Upgrading pump packing to mechanical seals

An alternative to compression packing in centrifugal pumps, mechanical seal technology conserves water, improves energy efficiency and minimizes environmental impact.

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The environmental performance of products and processes in all industrial sectors is increasingly coming under critical inspection — with sustainability, conservation of natural resources and reduced environmental contamination directly influencing the design and selection of equipment. Many industrial processes can improve sustainability, water use and energy efficiency as well as minimize environmental impact while maintaining or reducing operating costs. Implementing water conservation, energy-efficient and environmentally friendly processes and technologies should be embraced as a priority at the component, process and system levels.

Included in these processes is mission-critical rotating equipment, specifically centrifugal pumps, which represent a significant proportion of the equipment in most industrial manufacturing and processing operations. One of the vital components of a centrifugal pump is the seal around the rotating shaft that passes through a stationary pressure casing or housing. The seal keeps the liquid or gas from escaping to the environment.

Sealing systems are vital in maintaining pump efficiency, reliability, energy consumption, water usage and control of emissions to the environment. These factors can materially facilitate a process plant in achieving total life-cycle cost reduction and sustainability objectives. To achieve these objectives, sealing performance can be improved in most centrifugal pump applications by upgrading from traditional compression packing to mechanical seal technology.

Compression packing

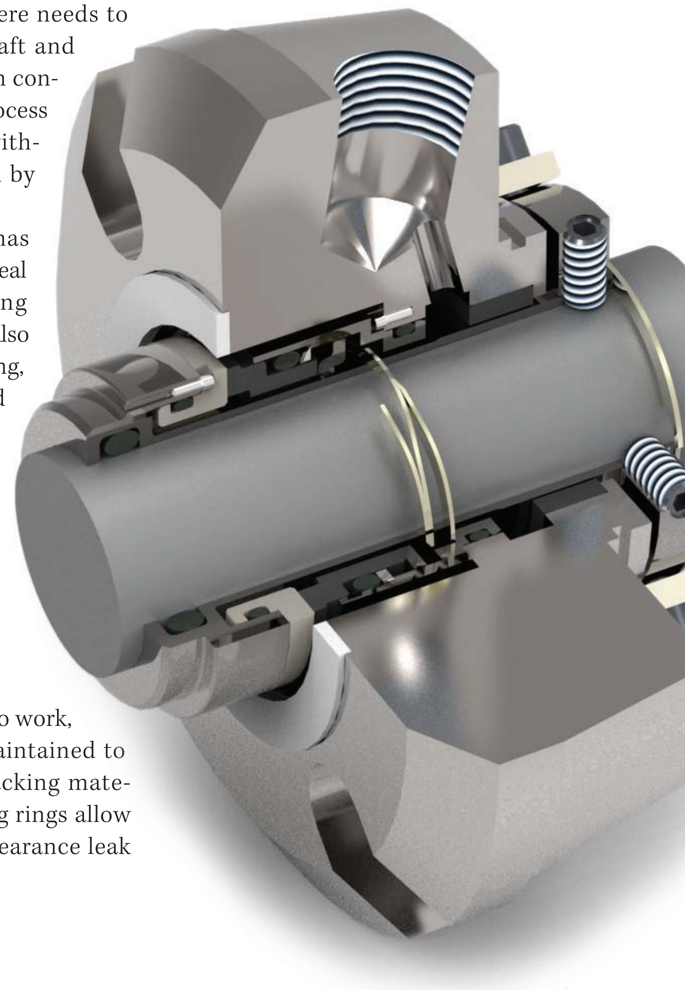
When sealing a centrifugal pump, the objective is to allow the rotating shaft to enter the wet area of the pump without allowing large volumes of pressurized fluid to escape. The discharge pressure of the pump will force fluid back behind the impeller where it attempts to exit by way of the rotating drive shaft. To minimize this leakage, there needs to be a seal between the shaft and the pump housing that can contain the pressure of the process being pumped and can withstand the friction caused by the shaft rotating.

Compression packing has traditionally been used to seal centrifugal pumps, dating back more than 100 years. Also referred to as gland packing, it is a braided, rope-like and lubricated material packed around the shaft in rings — physically stuffing the gap between the shaft and the pump housing — within a stuffing box.

Water leakage & consumption

For compression packing to work, some leakage must be maintained to lubricate and cool the packing material. Therefore, the packing rings allow for an adjustable, close-clearance leak path parallel to the axis of the shaft. But, as the packing ages through use, some of the lubricant that is embedded into the packing is lost, reducing the volume of the packing rings. The pressure that is squeezing the rings together is also reduced, increasing the amount of leakage.

Periodic adjustment of the packing follower will bring the pressure back into specification and control the



Examples of pump packing seal exhibiting excessive leakage to the environment

excess leakage. But increasingly, that maintenance is not always performed at required intervals or adjusted correctly. Because the number of centrifugal pumps that incorporate the use of compression packing has decreased, the training and understanding of packing maintenance has waned.

Consequently, undertightening and overtightening of the packing rings is a prevalent and growing misapplication of centrifugal pump maintenance — with critical consequences to both water consumption and energy draw.

Undertightening results in too much leakage. Already, when properly adjusted, packing leakage can amount to gallons of liquid leaked per minute. This can be aqueous solutions comprised of varied benign or caustic chemical compositions, or it can be particles in suspension or slurry, depending on what is being processed.

The heavier the suspension or slurry content in the liquid being pumped, the more water is needed for packing to work reliably. Typically, a clean external flush is piped into the stuffing box through a lantern ring, which keeps the packing lubricated, cool and flushed of abrasives and chemicals.

Normally, some portion of the leakage is continually released into the atmosphere. Undertightening of the packing rings and use of external flushes increase this atmospheric release proportionately, along with the potential for environmental impact.

Cutaway of a mechanical seal

All graphics courtesy of John Crane Inc.

Friction & parasitic energy draw

Friction is always present in centrifugal pumps with compression packing due to the large surface area of the packing rings in contact with the shaft. Overtightening of the packing rings restricts leakage flow, increases friction between the packing and the shaft and generates excessive heat, which degrades the packing. The increased friction also wears the shaft prematurely.

From an energy-consumption perspective, the additional friction of the packing that is gripping the shaft creates increased drag, requiring more drive power to turn the shaft. The drag creates an additional and significant parasitic energy draw. The importance of this friction-induced energy draw is critical to assessing the energy efficiency of compression packing.

This is not the only factor influencing energy usage with compression packing. When examining the energy draw component of a total life-cycle cost analysis related to the use of compression packing in centrifugal pumps, other factors need to be considered. First, the external flush that is piped into the stuffing box is pressurized water or fluid that needs to be moved from a source location to the packing, which requires a pump that draws electricity. Second, in applications like mining where compression packing is more commonly used, water added — via the packing flush to maintain a clean environment around the packing —

needs to be later removed. The removal of this water requires energy, typically through boiling. Third, the pump heat soak — energy transferred from the hot metal of the pump to the fluid within the packing chamber — also needs to be considered.

These energy draws are not typically measured directly. Instead, current and voltage fluctuations used by the pump motor are assessed under varied operating conditions to determine how much power is consumed by parasitic influences, which enables packing energy deficiencies to be identified.

Mechanical seals

An alternative to compression packing is the mechanical seal, which resolves many of the sustainability and environmental issues inherent in compression packing. Mechanical seals require lower water and energy demand and have substantially reduced leakage, making them more efficient at containing volatile or hazardous fluids, aqueous solutions and slurry suspensions. And, once installed, mechanical seals require no maintenance.

A mechanical seal is comprised of a stationary primary element, which is fixed within the pump housing, and a rotating mating element fixed to the shaft. Precisely machined, these two components are pressed together by a flexible load element, meeting at a wear face, while the extreme tolerance precisions between the two elements minimize leakage. The wear faces are supported on an extremely thin lubricating film, typically 0.25 microns (9.8 microinches) in thickness.

Available in a variety of types, arrangements and materials, mechanical seals are found in the majority of centrifugal pumps today.

Minimized water consumption & leakage

Mechanical seals require very little flush water injected into the seal chamber. Compression packing used in abrasive pumping applications requires significant volumes of water injected into the stuffing box. A mechanical seal in the same service requires only a small fraction of this water volume.

Mechanical seals create an extremely restrictive leak path perpendicular to the axis of the shaft between the two sliding seal faces. This results in almost no leakage to the atmosphere.

Reduced power consumption

The amount of power required to drive a mechanical seal is up to 80 percent less compared to compression packing, primarily because the seal faces have less frictional energy losses due to the extremely precise mating between the stationary and rotating elements. Additional energy reduction results from the reduced need for flush water pumped into the seal.

Dual mechanical seals

Designed to ensure maximum sealing safety, dual mechanical seals are typically defined as a single assembly that contains a pair of seals. A cavity is formed between the two seals within the assembly filled with a barrier or buffer fluid that separates the pumped liquid from the atmosphere and environment.

Dual mechanical seals allow for near-complete control over the seal operating environment and the fluid film lubricating the seal faces. They provide maximum elimination of leakage of the fluid handled in centrifugal pumps.

> "Mechanical seals require lower water and energy demand and have reduced leakage, making them more efficient at containing volatile or hazardous fluids."

Environmental impact

Efforts made toward improving sustainability in manufacturing processes, whether it is by reduced water and energy use or by eliminating the discharge of harmful fluids and gases, provide a benefit to the environment by reducing environmental impact as well as a benefit to manufacturers by reducing operational costs.

Mechanical seals in centrifugal pumps and particularly dual mechanical seals are well-suited to reduce or eliminate volatile or hazardous fluids and their harmful vapors from escaping into the environment. They should be specified as the standard sealing solution, especially when the pumped fluids present a safety, health or environmental hazard. WT

Mark Savage is a product group manager at John Crane Inc., part of Smiths Group. The company designs and manufactures mechanical seals and systems, couplings, filtration systems and predictive digital monitoring technologies. Savage is responsible for the application, design and development of metal bellows seals for pumps, compressors and rotating machinery. He has worked in the sealing industry for 24 years and has been involved with development of best practices for shaft seals and their support systems. Savage has a Bachelor of Engineering (mechanical) from the University of Sydney, Australia. He is a member of the Fluid Sealing Association, vice chair of the mechanical seal division, chair of the mechanical seal technical committee, vice chair of the government relations committee, a member of NACE International and the Society of Tribologists and Lubrication Engineers (STLE). He has authored documents on mechanical seals and support systems and their application to minimize environmental impact. Savage is based in Warwick, Rhode Island. For more information, visit johncrane.com.