METHODS OF OBTAINING SURFACE FINISHES

Technical Report

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1.0 SUMMARY

Performance of BAL™ Seals in dynamic sealing applications is affected by numerous factors including alignment of moving parts, shaft or bore material, hardness, surface finish, use of lubricant films, seal material flexibility, friction and wear properties, etc. This report discusses the effect surface finish has on BAL™ Seal performance and methods used to obtain surface finishes. Although one factor alone cannot determine the overall performance, surface finish contributes significantly to BAL Seal performance. The prominent areas discussed in this report are the

- Effect surface finish has on BAL Seal performance.
- Basic characteristics of surface finish
- Machining methods for finishing harder metals.
- Cold working methods for finishing softer metals.

2.0 The effect surface finish has on BAL™ Seal performance

The performance of a BAL Seal is improved when the seal is in contact with a smooth counterface. A very smooth finish reduces abrasive wear and enhances sealing ability.

2.1 Wear properties

The abrasion to a BAL Seal decreases as the finish of the mating surface improves. PTFE-based materials have low intermolecular strength and are abraded by dynamic mating parts with rough surface finishes. Abrasion is exaggerated by high speeds and pressures. In critical dynamic applications, it is essential to attain the best surface finish possible to extend the life of the BAL Seal.

2.2 Sealing ability

A smooth surface finish on the mating part typically enhances the sealing ability of the BAL Seal. Smoother surface finishes create greater sealing contact between the seal and the mating surface.

3.0 BASIC CHARACTERISTICS OF SURFACE FINISH

Surfaces are very complex in character; each has a variety of features, which affect the function of the part in different ways. Some basic surface finish characteristics include texture, roughness, waviness, and lay. These are shown in Figure 1.

3.1 Texture

Texture is the arrangement of repetitive or random deviations from the nominal surface, which forms the dimensional topography of the surface. This includes roughness, waviness, and lay.

3.2 Roughness

Roughness refers to the degrees of variation from a smooth, nominal surface. It comprises the irregularities in the surface texture, excluding waviness, which are inherent to the production method used on the part.

3.3 Waviness

Waviness is a component of surface texture upon which roughness is superimposed. Waviness can result from machine deflections, vibrations, chatter, heat treatment or warping strains.

3.4 Lay

Lay refers to the direction of the predominant surface pattern, ordinarily determined by the production method used.

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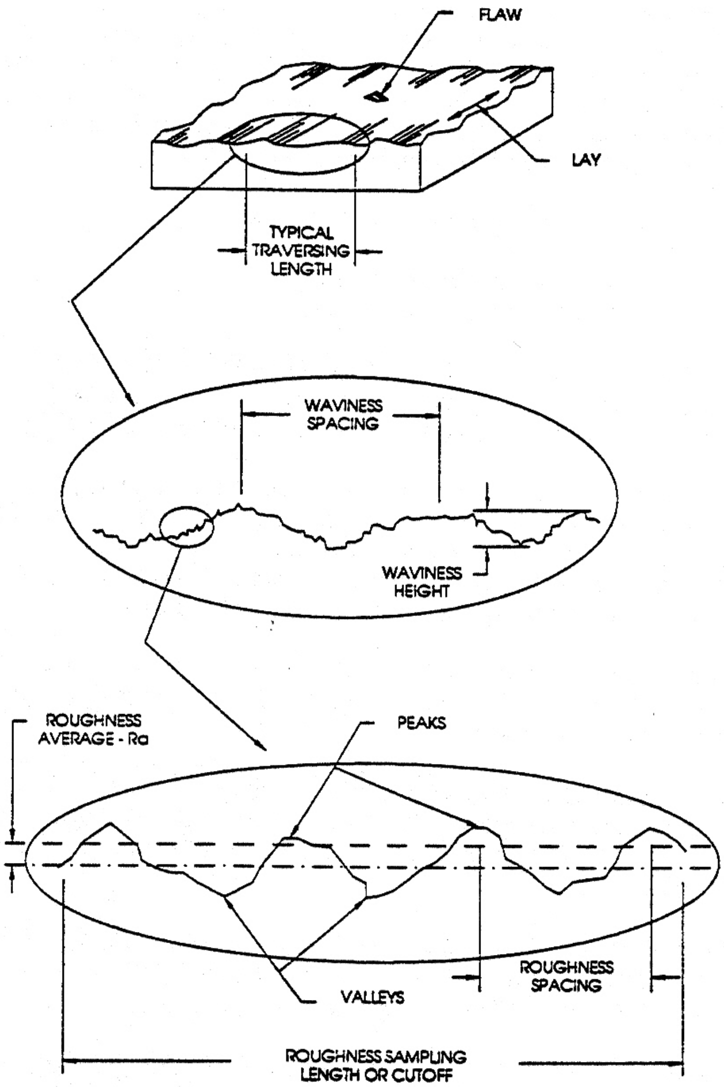


Surface Finish Characteristics
FIGURE 1

4.0 METHODS OF OBTAINING SURFACE FINISHES

Different finishing processes result in distinct surface finish characteristics. Some methods such as grinding, honing, polishing, buffing, and super finishing remove material from the work surface. Other methods such as burnishing, bearingizing, and ballizing provide smooth surfaces without removing any material from the work surface. The graph in Figure 2 indicates the surface finishes produced by some machining methods.

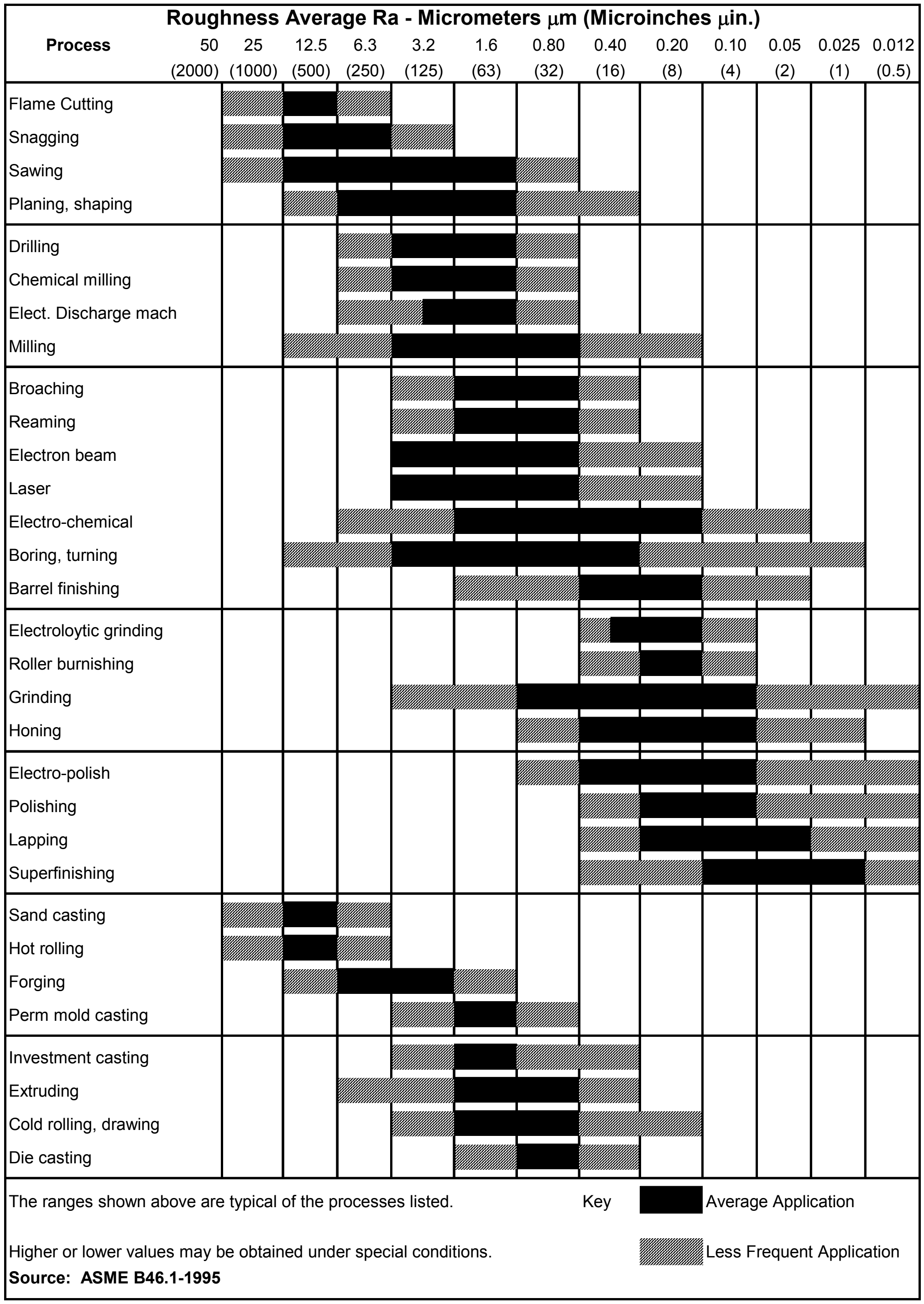


FIGURE 2: Surface roughness produced by various machining methods

4.1 Finishing harder materials by material removal

The following machining methods are used to obtain smooth surfaces on materials with a hardness of 40 Rc or greater.

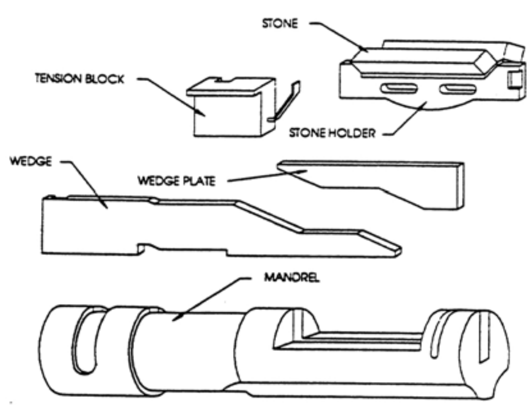
4.1.1 Precision grinding

Precision grinding uses abrasives, which are firmly attached to a rigid backing, such as a wheel. This method is used prior to polishing to remove large surface imperfections and is often the first operation in a finishing sequence. Progressive grinding employs a series of wheels with decreasing grit sizes. Grinding can produce a surface finish as low as 3 to 6 micro inch Ra.

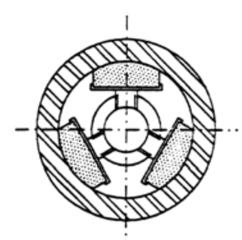
4.1.2 Honing

Honing after turning, boring, reaming or grinding can produce a surface finish of 2 to 4 micro inches Ra. See Figure 3. Honing uses an aluminum oxide or silicone carbide abrasive and produces straight and round bores by correcting taper, out-of-roundness, or spirals produced by previous machining. Honing also provides an accurate control of size. Any metal can be honed including steels and carbides as well as non-metallic materials such as glass or ceramic. The hardness of the material does not limit the honing process; it only affects the rate at which stock can be removed. Honing produces a characteristic crosshatched finish, resulting in a stress-free surface, which improves sealing ability. The quality of the finish depends on the hardness of the material being machined, abrasion, speed, and, in some cases, the coolant. To obtain a smoother surface finish while honing, the following steps should be taken into consideration.

- Use a finer grit abrasive
- Increase the rotation speed, or decrease reciprocation speed.
- Decrease the pressure.
- Use a higher viscosity coolant.



MANDREL HONING ASSEMBLY
FIGURE 3A



HONING ASSEMBLY TOOL IN CROSS-SECTION
FIGURE 3B

Honing Assembly Tools and Assembly of Tools in Cross-Section
FIGURE 3

4.1.3 Polishing

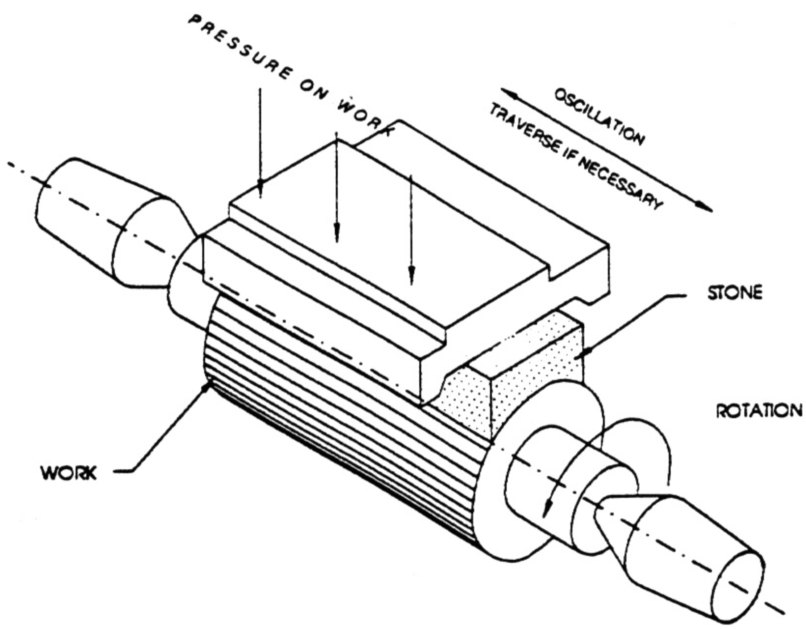
Polishing uses abrasives firmly attached to a flexible backing, such as a wheel or belt. This process is used to maintain close tolerances while improving the surface finish.

4.1.4 Buffing

Buffing uses a fine abrasive, which is suspended in a lubricating binder to smooth and brighten a surface. The abrasive compound is applied to the surface with a flexible wheel of cloth or felt. Buffing is used to smooth the surface of a part that may or may not have been previously polished and can produce a very good finish, 4 to 8 micro inch Ra.

4.1.5 Super finishing

Super finishing is an abrasion process for refining the outside diameter of cylindrical parts. It is similar in action and effect to honing, but it works on the outside diameter of a cylinder only. See Figure 4. A very small amount of stock is removed, averaging from 0l.0001 to 0.0002 inch (0.003 to 0.005 mm) in diameter. Super finishing can produce surface finishes of 2 micro inches Ra, free from scratches exhibiting directional effect or pattern. Super finishing is often faster and more economical than other finishing methods that produce rougher finishes.



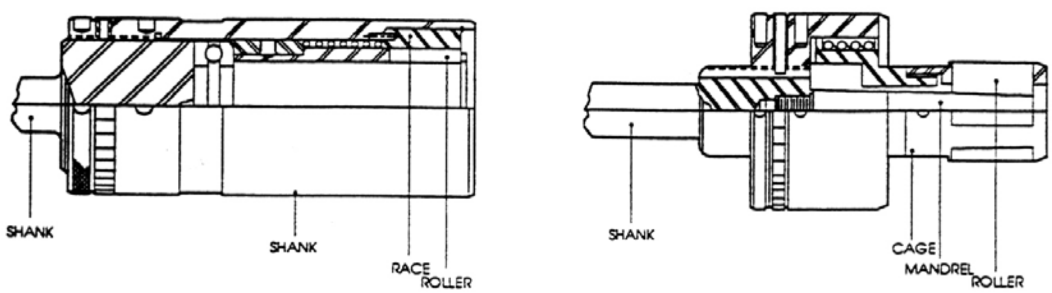
Typical Set Up for Superfinishing
FIGURE 4

4.2 Finishing softer materials without material removal

The following cold working methods are used to obtain smooth surfaces on materials with a hardness of 40 Rc or less. Cold worked parts tend to have surface variations, which affect BAL Seal performance. Hones and super finished surfaces are preferred for contact with BAL Seals.

4.2.1 Roller burnishing

Roller burnishing improves the finish of internal or external diameters by using a tool consisting of caged rollers (See Figure 5). Hardened and highly polished precision tapered rollers rotate around and bear upon an inversely tapered mandrel, or race. The rollers are rotated by the movement of the mandrel and apply a steady rolling pressure against the work surface. The cage retains the rollers and keeps them against the work surface. The cage retains the rollers and keeps them properly spaced. The combined diameter of the rollers and mandrel of I.D. burnishing tools is slightly greater than the size of the unburnished hole. As the tool is fed into the hole, it causes the peaks to flow into the valleys.



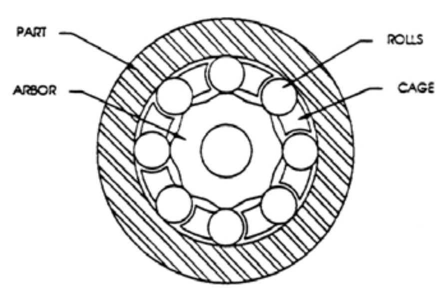
Outside Diameter Roller Burnishing Tool Assembly
FIGURE 5A

Inside Diameter Roller Burnishing Tool Assembly
FIGURE 5B

Tools for Outside and Inside Burnishing
FIGURE 5

4.2.2 Bearingizing

The basic difference between bearingizing and roller burnishing is that, although both processes use roller action to cold work the surface material, bearingizing uses a peening action. In operation, the peening sequence is produced by straight, caged rollers rolling over a cam-shaped arbor (See Figure 6). As it is fed through the hole, the bearingizing tools deliver up to 200,000 blows, or peens, per minute to the work piece. Bearingizing has all of the advantages of roller burnishing. In addition to increasing the hardness by 10 to 30 percent, tolerances are held with more precision, and the job is completed two to five times faster than roller burnishing.



Bearingizing Tool
FIGURE 6

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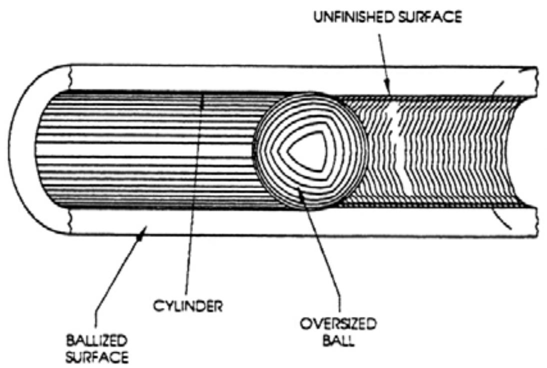

Typical Set Up for Ballizing
FIGURE 7

4.2.3 Ballizing

Ballizing is fast, low-cost process for sizing and finishing holes in metal. It consists of pressing a slightly oversized precision ball through an unfinished hole to quickly bring the hole to size (See Figure 7). The ball is typically made from a very hard material such as tungsten carbide. Ballizing works by cold working the surface structure, thereby leaving a layer of harder material. The based material is disturbed very little and acts as a matrix, or cushion, into which tool marks, waviness and other surface imperfections are smoothed. Ballizing is used to finish holes from 0.020 to 5.000 inches in diameter. Results are usually best, however, with diameters of 0.062 to 1.000 inch. Material harder than 40 Rc will be sized, but the surface finish may not be improved. When heat-treating follows ballizing, precise size control is difficult because balized holes tend to change size during the heating cycle. However, improvements in surface finish are usually retained. Ballizing can produce tolerances as tight as ±0.0002 inch on an inside diameter of 0.500 inch.

5.0 CONCLUSION

Bal Seal Engineering uses honing to attain appropriate surface finishes necessary for testing. Honed surfaces are generally superior to cold worked surface finishes. They are free of stress and dimensional variations and provide longer seal performance. Customers may wish to use the most practical and inexpensive surface finishing method available; keeping in mind that smoother surface finishes bring about lower abrasion to BAL Seal and longer seal life.

6.0 References

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Note: Request BAL Seal Technical Report #51, "Measuring Surface Finishes," for information about surface finish values and measuring instruments.