Fluid Sealing Association FSA

From the voice of the fluid sealing industry

SEALING SENSE

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

A. The reliability and safety, as well as the total life cycle cost, of mechanical seals is determined to a large extent by the choice of the face materials. Their selection will depend on the pumped or sealed fluid. The corrosion, erosion, and/or abrasion resistance and lubricity of the material, as well as the temperature, pressure and pump speed, must all be considered.

To ensure a long service life, high quality materials must be used and they must be sufficiently hard to oppose wear, resist corrosion and be capable of producing a very flat and smooth surface when lapped. The diagram in Figure 1 shows a general classification of commonly used face or sliding materials.

Most materials exhibit poor wear behavior when in sliding contact with a surface fabricated from the same material. Therefore, two dissimilar materials – one softer then the other – are usually chosen. In extremely abrasive or corrosive environments it is usually preferable to utilize two hard materials because a soft face would wear excessively and cause higher then normal leakage rates. In such applications extremely hard materials such as tungsten carbide (WC) and silicon carbide (SiC) are ideal.

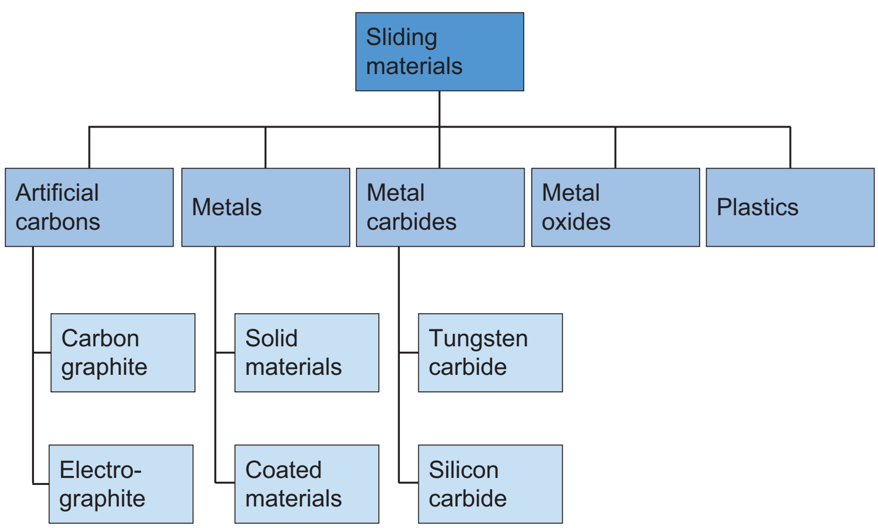

Figure 1. General classification of face materials.

In applications involving high pressures and/or large diameters, two faces fabricated from WC and/or SiC are sometimes applied to minimize the face deformations caused by the pressure forces. Although these two super-hard faces can handle quite a bit of load, it is important to realize that when two hard surfaces are chosen an important hidden compromise is made in the mechanical seal design. The compromise is that the faces will be more sensitive to damage or failure if lubrication is lost or reduced.

Tungsten and silicon carbide are two of the most common face materials and are used in a wide variety of applications. Their cost is usually higher than the pure metallic and oxide ceramic types, but their superior wear resistance results in a higher degree of reliability and longer service life. Tungsten and silicon carbide outperform the other groups decisively, particularly in harsh lubricating environments, high pressures, speeds and temperatures, or in the presence of corrosive and abrasive solids.

In clean fluids, they are usually paired with a softer carbon-graphite material. In dirty fluids or fluids containing abrasive particles, they can be paired or even matched against a surface of the same material. With the soft counter face, the maximum load capability, i.e. the "PV" (pressure x velocity limit), is the highest and even fluids with low viscosity do not pose wear problems in most applications.

Figure 2 shows nominal PV limits for different face material combinations in non-lubricating fluids and demonstrates the effectiveness of both WC and SiC when paired against a carbon face.

In a hard-versus-hard configuration, the abrasive wear resistance is maximized at the expense of a reduced load capability. In fluids with minimal lubricating qualities such as water, a hard-versus-hard combination becomes especially sensitive to rubbing wear and face damage from excessive friction.

Air or other entrained gases are potentially troublesome for any hard-versus-hard face combination. Fluids that tend to vaporize upon escape to the atmosphere are also most likely troublesome for hard-versus-hard face pairs.

In lubricating fluids, the PV limits of materials increase significantly and a rule of thumb is to multiply the values in Figure 2 by a factor of 1.5. What's important about these values is that they are not cast in stone. PV limits are indicative of the severity of an application that materials can withstand, but do not take the design or shape of the seal face into consideration.

The PV limit of materials is degraded when the seal faces deflect too much and cause edge contact. In such cases the PV limit would be substantially reduced and thus the probability for damage would be high.

Both tungsten and silicon carbide have excellent physical properties (Figure 3) that drive the operational capabilities of a mechanical seal. Nevertheless, behavioral differences between the materials have come to light over the years and preference has gone to silicon carbide for many applications involving clean and dirty fluids.

New product and industry standard developments during the last 10 years have clearly shown a trend toward more use of silicon carbide because of its greater versatility with respect to corrosion, abrasion, and erosion resistance, as well as its lower sensitivity to face damage.

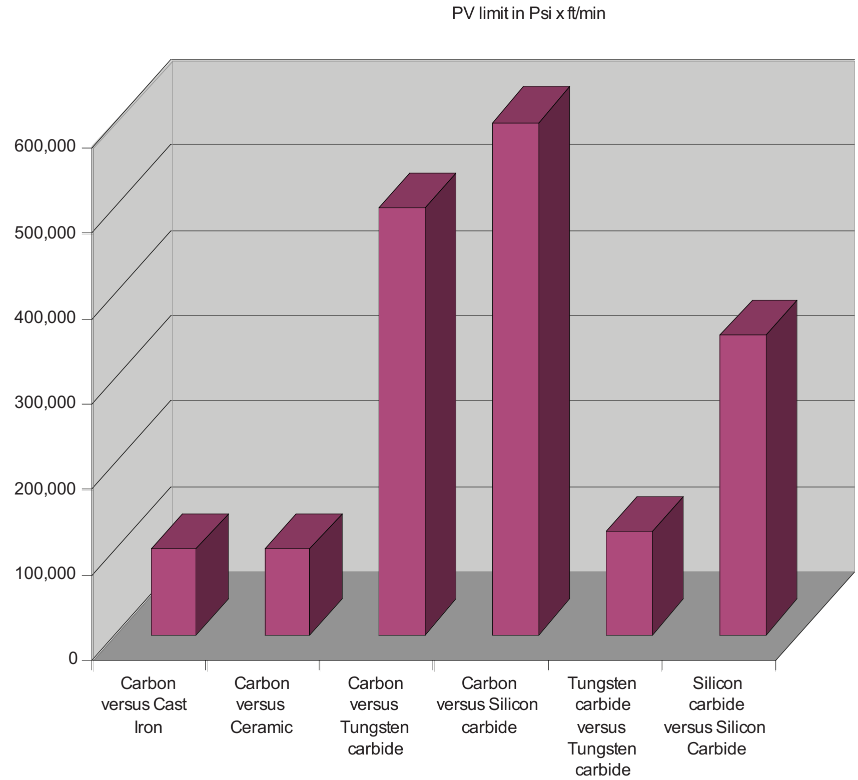

Figure 2. Nominal PV limits for typical face materials in non-lubricating fluids.

For example, the current revision of mechanical seal standard API 682 favors reaction-bonded silicon carbide as the mating surface for the majority of refinery applications. The other type of commonly used silicon carbide, sintered, is favored in the chemical industry because of its

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).

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

Advanced Sealing International (ASI)
A.W. Chesterton Co.
Daikin America, Inc.
DuPont Performance Elastomers, LLC
EagleBurgmann Industries LP
Flex-A-Seal, Inc.
Flowserve Flow Solutions Div.-
  Seal Group
Garlock Sealing Technologies
Greene Tweed & Co./Palmetto, Inc.
Industrias Vago de Mexico SA de CV
John Crane
KC America
Latty International S.A.
Manufacturas Multiples
  Industriales SA
Metallized Carbon Corp.
Morgan AM&T
PPC Mechanical Seals
Sealing Equipment Products Co., Inc.
Simrit-Div. of Freudenberg-NOK

excellent corrosion resistance. Although the most brittle, the chemical and tribological advantages of sintered SiC usually outweigh its sensitivity to fracture as compared with tungsten carbide.

Cartridge design seals offer a solution to overcome the drawback of brittleness during installation of the seal in pumps. Modern seals are designed with torque transmission features that reduce the risk of fractures during operation. Examples are square pin heads and transmission of the torque via a shrink or press fit ring in a metal housing.

Seal manufacturers have developed creative features that suppress the brittleness of silicon carbide and deal with operational or installation related events that can cause a seal face to break or crack. Also, the cost of SiC has been reduced significantly over the years and today is actually lower than WC, thereby providing greater value to the pump user.

Property	Units	Carbon Graphite	Tungsten Carbide	Reaction Bonded Silicon Carbide	Alpha Sintered Silicon Carbide
Density	g/cm^3	1.85	14.95	3.09	3.1
Hardness (Knoop)	kg/mm^2	95 *	1500	2100	2800
Tensile Strength	MPa (psi X 10^3)	48 (7)	896 (130)	307 (44.5)	206 (30)
Compressive Strength	MPa (psi X 10^3)	234 (34)	4205 (610)	2000 (290)	3900 (560)
Modulus of Elasticity	GPa (psi X 10^6)	24 (3.5)	607 (88)	390 (56)	410 (59)
Thermal Conductivity	W/m°K (Btu/Hr-Ft-°F)	9 (5)	83 (48)	147 (85)	126 (73)
Thermal Expansion	x10^{-6} mm/mm°K (x10^{-6} in/in°F)	4.9 (2.7)	4.9 (2.7)	5.0 (2.8)	4.0 (2.2)
Max. Operating Temperature	°C (°F)	260 (500)	1090 (2000)	1370 (2500)	1650 (3000)

* Shore A Hardness

Figure 3. Physical properties of commonly used face materials.

Next Month: What is the best silicon carbide wear face material for my mechanical seal?

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

PUMPS&SYSTEMS

The Magazine for Pump Users Worldwide

Improve Pump Reliability & Cut Costs!

The PUMP Handbook

The #1 Reference Series on Pump Troubleshooting, Maintenance & Reliability

This one-of-a-kind CD offers first-class coverage of virtually every aspect of pumping systems - from pump selection guidelines and pre-startup through long-term operation and maintenance strategies. It gives you access to the best thinking of many of industry's top experts on:

- Pump Specification
- Pump and Seal Maintenance
- Pump Selection
- Repair Techniques
- Pump and Seal Troubleshooting
- Pump Operations
- Profiles of Plant Pumping Solutions
- New Insight on Technical Pump Issues

The Pump Handbook Series on CD Contains:

Volume 1: Centrifugal Pumps
Volume 2: Positive Displacement Pumps
Volume 3: Mechanical Seals & Sealing Systems
Volume 4: Pump Maintenance and Reliability
Volume 5: Pump and System Troubleshooting

visit www.pump-zone.com for complete Table of Contents

Only $195

plus $3.50 shipping & handling

Order Today! Call (205) 212-9402
or download order form at www.pump-zone.com/handbook.php