acceptable. In nearly every case it will be sufficient to use only the roughness values shown on the General Electric Surface Roughness Scale. (These are stock items in ORNL Stores.)

*Designer shall specify this. (In general 125 will be suitable for this.)

6. Unless otherwise restricted, it is understood that for any surface whose finish is designated by a symbol, that finish applies to the entire surface whose bounds are shown by its dimensions.

7. All surfaces 63 microinches and/or smoother should be designated by symbols on the part detail (or by note to effect: i.e., "machine all surfaces xx".)

8. Do not specify finishes finer than that required for proper functioning or appearance. (See cost column of Application Table)

9. The Application Table may be used as a guide in specifying the surface on a particular part. However, if the specified finish proves unsatisfactory then the remarks concerning the effect of surface finish on various properties will indicate the direction of change.

D I S C U S S I O N

Effects of Surface Finish

Since operating conditions are many and varied for parts performing similar functions in different machines, it is incorrect to propose that such parts should always carry identical surface finishes. So for the present at least, reason and experience must be relied upon. Surface finish control may be desirable from the standpoint of one or more of the following factors.

Wear

Wear is the tearing away of minute particles of material at the surface due to the abrasive action of one surface on another. This intimates mechanical interlocking of roughness and consequently initial wear is minimized by using a fine finish. Wear improves the surface finish, but in the case of a hard material rubbing on a soft material the roughness may remain almost unaltered on the hard material when the soft one is worn beyond use. (For example, a file.)

Friction

Friction is the force (in addition to that required to overcome inertia) necessary to move one body relative to another when their surfaces are in contact. It can be attributed to mechanical interlocking and the molecular fields of force that exist at all surfaces. It can be reduced by improving the surface and or separating the surfaces by a film of material (such as oil) that shears easily and without damage to the surfaces.

Seizing, Galling and Fretting

Seizing is the "cold welding" or joining of particles of mating surfaces when brought into intimate contact by high localized pressure and/or temperature. These molecular forces causing the bond are sometimes stronger than the parent material and when relative motion occurs, tear out a macroscopic quantity of the weaker material. This process is known as galling and can result in quick destruction of the surface. It is accelerated by abrading, fluxing, etc., and can be prevented by separating the surfaces by a film of material that shears more easily than the parent material. Fretting, on the otherhand, occurs in supposedly tight joints and shows up in pit formations. It is believed to be caused by minute motion at the surface due to strain action under alternating loads. Assuming that "cold welding" occurs and a tiny fragment is loosened due to the motion; this oxidizes rapidly and works its way to the outside under the influence of vibration. The removal of this particle exposes a fresh surface subject to further cold welding and/or oxidation and a pit is progressively formed.

Lubrication

Lubrication is the process of maintaining a film of a third substance between two surfaces that have relative motion. All types of lubricants would include solids, liquids and gases. Some lubricants also serve as coolants. Selection is usually based on operating pressures and temperatures. Generally, the finer the finish, the easier it is to maintain the film to give absolute separation of the surfaces.

Emissivity and Reflectivity

Emissivity is the ratio of the thermal radiation emitted (or absorbed - since for thermal equilibrium these are equal) to the total radiation falling upon the surface. Reflectivity is the ratio of the radiation reflected to the total falling upon the surface. Their sum is always one (1) for any surface. For a particular material, the rougher the surface, the better absorber it is and conversely the smoother the surface the better reflector it is. These are affected not only by height of roughness but also by the geometry of the roughness.

Actual Contact Area

This might be thought of as percent of bluing. This again is affected by both height and geometry of roughness. It is of importance on parts subject to high unit pressures and on electrical contacts.

Closeness of Fit

Wet seal faces which depend on surface tension to prevent leakage require thin films and therefore smooth uniform surfaces. Also on close tolerance work, the surface roughness height must be a small percentage of the tolerance in order to maintain the tolerance when in service.

Fatigue Strength

The fatigue strength of a part is many times limited by crack formation. A rough surface acts as a stress riser which may cause crack formation and premature failure of a part.

Cost

Cost of production rises rapidly with refinement in finish and from this standpoint the finish should be no better than is necessary.

Appearance

Appearance certainly does not add to performance but in cases of precision or delicate devices a refined appearance encourages proper handling. Ease of cleaning may also be a factor.

COST COMPARISONS AND SURFACE FINISH APPLICATION TABLE

Roughness Height Value (microinches)	Typical Applications	Typical Methods of Producing Finish	Approx. Relative Cost
1	Micrometer anvils, mirrors, high grade gages	Lapping, polishing, superfinishing	40
2	Shop gages, comparator anvils, metal to metal seal faces	Lapping, polishing, superfinishing, micro-honing	35
4	Vernier caliper faces, sliding contact under heavy loads, precision roller and ball bearings, seal faces moving relative to flexible seals retaining gases	Grinding, micro-honing, lapping, superfinishing, burnishing, polishing, etc.	30
8	Sliding contact under high load such as cam faces and journal bearings, good grade ball and roller bearings, seal faces moving relative to flexible seals retaining liquids and greases	Grinding, honing, lapping, rolling, polishing, burnishing, etc.	26
16	High speed shaft journals under moderate load, commercial grade ball and roller bearings, ball and roller bearing seats, "O" ring grooves for static seals, valve plugs and seats, cylinder bores, gear teeth	Grinding, rolling, lapping, honing, some moulding and extruding, etc.	20
32	Sliding contact under light loads, splined shafts, key seats, facing for friction clutches and brakes, solid metal gaskets, mating faces of precision parts, gear teeth, highly stressed parts, piston O.D.s	Grinding, turning, milling, broaching, reaming, honing, extruding, moulding, boring, etc.	15

Roughness Height Value (microinches)	Typical Applications	Typical Methods of Producing Finish	Approx. Relative Cost
63	Mating faces of machine parts (no motion), for appearance on outside faces, to obtain size dimensions to decimal tolerances	Shaping, grinding, broaching, turning, milling, extruding, permanent mould casting, drilling, boring, etc.	10
125	For a great variety of non-critical assemblies, such as housing parts, facings on pipe flanges trueing up and stock removal, sizing to decimal tolerance	Shaping, turning, milling, grinding, boring, forging, rolling, extruding, drilling, permanent mould casting	7
250	Flange facing using soft gaskets, clearance dimensions (airfits), for rough machine parts, for stock removal, for trueing up or to obtain size to fractional tolerances	Shaping, turning, milling, rough grinding, shearing, forging, boring	5
500	Primarily for stock removal only	Shaping, turning, milling, sand casting, sawing, planing	3.0
1000	For stock removal prior to finishing cuts	Rough turning, planing, milling, torch cutting, sawing, etc.	1.5
2000	For stock removal prior to finishing	Very rough turning, planing, milling, torch cutting, sawing	1

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