Prolonging seal life with monolithic carbon design

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A major petrochemical plant increased seal life from three months to one year by switching to a new seal design with narrow, monolithic carbon stationary faces that stay cool and in full contact under fluctuating conditions. The seals used before could not achieve reliable control of emissions below 1000 ppm. The monolithic carbon faces used in the new seals exhibit controlled thermal growth and maintain full face contact throughout cycling. The new seals also use a carbon grade that covers such a wide application range that it handles all applications in the plant, where carbon is compatible, thus reducing inventory and purchasing costs.

Seal faces

Many seals used in the past had carbon stationary faces press fitted inside steel holders. The difference in the coefficient of thermal expansion caused the press fit to relax. This had a negative impact on face flatness and caused leaks. In addition, common operating conditions, including pressure changes, created dynamic stresses that distorted the faces. Many older designs had wide faces to prevent this distortion. An undesirably large balance ratio was then required to keep the overheated faces together.

The faces distorted under dynamic stresses. As the fluid film thickness between the faces increased, emissions progressively increased which made it necessary to replace the seals.

The faces in the 155A seals used now mate over a narrow cross-section for low frictional heat generation compared to traditional wide faces. Over 80% of the heat which is generated by the 155A faces is transferred into the fluid through the carbide seal ring. This seal ring has a large surface area and rotates in the fluid for better heat transfer into the medium. The previous rotary seals buried the carbide seal ring in the gland where the heat transfer to the fluid is poor and flush injection in one location contributed to uneven temperature distribution in the stationary ring.

Making the seal narrower makes it much easier to control deflections due to temperature. The new rings were developed with finite element analysis. A proprietary finite element analysis program developed specially for seal applications was used. This technology made it possible to optimize the design to relieve dynamic and thermal stresses and prevent distortion at the face mating surfaces. Optimum balance from 60% to 75% was achieved. The face remains flat for effective, consistent emissions control and long, predictable life.

Squareness to shaft

The 155A seal has a self-centering locking ring that works in conjunction with the standard gland pilot to ensure that faces start out square to the shaft and stay that way after attachment of the cartridge lock ring to the shaft.

Figure 1. Mechanical seal on pump.

Figure 2. The seal faces are machined to make over a narrower cross-section.
The previous seals did not have a mechanism to establish squareness to the shaft and, as a result, were subject to cocking of the rotary face relative to the stationary. The inability of the rotary face to completely track the stationary face permits fugitive emissions and contributed to shortened life.

**Materials selection**

Another improvement with the new seals is the use of Purebon P-658RC carbon graphite, on the stationary face of the seal. The key properties that make it perform well on this application are high hardness, good corrosion resistance and good strength. Another advantage of P-658RC is that it conforms well to the harder silicon carbide opposing face as it wears.

This material provides consistently high performance over a wide range of applications, thus making it possible to standardize. In the past, it was necessary to stock four different grades to cover the usual range of applications. Now, P-658RC grade is used on nine of the 10 major seal types produced by the company. The exception is the split mechanical seal that uses P-8412 grade, which material is especially good for dry running situations. These situations are common in many mixer applications where split mechanical seals are used.

The advent of P-658RC was a key factor in the advent of off-the-shelf seals such as the 155A. The need to select particular grades of carbon for different applications was the main reason why seals had to be customized for specific applications in the past. One factor that helped in establishing the off-the-shelf concept was switching to 316 stainless steel as the standard material for seal housings. Offering alternative O-rings with each seal that cover nearly all applications was another.

The company has also standardized on one grade of sintered silicon carbide for rotating seal faces. Other hard face materials used are tungsten carbide and aluminum oxide. Tungsten carbide is typically used for applications which undergo considerable amounts of shock and vibration. Silicon carbide is used in the larger number of applications including most of those in the chemical and petrochemical industries. A particular advantage of silicon carbide is that it works well with light hydrocarbons, which have a tendency to flash or turn into gas at the seal interface depending on pressure and temperature. The ability of the seal to minimize heat generation is a key factor in preventing this situation which can release vapours into the atmosphere.

The result is a configuration that covers over 90% of all applications, leaving very few that still require special seals. The advantage to the customer is lower inventory and simplified purchasing. There is less potential for mistakes and delivery times are normally shorter because distributors can usually cover all their customers needs by carrying just a few seals.

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