FLUID SEALING ASSOCIATION FSA

From the voice of the fluid sealing industry

SEALING SENSE

5th Anniversary

What are the basics of gas lubricated seals? (Part Two)

This month's *Sealing Sense* was prepared by FSA Member Rob Phillips

Last month's *Sealing Sense* provided an overview of pump gas seal benefits and general design issues. This article will discuss some application conditions that must be considered when applying gas seals to pumps.

As noted in Part One, gas seal technology for pump applications offers a number of benefits, including zero emissions, high reliability and low power consumption. Gas seal support systems are also simpler and require less maintenance than the buffer or barrier systems required for dual wet seals.

However, some application conditions require special consideration when choosing gas seals for rotating equipment. Considerations include selecting the optimal topographical seal face features to create face separation and finding the seal types and arrangements best suited for the process fluids being pumped.

Rotational Speeds

Gas seal faces are designed to generate hydrodynamic forces that separate the seal faces during operation of the rotating equipment. These forces are proportional to the rotational speed of the shaft. Seal face topographies are designed for optimal performance within a specified range of rotational speeds. The gas film stiffness can be significantly reduced if the seal is operated at rotational speeds below the lower limits of the design.

Normal operating speeds of the equipment may be within the gas seal's design range. However, transient slow roll conditions can occur as the equipment shuts down, especially in applications where a variable frequency drive with an extended soft start or shutdown is applied. High temperature applications may also implement slow roll conditions to avoid shaft droop during periods of non-operation, and pumps with steam turbine drivers are typically slow rolled for long periods.

Gas seals can be successfully applied under these conditions so long as they are recognized at the time the gas seal is specified. The face topography can be modified to rely more on hydrostatic forces and less on hydrodynamic forces to create face separation. This can be effective even under slow rotational speeds, but the possibility of increased barrier gas consumption must then be considered.

Another option is to apply a coating to the hard face (typically silicon carbide) that will minimize the potential for scuffing of the seal faces if contact occurs during the slow roll condition. Diamond-like coatings (DLC) and true diamond coatings can be applied for this purpose.

Rotational Direction

Many topographical seal face patterns are designed to create hydrodynamic load support and seal face separation when the seal faces rotate in a specific direction, but act to draw the seal faces into contact when the direction of rotation is reversed. These seal face patterns are called *unidirectional*.

For most pump applications, a unidirectional seal face does not present problems because the pump shaft only rotates in one direction. However, this may not be the case for some pump system designs with a significant length of vertical discharge and a piping configuration that allows the fluid in the discharge line to drain back through the pump when the pump is shut down. The draining of the discharge line can cause the impeller to rotate in a reverse direction, resulting in reverse rotation of the pump shaft and seal faces.

Most gas seals readily tolerate short duration reverse rotation without damage to the seal. However, if the pumping system design allows reverse flow through the idle pump for long periods, it becomes imperative to recognize that this condition can result in reverse rotation of the seal. Make sure to advise the seal manufacturer of this pumping system design situation during the selection process.

As with rotational speeds, the face topography for unidirectional seal faces can be modified to rely more on hydrostatic and less on hydrodynamic forces to provide face separation for successful performance. In this case as well, some application conditions and seal designs may lead to increased seal face separation with a corresponding increase in barrier gas consumption.

Bidirectional seal face topography can also be employed. While bidirectional topographies are able to generate hydrodynamic separating forces regardless of the rotational direction, they typically generate lower gas film stiffness. This can potentially allow seal face contact when axial perturbations of the seal rings occur.

Solids in Process Fluid

Solids are a common cause of mechanical seal failure in pump applications, but can be particularly problematic in some gas seal designs. Solids may be dispersed throughout the process stream or may be dissolved and crystallize out of solution between the inboard and outboard seals. In either situation, the solids cause two significant problems for gas seal performance.

First, gas seal faces are designed to operate with a gap between the mating faces on the order of 0.0001 in (2.54 μm). The solids can migrate into the seal face gap as shown in Figure 1 and cause third body erosion, degrading the seal face topography and diminishing its effect. For gas seal configurations where the process fluid is at the I.D. of the inboard seal faces, centrifugal forces will act to aid the migration of solids into the gap between the seal faces.

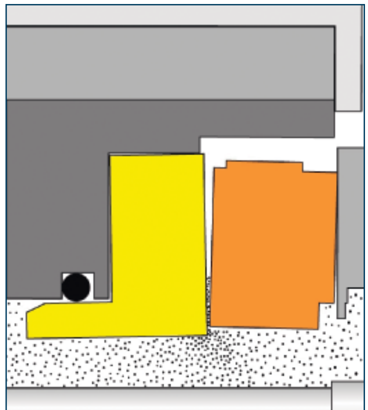

Figure 1. Solids migration into seal face gap

Spring Loads

Second, the spring loads that provide the closing force of the seal faces in pusher type seals are typically about 50 percent lower for pump gas seals than for liquid lubricated seals. These lower spring loads are employed to avoid overcoming the gas film stiffness created by the hydrodynamic opening forces (F_o) and minimize the risk of seal face contact.

Due to these low spring loads, pusher type gas seals can be susceptible to secondary seal hang-up, which occurs when the dynamic secondary seal cannot move axially to allow the flexibly mounted seal ring to track the mating ring. Hang-up can occur when the seal ring is displaced axially from the mating ring, resulting in excessive barrier gas consumption, or when the seal ring is displaced axially toward the mating ring, resulting in excessive closing forces and possible seal face contact.

Design Solutions

Several design features can be incorporated into pump gas seal

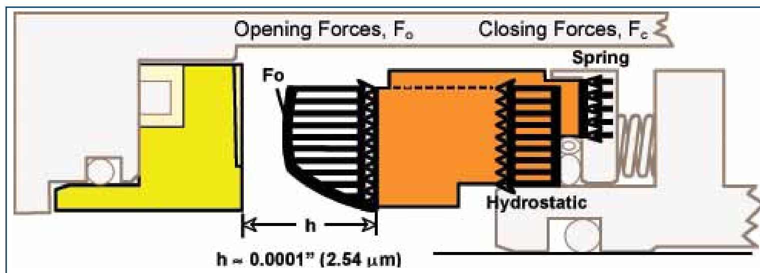

Figure 2. Forces on gas seal faces

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 systems 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 was also 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* series:

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systems when solids are known to exist in the process fluid. One approach is to prevent the solids from entering the seal chamber area. This can be achieved using solids exclusion devices that are mounted at the impeller end of the seal chamber. These devices may include volute-like geometries that convert the rotational velocity of the process fluid in the seal chamber into axial velocity, directing the fluid and its solids out of the seal chamber.

Seal configurations with process fluid at the O.D. of the inboard faces also help to reduce the migration of solids into the seal face gap.

Other designs may use a restriction at the seal chamber throat such as a labyrinth seal (see Figure 3). API Plan 32 can also be used to prevent the ingress of process fluid and solids into the seal chamber with a close clearance bushing and injection of a clean fluid into the seal chamber.

Special dynamic secondary seal designs can be employed to minimize the chance of hang-up. These designs typically minimize the amount of drag that the secondary seal creates when it moves axially. They may also prevent solids from collecting at the process side and restrict axial movement of the secondary seal. The designs often control the secondary seal squeeze in the radial direction by using a canted coil or leaf spring to energize the secondary sealing surfaces against the axial sealing surfaces.

Gas seal designs incorporating metal bellows seals are also available. The use of a metal bellows seal instead of a pusher type seal completely eliminates O-ring secondary seal hang-up.

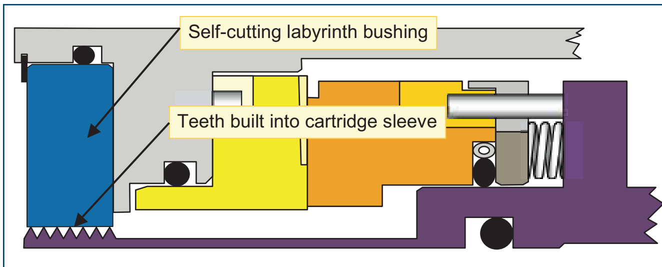

Figure 3. Typical labyrinth seal design feature

Conclusion

With clear identification of these conditions during seal specification, gas seal designs can be applied that mitigate these application challenges. With proper engineering and application, gas seals provide a highly reliable, energy efficient method for providing zero emissions sealing solutions for pump applications. Contacting a seal manufacturer with complete application details first can ensure optimum results.

Next Month: *How do I prevent gasket blow out?*

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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