SEALING SENSE

Q. *What is the best silicon carbide wear face material for my mechanical seal?*

A. Silicon carbide (SiC) mechanical seal face material has been available for more than twenty-five years.

It is a member of the ceramic face materials family and is considered to be a "hard-face" material. While most commonly used against a softer face material, in many applications it can be used against another hard face material.

Silicon carbide can be used either as a rotating or stationary face depending upon the seal design, manufacturer, and the other mating face material. Like other mechanical seal materials and designs, silicon carbide has distinct advantages as well as some disadvantages.

Silicon carbide is very hard and has excellent abrasion and wear resistance. It has a low coefficient of friction, high hardness, and high modulus of elasticity. It also retains its strength at elevated temperatures, has a low coefficient of thermal expansion, a high thermal conductivity, and excellent corrosion resistance.

These characteristics make it an excellent material for mechanical seal faces, particularly since it resists deflection in high-pressure, high temperature, and high-speed pump applications.

As a ceramic material, on the other hand, silicon carbide is quite brittle and its mechanical strength is less than that of other hard metal carbide faces such as tungsten carbide. It is susceptible to chipping and/or fracture when placed under mechanical stress or shock.

It is very common to see silicon carbide placed into a metal holder. Sometimes a metal shroud will be mounted on the outside diameter of a rotating silicon carbide face to give it more mechanical strength and prevent catastrophic failure.

A commonly used metal is Alloy 42 stainless steel, which will allow application to temperatures to 750-deg F. Other stainless steels are and can be used; however, the temperature limit is decreased depending on the material being used.

Silicon carbide is typically run against a softer face, such as carbon-graphite in many applications. (The industry distinguishes carbon as the less crystalline form of the element, while graphite refers to the more highly crystalline form.)

It also runs frequently against tungsten carbide (WC) for a two-hard face material combination.

Today, there are two principal types of silicon carbide produced: *Reaction Bonded* and *Sintered*.

Reaction Bonded Silicon Carbide

Reaction Bonded silicon carbide is produced by infiltrating compacts made of silicon carbide and carbon with liquid silicon metal.

The silicon reacts with the carbon to form silicon carbide. The reaction product bonds the silicon carbide particles in the compact. It has an inherently impervious structure, so it requires no impregnant.

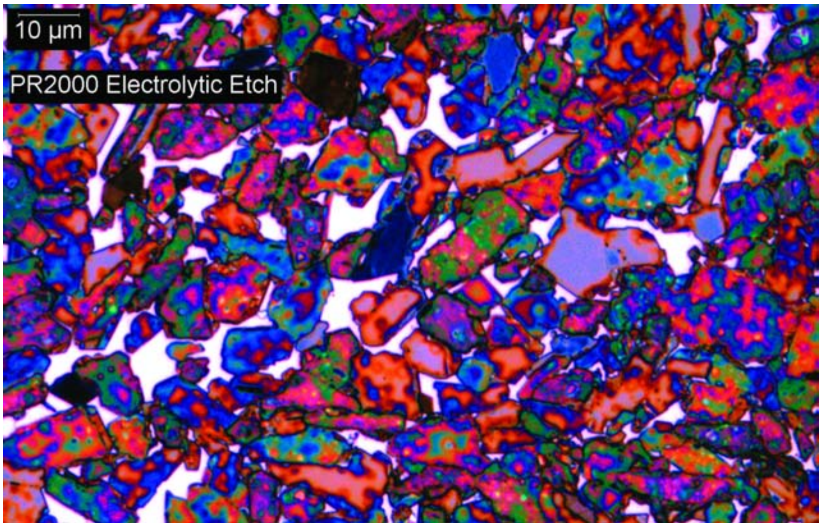

Figure 1.The grain structure of reaction bonded silicon carbide with free silicon.

The corrosion and abrasion resistance will vary depending upon the material's content and distribution of free silicon, grain size, and free carbon content. Most mechanical seal manufactures specify the free silicon to be in the range of 8 to12 percent and require a fine-grain material.

The wear and lubricating characteristics of Reaction Bonded silicon carbide are the best of all hard face materials, therefore it is the preferred material for high pressures and speeds.

It also has good chemical resistance; however, some chemicals will attack the free silicon within the structure. Examples include sodium hydroxide and other caustics, amines, hydrofluoric acid and phosphoric acid containing small amounts of hydrofluoric acid.

Sintered Silicon Carbide

Sintered silicon carbide is the other common type and the most widely used today as a hard face material.

Sintered silicon carbide is produced from pure silicon carbide powder with non-oxide sintering aids. It is a homogeneous form of silicon carbide that does not contain any free silicon. It also has an impervious structure requiring no impregnant.

The absence of the free silicon makes Sintered chemically inert to virtually all corrosive environments. It is the most resistant to chemically-aggressive fluids and can be used in virtually any fluid. However, it does not have the pressure-velocity (PV) capabilities of the other type of silicon carbide, and being the most brittle material it tends to chip very easily.

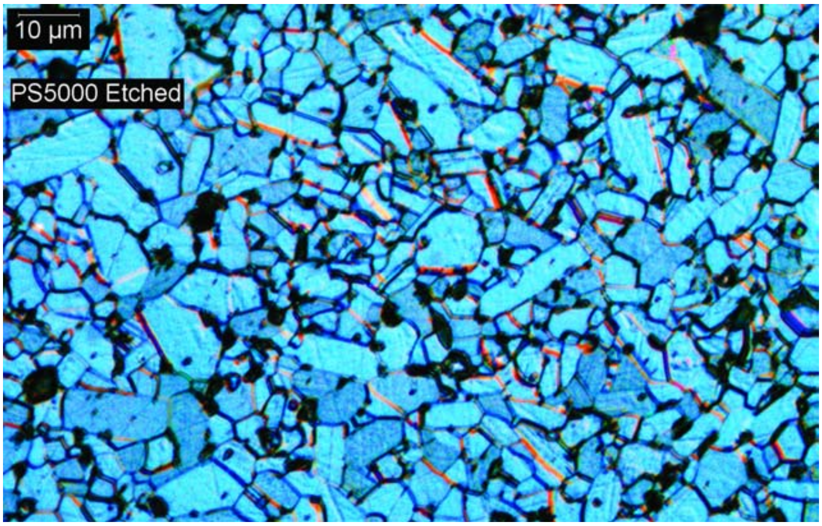

Figure 2. The grain structure of sintered silicon carbide.

Both types have excellent abrasion resistance and work well in applications where abrasive particles are present. They also both have low coefficients of friction against most other face materials, which minimizes the amount of seal face generated heat.

Ideally, another material, such as tungsten carbide, should be used as the mating material for the silicon carbide. However, silicon carbide can be mated with itself in those cases where the product being sealed has good lubricating qualities. Also, when using the same material, one of the faces should be lapped to a different roughness to assure optimum performance.

Tungsten carbide is still readily available for many component-style seal types, but most new off-the-shelf cartridge seals for chemical services use sintered silicon carbide as one of the face materials for clean services and both faces for dirty fluids.

Particularly in cyclic high pressure applications, two hard faces with high strength make sense, but a careful selection process is necessary because of the consequent reduced load capability.

Silicon carbide versus silicon carbide face combinations also are vulnerable to shock loads and can break suddenly if not properly designed.

Fluid Sealing Association

Sealing Sense is produced by the **Fluid Sealing Association** as part of our commitment to industry-consensus technical education for pump users, contractors, distributors, OEMs, and reps. As a source of technical information on sealing systems and devices, and in cooperation with the **European Sealing Association**, the FSA also supports development of harmonized standards in all areas of fluid sealing technology. The education is provided in the public interest to enable a balanced assessment of the most effective solutions to pump technology issues on rational Total Life Cycle Cost principles.

The **Mechanical Seal Division** of the FSA is one of six divisions with a specific product technology focus. As part of their educational mission they develop publications such as the *Mechanical Seal Handbook*, a primer intended to complement the more detailed manufacturer's documents produced by the member companies. Joint FSA/ESA publications such as the *Seal Forum*, a series of case studies in pump performance, are another example. The most recent contribution is the *Life Cycle Cost Estimator*, a web-based software tool for determination of pump sealing total Life Cycle Costs (LCC).

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Graphite-Loaded Silicon Carbide

While silicon carbide is available in other forms, the above two basic types are by far the most common in use as a mechanical seal hard face.

However, another popular composite is graphite-loaded silicon carbide. It is most commonly used in split seal designs, since the grain structure facilitates re-assembly of split seal faces.

Typically, a sintered silicon carbide is the matrix so the material has superior oxidation resistance even though it contains free graphite.

Methods to improve the dry running capability and PV limits of hard-versus-hard face combinations, such as silicon carbide against silicon carbide, have gained considerable attention. The techniques range from new compositions to surface texturing features.

New composites of silicon carbide and graphite, controlled porosity, laser-edged pockets, hydro-grooves, wavy faces, etc. have been introduced to counteract the lubrication sensitivity and reduced PV limit issues.

The surface texturing techniques have the disadvantage of not being useful in abrasive environments. Grooves, pockets, pores, etc. tend to get plugged and thus loose their effectiveness. Thus, these techniques can only be used in clean fluids.

The new compositions are silicon carbide-based and are called composite grades because they contain both silicon carbide and free graphite. Composite manufacturing processes provide graphite contents from a few percent up to 50 percent.

The addition of graphite to the silicon carbide base reduces strength somewhat, but improves tribological behavior greatly. These materials are popular in high pressure and speed applications. Their ability to handle abrasives is not as good as that of pure silicon carbide, but is still significantly better than that of carbon-graphite.

Consult a seal manufacturer for further information on these materials because a wide variety is available, each with strengths and weaknesses and/or advantages and disadvantages.

Ongoing research and product development continues to provide improvements in strength and resistance to chipping and breaking. Silicon carbide remains one of the most popular and cost-effective hard face materials for mechanical seals.

Next Month: How can expansion joint prevent pump system leaks?

We invite your questions on sealing issues and will provide best efforts answers based on FSA publications. Please direct your questions to: sealingquestions@fluidsealing.com. **P&S**