SEALING SENSE

How can the capabilities of primary seal materials be improved?

One approach to improving mechanical seal performance is to upgrade to a sintered silicon carbide composite material. Silicon carbide based materials have been increasing the limits of mechanical seals for more than 25 years, starting with Chemical Vapor Reacted (CVR) silicon carbide whose cross section resembles that of a piece of M&M'S® candy. The porous outer surface is a combination of silicon carbide and graphite. This surface coating encapsulates a carbon-graphite core. This material provided a hardened surface with a unique topography for increased interfacial lubrication.

However, it needed an impregnation to make it impervious for sealing applications. The graphite core also limited desirable physical characteristics such as high elastic modulus. This material did demonstrate that a hard, non-self-lubricating material could be run against itself and improve performance to a primary seal pair.

Reaction Bonded Silicon Carbide

Homogeneous materials such as reaction bonded silicon carbide provided the advantages of lower porosity, higher elastic modulus (stiffness) and improved thermal conductivity and tribological behavior. Initially, the costs associated with the processing of this family of materials somewhat limited their use to high duty applications with less aggressive chemicals. These materials required extensive grinding and the free silicon in the structure was susceptible to highly caustic or acidic environments.

This family of materials quickly gained acceptance in a variety of applications as contact pressures could be increased with less face deflection than that of metallic materials. Normal protocol was to run a high duty, hard, mechanical carbon-graphite against the reaction bonded silicon carbide.

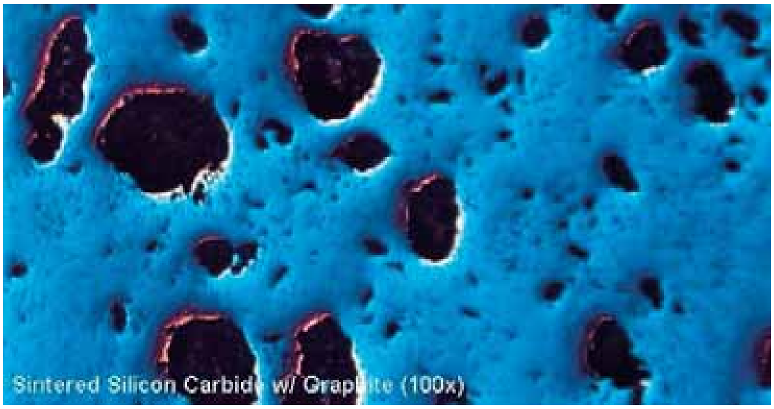

Figure 1. Graphite-loaded sintered SiC structure

Sintered Silicon Carbide

The need for greater abrasion and chemical resistance drove the development of sintered silicon carbide. Because of the chemical resistance in virtually all corrosive environments sintered (self-sintered, direct sintered or pressure less sintered) silicon carbide began to enter the market. This material could be formed into specific shapes and then sintered to, or nearly to, the finished size, limiting the amount of expensive grinding for the finished item.

This reduction in production cost, coupled with the homogeneous nature of the material, enabled its use in highly corrosive environments and higher volume applications. It began to displace other materials such as alumina where higher pressure-velocity (P-V) capabilities were required. (The P-V parameter is an index of the severity of the application. It is a relative measure of the material pair and is affected by other variables such as the fluid being sealed.)

Unfortunately, this virtually impervious material does not have all the tribological characteristics of a reaction bonded silicon carbide, nor can it run at the higher duties of that material.

Graphite-Loaded Silicon Carbide

The marriage of silicon carbide and graphite was a normal progression. Graphite initially was added to reaction-bonded silicon carbide and quickly exhibited an increase in the performance capabilities of hard face combinations. While strength is reduced somewhat and the ability to handle abrasives is not as good as that of pure silicon carbide, tribological behavior is improved significantly. Using this type of material in at least one of the two hard faces extended the seal life cycle in some cases from minutes (i.e., unacceptable) to hundreds of hours.

Graphite-loaded sintered silicon carbide was more recently applied in hard face combinations. This unique family of composite materials has the benefits of sintered silicon carbide while incorporating a second, abradable phase that provides pockets or reservoirs for the "storage" of fluid.

These composite silicon carbide hard face combinations enable higher contact pressures and speeds by improving interfacial lubrication in the same way a matte lap finish does. As shown in Figure 2, both graphite-loaded silicon carbide composites running against themselves have the highest relative P-V values of any of the hard-face pairs. When they are combined with a carbon-graphite mating material, P-V is further enhanced.

The need for greater abrasion and chemical resistance drove the development of sintered silicon carbide.

The reservoir's configuration is critical so as to not create other issues during operation. Specifically, edge breakdown around the reservoir can create debris that then damages the interface. A graphite-loaded sintered silicon carbide composite with properly configured reservoirs can provide for a smooth transition between the reservoir and the silicon carbide matrix.

Because of the uniformity of these composites, their characteristic performance will not change during operation, which can happen with matte lapping or other shallow surface treatments. Once the benefits of the matte lap have been removed, tribological behavior can change, especially during start-stop

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. *This month's Sealing Sense was prepared by FSA Member Joe Boylan.* 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 (LCC) principles.

The **Mechanical Seal Division** of the FSA is one of six 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. This document served as the basis for joint development of the more comprehensive *Hydraulic Institute* publication: *Mechanical Seals for Pumps: Application Guidelines*. Joint FSA/ESA publications such as the Seal Forum, a series of case studies in pump performance, are another example as is the *Life Cycle Cost Estimator*, a web-based software tool for determination of pump seal total Life Cycle Costs. The *Sealing Systems Matter* initiative also was launched to support the case for choosing mechanical seals that optimize life cycle cost, reliability, safety and environmental compliance.

The following members of the **Mechanical Seal Division** sponsor this *Sealing Sense*:

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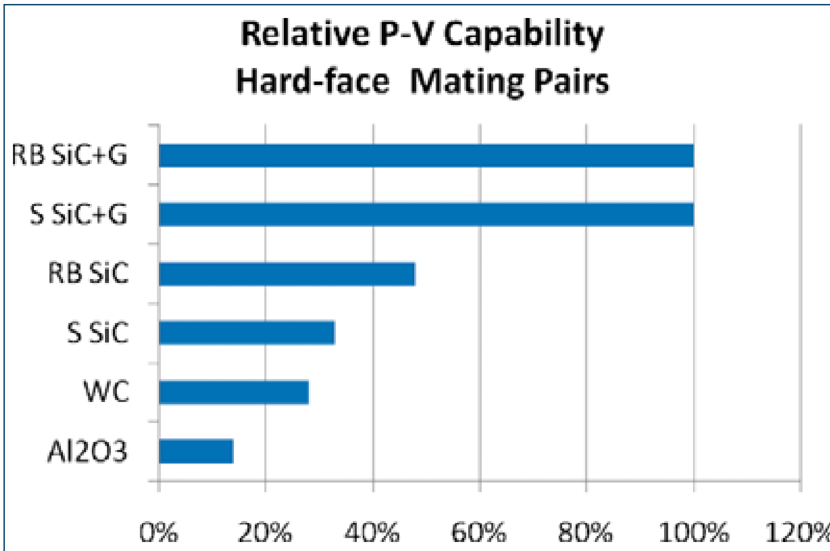

Figure 2. Relative pressure-velocity capability

situations. Other surface treatments, should they separate from the substrate, can cause rapid and extensive damage to the interface.

Lubricant: The Essential Ingredient

Silicon carbide primary seal pairs do not perform well in the absence of a lubricant. Fortunately, only a small amount of lubricant is needed to significantly improve tribological characteristics. The abradable graphite phase creates reservoirs that provide dry run survivability, increasing the amount of time a mating pair can operate in the absence of the fluid. In addition, the composite creates a material that is even more resistant to thermal shock than the silicon carbide itself, providing enhanced resistance to those upset conditions that are difficult to predict and control.

Conclusion

These graphite-loaded silicon carbide materials have been around for several years, and new applications are regularly identified. Initially, they were developed to address the highest P-V applications, with a focus on the highest pressures. Now they are being applied to lower pressure and speed applications because they can offer total cost savings to the user through reduction in warranty claims and improved tribological consistency.

It is always best to consult the mechanical seal manufacturer for proper selection and application, since a wide range of primary ring materials are available. The manufacturer can provide further information on their strengths and weaknesses.

Further information on silicon carbide and other hard face seal materials can be found in the December 2005 and January 2006 Sealing Sense *columns.*

Next Month: *How should I store my gaskets?*

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

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