BAL SEAL ENGINEERING, INC.

Custom components that drive tomorrow's technologies.

Plasma spray-coated shafts for rotary and reciprocating service in contact with Bal Seal® spring-energized seals

Technical Report
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1.0 Summary

Plasma-sprayed coatings are recommended for rotary and reciprocating service when greater Bal Seal® spring-energized seal performance is desired. The plasma-sprayed coatings provide a very hard shaft surface that reduces adhesion between the seal and the sealing surface.

2.0 Discussion

Plasma-sprayed coatings are used in rotary and reciprocating service to improve Bal Seal® spring-energized seal performance. Typical applications are in high-pressure (1,500–3,000 psi) service, high-speed (1500–3500 fpm) service, and abrasive environments in contact with non-lubricating fluids such as dry gases, water, steam, and solvents. Plasma coatings are extremely hard and uniform in surface structure, and they have a nodular matrix, virtually eliminating wear grooves on rotary shafts normally caused by abrasive seal compounds.

Plasma-sprayed coatings are heated powders applied on the shaft surface at a high temperature (3000 °F) and high speed, resulting in high adherence to the shaft. The shaft surface hardness will be equal to the hardness of the coating being applied.

After the coating is applied, the shaft must be machined to the desired surface finish. Because the materials being applied are very hard and the surface finish is very rough after application, it is necessary to grind and hone the shaft to the required surface finish.

The coating process also leaves a porous surface, which can be sealed or coated with a lubricant. The pores can be filled with a phenolic sealer or graphite-molybdenum disulfide dry lubricant to protect the substrate from harmful media.

3.0 Properties of Plasma-Sprayed Coated Surfaces for Use With Bal Seal® Spring-Energized Seals

Plasma-sprayed coatings provide high hardness, high abrasion resistance, excellent material uniformity, low abrasion to the seal, and good corrosion resistance when pores are effectively sealed.

3.1 High Hardness

The hardness of a plasma-sprayed surface is determined by the coating being used. A hardness of 1300 HV (approximately 74 Rockwell C) can be obtained with chromium oxide coatings. Lower hardness is obtained with aluminum oxide and tungsten carbide coatings.

3.2 High Abrasion Resistance

Plasma-sprayed shafts attain excellent abrasion resistance, which makes the materials ideal for use in abrasive environments such as steam, water, abrasive materials, non-lubricated areas, and in high-speed or high-pressure rotary/reciprocating service.

3.3 Uniformity

Plasma-sprayed coatings do not need a binding agent to hold the material together as is the case with other coatings. When applied correctly, the plasma-sprayed coating has excellent matrix uniformity, as illustrated in *Figure 1*. This uniformity results in greater seal performance.

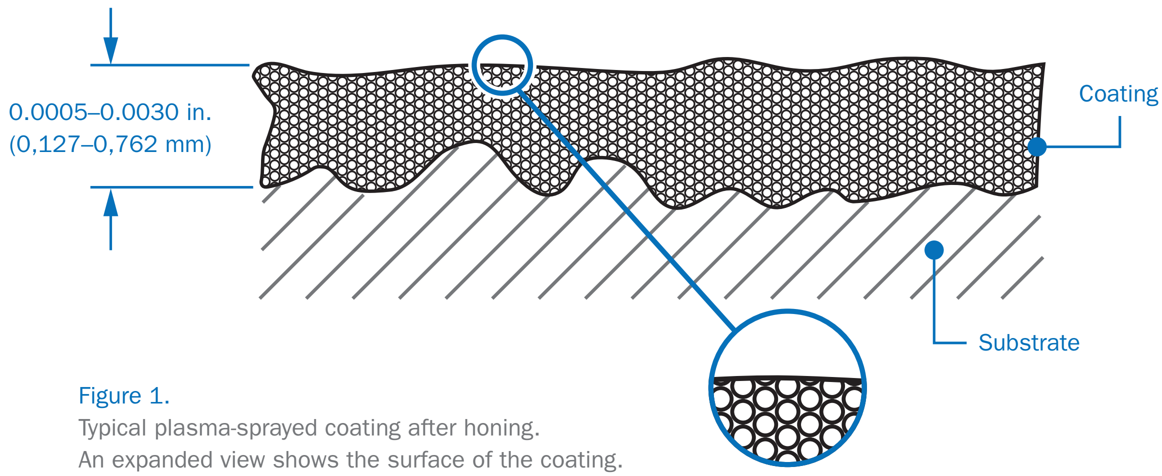

Figure 1.
Typical plasma-sprayed coating after honing.
An expanded view shows the surface of the coating.

3.4 Low Abrasion to the Seal

The coatings are generally nodular with rough edges, minimizing seal abrasion.

3.5 Corrosion Resistance

Plasma-sprayed coatings have a certain degree of porosity; however, such porosity can easily be sealed so that plasma-sprayed shafts may be used in many aggressive environments. After coating, a liquid phenolic sealer is applied to enhance corrosion resistance. The sealer must be compatible with the fluid media to be effective.

4.0 Different Types of Coatings for Use With Bal Seal® Spring-Energized Seals

Three types of plasma-sprayed coatings are generally used: chromium oxide, aluminum oxide, and tungsten carbide.

4.1 Chromium Oxide (Cr_2O_3)

- offers an antireflective surface
- provides high chemical resistance
- provides a high degree of hardness and wear resistance when required, e.g., when in contact with highly abrasive materials
- protects product from contamination

Note: should not be used in applications involving heavy shock loads

4.2 Aluminum Oxide (Al_2O_3)

- offers relatively high degree of hardness
- provides a passivation layer on coated substrates, preventing weathering and environmental corrosion
- provides electrical insulation and boost corrosion or wear resistance
- combines wear resistance with ductility (greater ductility than chromium oxide)

4.3 Tungsten Carbide (WC)

- offers excellent wear for extreme conditions
- provides good surface for extremely hard coating materials
- provides rigid and dense substrate
- offers a greater degree of flexibility when needed (i.e., in applications involving shaft flexibility)

5.0 Applications of Plasma Coatings

Various processes are used to apply plasma coatings, and careful consideration should be given to the process used, because performance can be significantly affected. Higher application speeds improve mechanical locking to the base metal and enhance the density of the coating.

Three companies that supply equipment for applying plasma sprayed coatings are Oerlikon Metco, Wall Colmonoy Corporation, and Union Carbide Corporation.

6.0 Shaft Preparation

Plasma coatings can be applied on either soft or hard shafts. Greater bonding occurs when the coatings are applied to a hard surface, and a hard substrate can be used to achieve a higher operating pressure. The pre-coated shaft should be prepared by either abrasive blasting or by rough undercutting the area to be coated.

7.0 Thickness of Coating

The coating thickness will depend on the application, but will vary from 0.0005 to 0.0030 in. (from 0.127 to 0.762 mm).

8.0 Application of Dry Lubricants and Corrosion-Resistant Sealers

Lubricants and sealers are used to fill pores in plasma-sprayed coatings.

8.1 Dry Lubricants

Dry lubricants may provide lower friction and enhance sealing ability. Typical dry lubricants are graphite and molybdenum disulfide. Dry lubricants must be baked onto the shaft for better bonding and more effective lubrication. Dry lubricants must be applied prior to final surface finishing of the shaft to prevent material contamination.

8.2 Sealers

To enhance corrosion resistance, air-dry phenolic sealers are available. Sealers are designed to fill the voids and pores while reducing chemical attack to the shaft substrate.

9.0 Surface Finish after Plasma Coating

Plasma coatings require a good surface finish for improved seal performance. Surfaces should be ground and honed to a surface finish consistent with the application. Most applications will require a surface finish from 2 to 8 µin. (from 0.051 to 0.203 µm) Ra. The actual requirement will depend on the pressure, speed, and temperature. A smoother surface finish should be achieved at high pressures, high speeds, and high temperatures.

10.0 Cost Considerations

Plasma coatings are expensive. The cost is much higher than that of hard chrome plating (by a factor of about five). Their use is limited to applications requiring reliability and long-term performance under harsh conditions.