WATER MANAGEMENT WITH MECHANICAL SEALS

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SEAL DESIGN AND TYPE CAN MAKE A DIFFERENCE IN REDUCING WATER CONSUMPTION.

REDUCING WATER USE HAS BECOME A MAJOR FOCAL point as both economic and environmental pressures continue to increase in the pulp and paper industry. Many mills have water reduction goals and have formed cross-functional teams to implement reduction plans. One area that is often targeted is water used on pumps, agitators, and screens. Many pulp and paper mills use millions of gallons of water each year with mechanical seals. Unchecked flush water injected into the stuffing box of sealed equipment can easily reach flow rates greater than 5 gal/min. This water requirement can be reduced and, in some cases, even eliminated by using the proper mechanical seal and piping arrangement.

It is critical to evaluate the piping arrangement, pressures, and flow rates when changing from packing to mechanical seals to prevent excessive water use. There are many options available to reduce water consumption with mechanical seals. The following is an overview of seal design features, piping arrangements, and common uses for the pulp and paper industry.

MECHANICAL SEAL WATER CONSUMPTION

Flushing water into the stuffing box of a mechanical seal minimizes the amount of solids and particles the seal contacts and increases heat removal from the seal, as shown in **Fig. 1.**

Flush fluid mixes into the process fluid and, if mixed correctly, it will displace all of the process fluid in the stuffing box with flush water. Several items influence the amount of flush water required for a mechanical seal to operate reliably. They are the type of mechanical seal used, the design of the mechanical seal, and the type of process fluid sealed.

SEAL DESIGN

The seal design and type play an important role in determining the amount of flush water required to operate the seal reliably. This is especially true with single seal designs. Dual seals by nature do not typically use an external flush that enters the process stream. To select the best mechanical seal design to work reliably at low or zero flush flows, it is important to analyze some important attributes.

Non-clogging

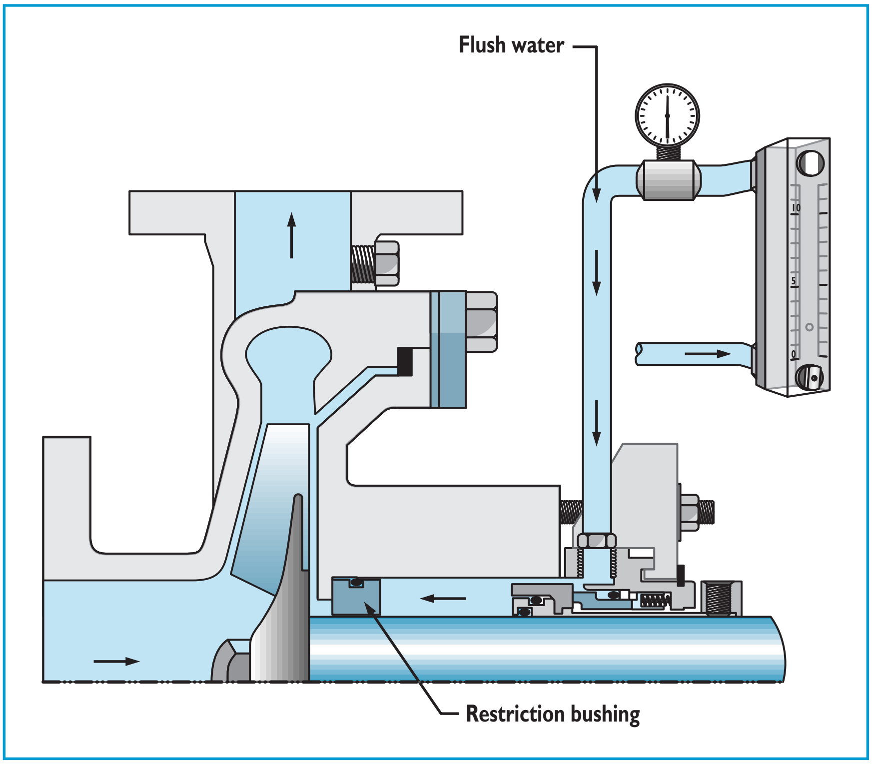
The mechanical seal should always have the spring mechanism out of the process fluid for optimum reliability, as illustrated in **Fig. 2.** This will prevent solids and particles from clogging the spring, which would lead to premature failure. Metal bellows seals inherently have their spring mechanism, the bellows, in the process. For this reason, they are not considered an ideal choice in services with high solids content such as stock.

Cool operation

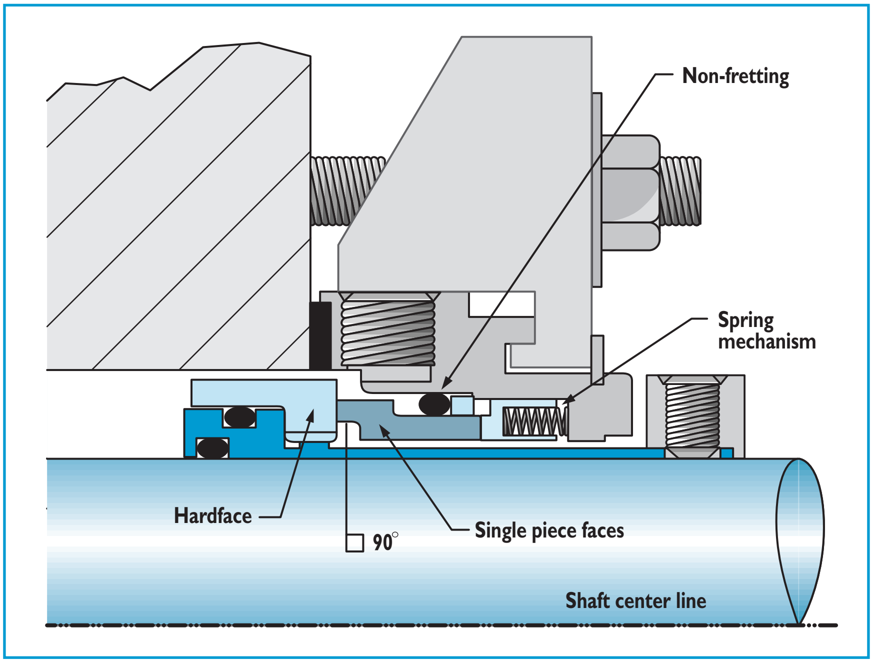
A seal that runs hot will have excessive amounts of dewatered and packed solids around its faces. Solids accumulation will eventually cause the seal face to hang up, leading to premature seal failure. To minimize this problem, water flush is used to remove the frictional heat generated by these seals. The two components involved in creating seal operating temperatures are heat generation and heat dissipation. Cooler operating seals have features that minimize heat generation and maximize heat removal. The need for a water flush for cooling the seal is minimized and often eliminated.

A cool operating seal has low heat generation. A hydraulically balanced seal reduces the hydraulic closing forces on the seal faces to reduce heat generation. Seals that are unbalanced and have wide seal faces can require three times the flush rate of cooler designs to achieve similar operating temperatures.

Maintaining seal face flatness during equipment operation can also reduce face temperature. Older seal models have their seal faces pressed into metal holders. This design cannot stay flat at elevated temperatures due to the different rates of thermal expansion between the seal face material and the metal holder. Today, seal face flatness is accomplished by balancing the effects of face



1. Water flushed into the stuffing box is used to minimize the amount of solids and particles that come into contact with the seal.



2. The seal design should keep the fixed seal face completely square (90°) to the shaft.

The other component of a cool operating seal is the amount of heat that is pulled away from the seal faces. The hardface, typically tungsten carbide or silicon carbide, is approximately ten times more thermally conductive than the carbon. The majority of heat developed at the seal faces moves through the hardface and out into the process fluid. To optimize heat dissipation in a seal design, the hardface should be located in the fluid, rotating and exposed to the process fluid.

If the hardface is the stationary face, air surrounds it, acting as an insulator. Air convects heat approximately 50 times less than water. Also, if the rotating hardface is surrounded by metal and not exposed to the process fluid, its ability to dissipate heat is limited.

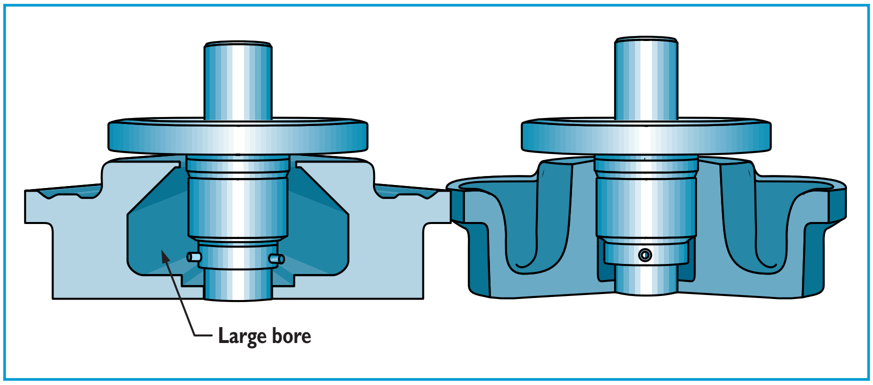
Seal face wobble

Once the temperature at the seal face is reduced, it is important to look at how the seal faces are kept closed during pump operation. The first step is to minimize seal ring movement. The seal design should have the ability to keep the unsprung or fixed seal face completely square (90°) to the shaft. Any out of squareness will require the spring loaded face to wobble twice each revolution. At the high speeds that rotating equipment operates, the spring-loaded seal face will not respond perfectly to the wobble of the fixed face. This time lag or hysteresis will allow solids to move across the faces, causing seal face scoring and premature seal failure. High flush rates are typically used to minimize the solids in the stuffing box and extend seal life by counteracting this wobble and resultant scoring. An ideal seal design will ensure the unsprung or fixed seal face is completely square to the shaft centerline after tightening.

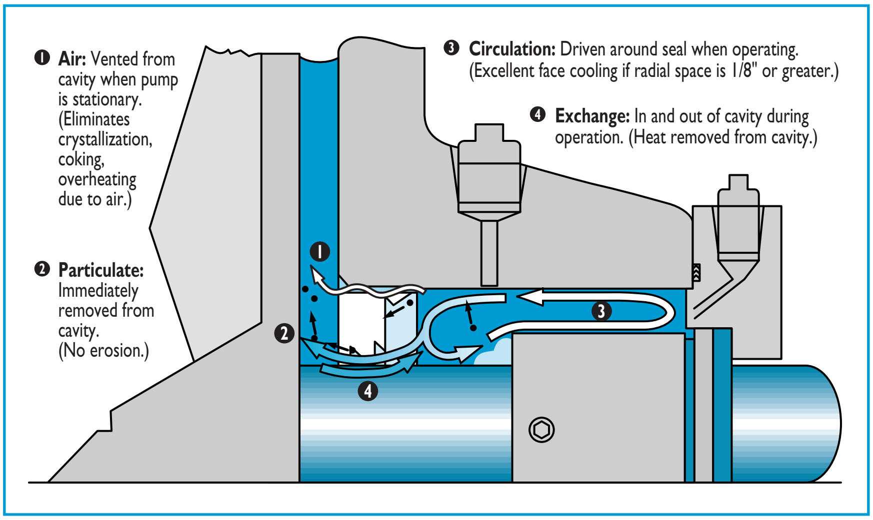
distortion due to pressure against the effects due to frictional heat generation. Sophisticated computer modeling has allowed this to become a reality.

Shaft vibration should also be minimized to prevent momentary seal face opening. Shaft vibration is caused by a variety of reasons such as impeller imbalance, poor coupling alignment, and pump cavitation. Since this movement cannot be completely eliminated, it is critical to ensure the seal face can move freely. Many mechanical seals use o-rings as secondary seals. It is important to minimize the drag underneath these dynamic o-rings. Drag on o-rings can cause the seal faces to open from hysteresis or lack of responsiveness, resulting in face scoring, leakage, and premature seal failure. This is an even greater concern when these o-rings cause fretting corrosion of the stainless steel surfaces. Fretting is an accelerated combination of corrosion and erosion. Fretting corrosion causes much more o-ring drag if the o-ring hangs up in the fretted grooves on the stainless steel component it rubs against.

To minimize the drag caused by the o-ring, many seal designs have completely eliminated fretting corrosion from the seal. The dynamic o-ring rides on the seal face material itself. If carbon, which contains graphite, is used, it minimizes o-ring drag and the resulting hysteresis and seal face opening. Another step that can be taken is to polish this surface to a fine finish to further reduce drag.



3. Large bore seal chambers



4. Operation of a centrifugal force device

Seals that have these features will work reliably, flush free, on 3% stock. This alone can eliminate millions of gallons of flush water use, reheating, and treatment throughout the mill.

SINGLE SEAL ARRANGEMENTS THAT MINIMIZE WATER USE

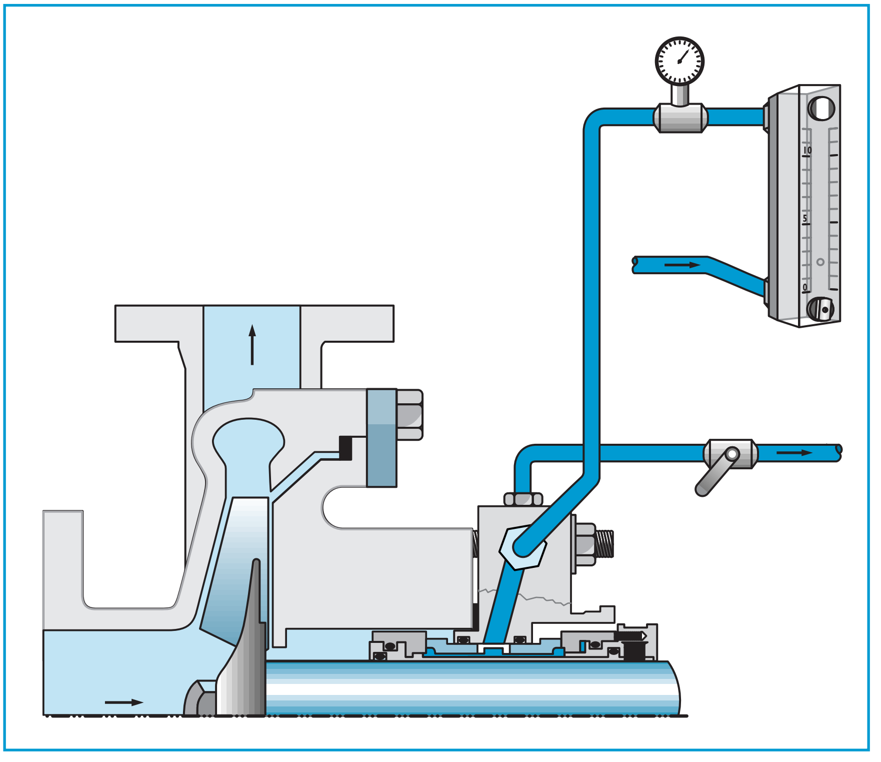
Large bore seal chamber

Newer large bore seal chambers, as shown in **Fig. 3,** are available on many pumps. The radial clearance between a mechanical seal and stuffing box is typically only 0.03 in. This narrow clearance is easily filled up by solids. Flush use can be minimized or eliminated altogether by using a large bore seal chamber. By opening up the clearance around the seal to 0.62 in., the problems associated with clogging inside the bore are reduced. However, caution needs to be taken in the use of open throat stuffing boxes, as erosion and abrasion can occur.

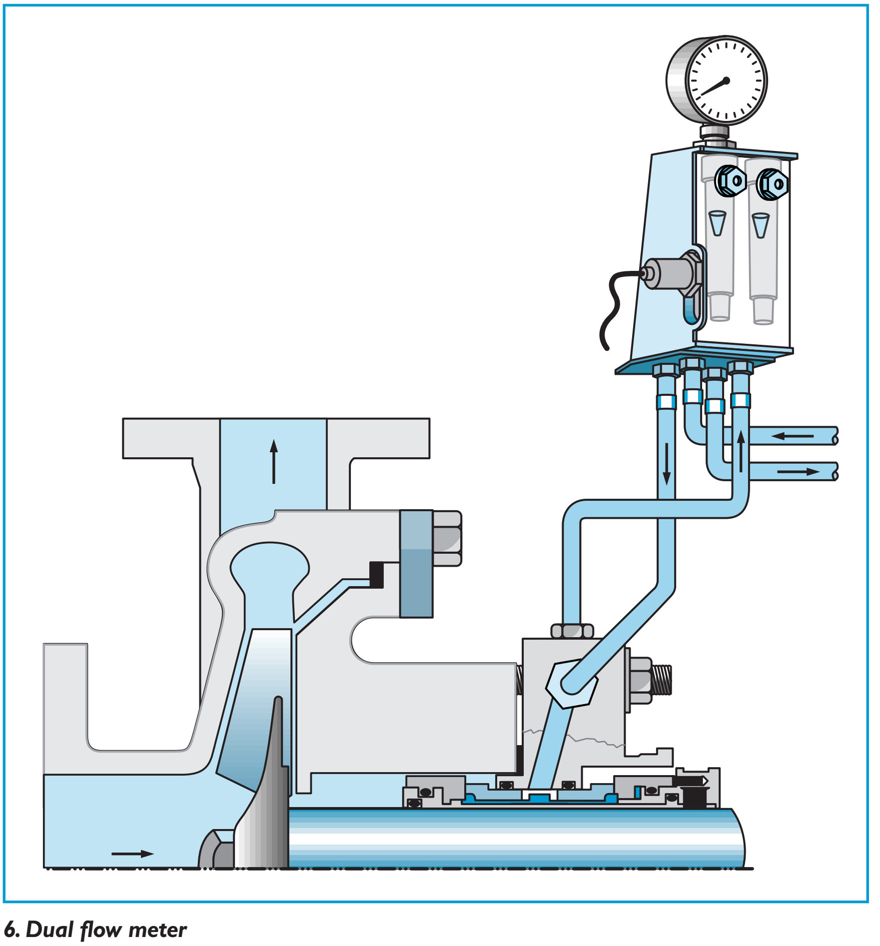
Centrifugal force devices, as shown in **Fig. 4,** can also be used to minimize the accumulation of abrasive particles in the stuffing box and eliminate air around the seal faces during operation. These devices have proven to be effective in minimizing particulate buildup in the stuffing box. Split single seals are currently working flush free on over 3% stock using these devices.

Suction recirculation, not discharge recirculation

Even on no-flush seal arrangements, circulation is desirable to prevent solids from accumulating around the seal. This can be accomplished by piping from the lantern ring connection on the stuffing box back to the suction pipe. This will promote flow from the stuffing box back to suction and minimize clogging. Make certain that the pump stuffing pressure is greater than the stuffing box pressure before doing this. Do not pipe from the discharge to the lantern ring connection, as this may cause severe erosion with process fluids that contain particles.



5. Flow-through piping arrangement



6. Dual flow meter

Flushing

To pipe this up correctly, source pressure needs to be reliable and to remain consistently above the seal chamber pressure of the pump. Reducing the clearance at the throat of the seal chamber with a restriction bushing is desirable. This will reduce flush water consumption and/or allow the use of a larger pressure differential between supply pressure and stuffing box pressure. This is especially important on equipment with variable stuffing box pressures (pumps that operate at more than one flow rate and/or have variable suction pressures).

The restriction bushing, shown in Fig. 1, also isolates the seal chamber from the process fluid and reduces the amount of flush flow required to prevent the process fluid from migrating into the stuffing box.

Some restriction bushing designs also work as a check valve during pressure reversals to positively exclude process fluid from entering the seal chamber during process or flush pressure upsets.

A flow meter is preferable to a gauge in most instances. A pressure gauge does not indicate whether any flush fluid is entering the seal chamber area, as seal chamber pressure is typically unknown and variable. A flow meter, however, inherently allows the user to set adequate flow to the seal.

Proper flush setup will not only reduce flush use in many cases but will also enhance seal reliability.

DUAL SEALS

Water injection into the process can be eliminated with dual seals. Using dual seals in conjunction with barrier fluid tanks reduces total water consumption to practically zero. Flow-through arrangements require continuous water flow through the seal.

Dual seals have two sets of seal faces, described as the inboard and outboard sets of seal faces. Barrier fluid flows between these two sets. The outboard set of faces seals the barrier fluid from atmosphere. The inboard set seals the interface of the barrier fluid and process fluid.

In a mill, dual seals are found in black, white, and green liquors, coatings, effluent, and bleaching services, to name a few. There are various methods and options to select from when using dual seals. A thorough knowledge of the advantages and disadvantages of each is essential to optimize performance.

Flow-through piping arrangement

Providing barrier fluid into and out of the mechanical seal is the most popular method of supplying barrier fluid to mechanical seals within a mill. **Figure 5** illustrates a flow-through piping arrangement.

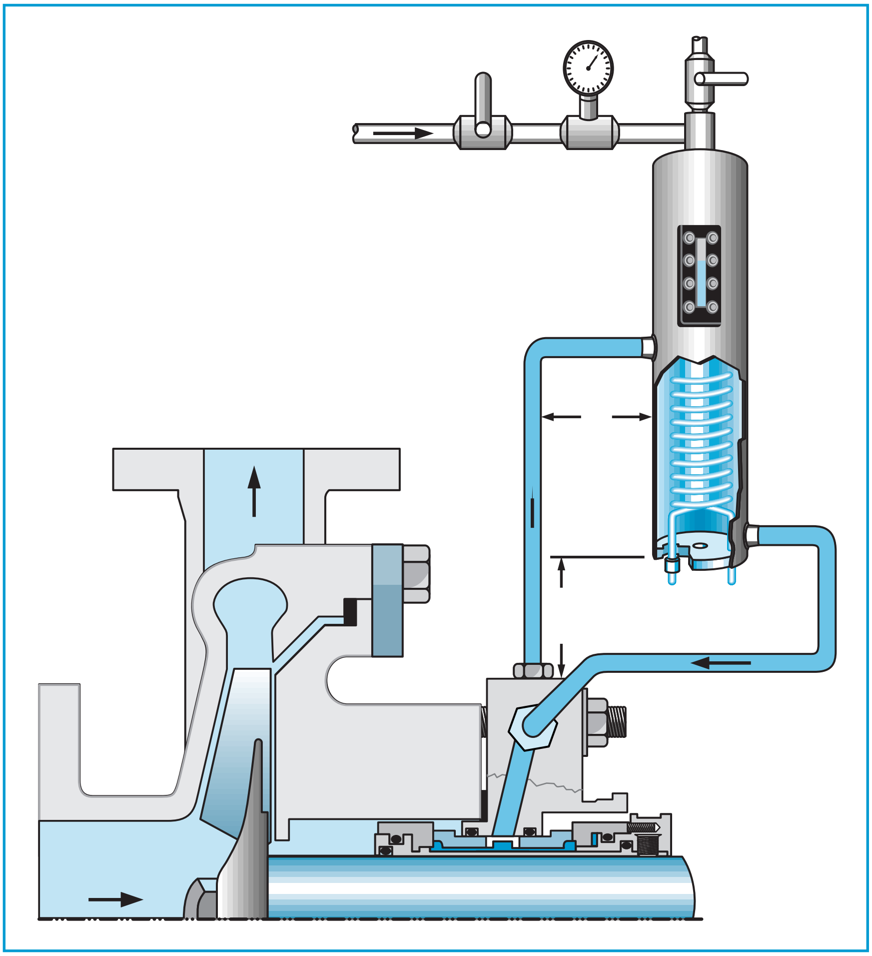
Flow-through operation will work in both double and tandem pressure modes. The biggest advantages of this arrangement are lower maintenance and up-front costs as compared to barrier fluid tanks. Barrier fluid tanks will lose pressure and fluid over time and need to be refilled periodically.

Supply pressure and flow need to be reliable. Filtered water should be used for maximum seal reliability. Pressure should be set on the downstream side of the seal. This arrangement typically sends the barrier fluid water to drain to be treated as effluent. If water leakage into the process is a problem, as in black liquor and some coatings services, a dual flow meter can be used to monitor inboard leakage. Such a meter is shown in **Fig. 6.**

This arrangement typically uses large amounts of water, especially if not properly set up. Water is sent to drain and treated as effluent, incurring more cost.

Barrier fluid tanks

Barrier fluid tanks are used widely in many industries but less so in pulp and paper, although their popularity is increasing. **Figure 7** shows a barrier fluid tank.



7. Barrier fluid tank

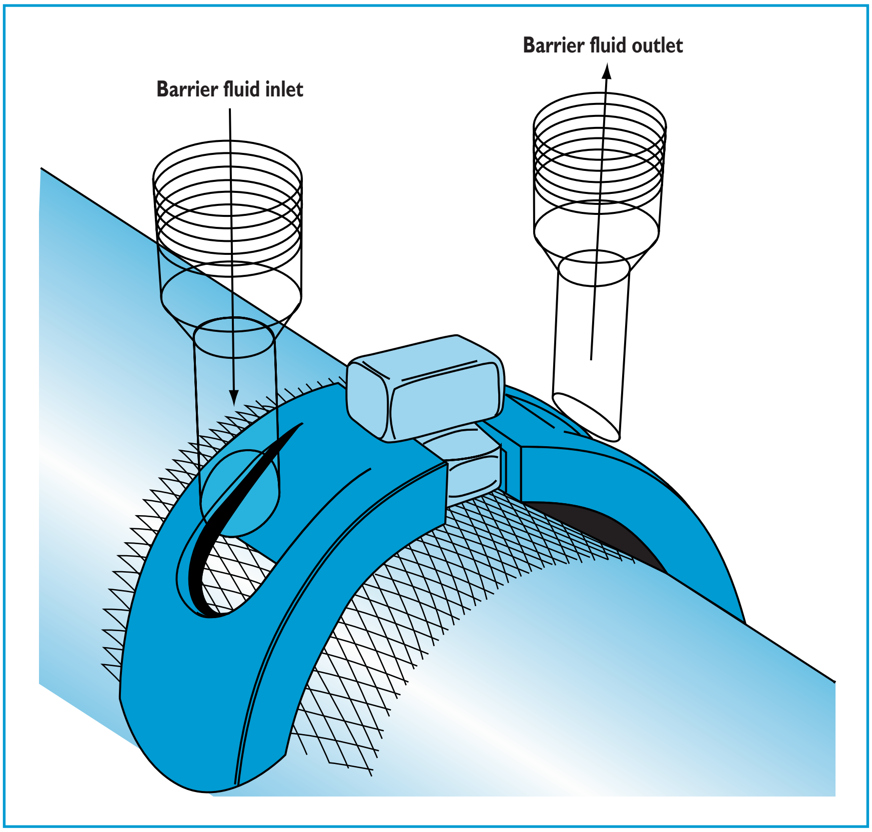
The barrier fluid is typically set at higher pressure than the stuffing box pressure. By utilizing a closed system, fluctuations in system pressure and fluid quality are minimized until the mechanical seal begins to leak. Typically, longer seal life can be obtained with this method when compared to flow-through operation. However, when the seal begins to leak, maintenance must be performed on the tank or the seal must be removed. It is important that the dual mechanical seals have a pumping device to promote flow. This will ensure that adequate heat removal is accomplished with the barrier fluid tank system on this type of arrangement. **Figure 8** illustrates barrier fluid input and output on such a system.

Double operation

Double operation defines the pressure mode where the barrier fluid is set at a higher pressure (15 to 30 psi) than the process pressure. The inboard set of seal faces will seal the clean barrier fluid from entering into the process.

The primary advantage of this pressure mode is that the barrier fluid rather than the process fluid is between the inboard set of seal faces. Barrier fluid, usually filtered water, is much cleaner than most process fluids. Scoring from sealing particulates is eliminated, resulting in greater seal reliability.

Another advantage gained by double operation is safety. If inboard leakage develops, barrier fluid will leak into the process. Process fluid will not leak out to atmosphere. Therefore, with hazardous fluids such as chlorine dioxide, sodium hypochlorite, and hydrogen peroxide,



8. Pumping device to promote barrier fluid flow

added safety is ensured by using dual seals in double mode. The disadvantage of this arrangement is that as the inboard set of seal faces begins to leak, water will get into the process. Monitoring can be used to detect inboard leakage if the application warrants it.

Tandem operation

Tandem operation defines the pressure mode where the barrier fluid is set at a pressure lower than process pressure. The inboard set of mechanical seal faces seals the process fluid. The outboard mechanical seal faces seal low pressure barrier fluids.

The primary uses of this pressure mode are to prevent precipitation of solids at the seal faces and utilize an installed spare set of faces for increased safety or uptime. Solutions such as caustic and brine can precipitate out on the atmospheric side of the seal faces, affecting single seal life. A barrier fluid set at 15 psi will prevent this. When the inboard seal fails, the barrier fluid does not enter the process fluid. This can be important on fluids such as coatings that can accept no contamination from barrier fluid.

Tandem mode allows the dual mechanical seal to act as an installed spare. The outboard faces seal the lower pressure, cleaner barrier fluid. The inboard faces seal the process fluid. Inboard seal failure will be contained by the outboard seal. Barrier fluid pressure or flow can be monitored to identify an inboard seal leak, and a convenient time for changeout can be scheduled. Thus, two seals can extend seal life and give advance warning of a leak to atmosphere.

The disadvantage of this arrangement is that the inboard seal faces operate on process fluid that often contains particulates detrimental to seal life.

SUMMARY

There are many options pulp and paper mills can use to reduce their water consumption and treatment. It is important to select both the correct seal design and the environmental control simultaneously for the application. By working together with your mechanical seal specialist, you can typically obtain substantial water savings while increasing mechanical seal reliability at the same time. **TJ**

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