Principles, Design and Applications of Mechanical Seals

An Online Continuing Education Course for Engineers

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Principles, Design, and Applications of Mechanical Seals

A. Bhatia, Mechanical Engineer

The process industry spends well over a billion dollars annually in maintenance of rotating equipment and a substantial amount of this expenditure is towards containing leakage and hazardous emissions. For decades, the rotating equipment was sealed with compression gland packing. This is no longer permitted in many industries by current environmental standards, set forth by the federal regulations. With the development and perfection of the mechanical seal, the leakage problem has been fixed to a large extent.

A mechanical seal is a sealing device that separates liquid from the atmosphere. It is widely used in rotating equipment such as pumps, mixers, compressors, blenders, rotary towers, centrifuges, drum filters and other process equipment to prevent leakage between a shaft and the housing.

The performance of the seals is greatly influenced by factors such as fluid pressure, service temperature, nature & characteristics of fluid, impurities, lubricating properties, rotating speed and hazard control measures. There are multitudes of different styles of rotating equipment and many dozens of sealing configurations. Seal design features that are considered are balanced or unbalanced; rotating or stationary seal head; single spring or multiple constructions; pusher or non-pusher secondary seal design; cartridge or non-cartridge; and split or non-split. The standards of modern mechanical seals are widely defined by the American Petroleum Institute, API Standard 682 - Shaft Sealing Systems for Centrifugal and Rotary Pumps.

This course provides a comprehensive overview of different types of mechanical seals and their applications. The course will assist design engineers in the specification and procurement of mechanical seals.

CHAPTER 1

1. Sealing Devices

Most pumps require a sealing device to prevent liquid escaping from where the drive shaft enters the pump casing. There are three common sealing devices:

1. Gland Packing
2. Mechanical Seals
3. Magnetic drives (seal-less pumps)

1.1 Gland Packing

Gland packing is the simplest and still widely used shaft sealing mechanism on many pumps. This packing consists of braided rings of compression material placed behind the impeller to restrict the clearance between the shaft and the pump back head or the "stuffing box." Most standard packing is an abrasion resistant, synthetic fiber material impregnated with PTFE for additional strength and lubrication.

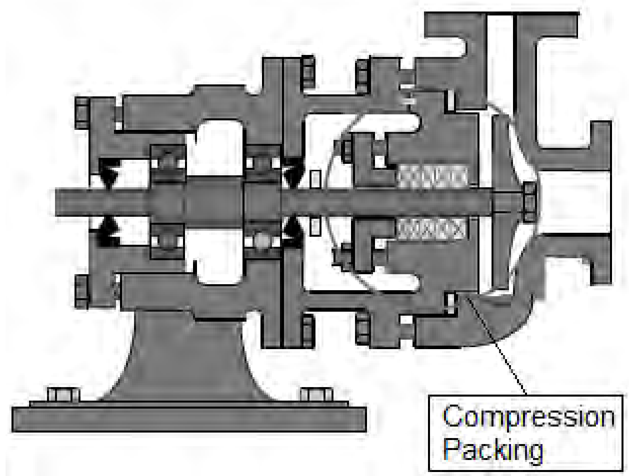
Gland packing is inexpensive but requires regular attention and maintenance. Periodic adjustments must be made to tighten the gland as the packing wears over time. A clean flush is almost always recommended to assist with packing lubrication – especially when pumping solids or abrasives.

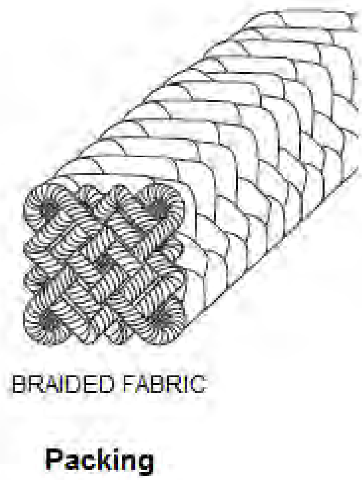
<u>Benefits</u>

- Low upfront cost.
- Excellent for sealing thick, difficult to seal liquids such as chocolate, molasses, asphalt, resins, tar, and some adhesives
- Seldom catastrophically fails, allowing for replacement at scheduled shutdown dates.

<u>Drawbacks</u>

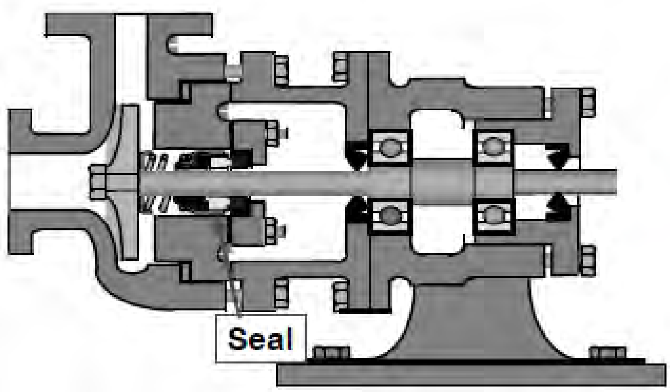
- Consumes 6 times more energy than mechanical seals. (Packing a pump would be like running your automobile with the emergency brake engaged).
- Require some leakage for lubrication and cooling. It is not suitable for use in toxic, flammable, hazardous or polluting fluids.
- Packing should be periodically adjusted when excessive leakage from the stuffing box is noticed.
- Poor seal for thin liquids, especially at higher pressures.
- Can damage the pump shaft if adjusted too tightly.
- Need longer stuffing box, which in turn results in higher shaft deflection.
- Vibrations and misalignment will cause this seal type to leak.
- Short life and need frequent replacement over the life cycle of pump.





1.2 Mechanical Seals

Mechanical seals use two highly polished surfaces (known as ring faces), pressed together axially through a spring mechanism. One face rotates and the other is stationary. An elastomer seals the primary ring to the shaft and an O-ring seals the mating ring in the housing.



Mechanical seals are available in a wide variety of designs and materials for nearly every application. Axial mechanical seals are generally used where pressure and/or surface speeds exceed the capabilities of radial shaft seals. These are used not only in pumps but also in other rotating equipment such as mixers, agitators, compressors, rotary unions, submersible motors, etc.

Other types of axial seals are “non-mechanical” ones, such as V-Rings.

Benefits

- Near zero leakage is possible. Good for toxic and hazardous chemicals.
- Provides longer life. It will not wear out itself or the shaft, or sleeve as fast as the packing rings.
- Lower frictional drag than traditional packing means improved pump efficiency.
- Requires less periodic maintenance than packing.
- Can be applied to higher pressures, temperatures and shaft speeds.

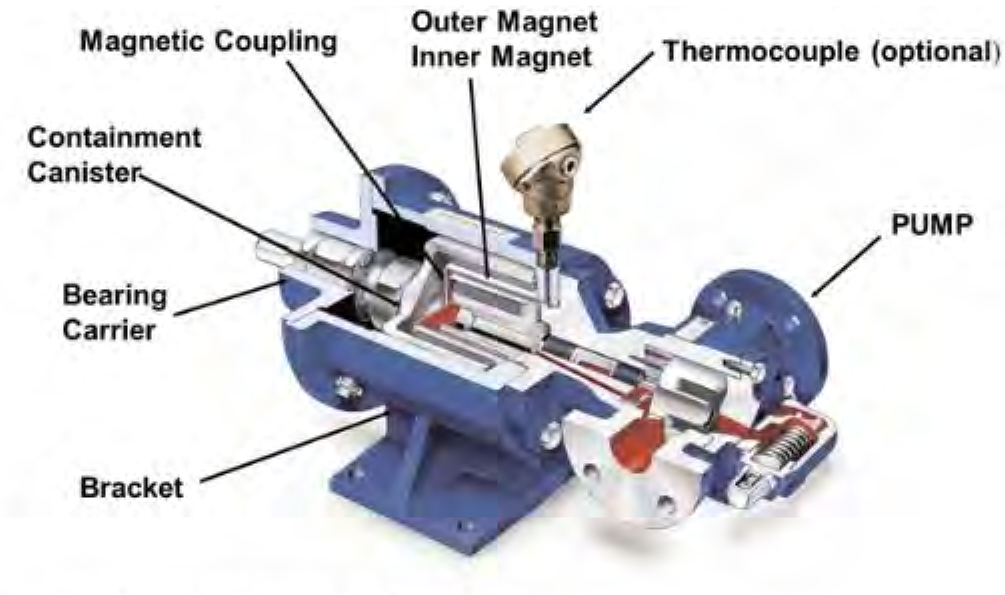
Drawbacks

- Less tolerant to shaft deflection and misalignment.
- Less tolerant to dirty or contaminated liquid. In some cases, will require auxiliary equipment such as cyclone separator to clean the liquid.
- Requires expensive seal piping to flush and quench.
- Costlier than packing rings; however, consume less power and require less maintenance.
- Sealing faces must be finished smooth (0.08 to 0.4 micrometer) and can catastrophically fail.

1.3 Magnetic Drive Seal-less Pump

A Mag Drive pump is a seal-less pump that utilizes a magnetic coupling to create a static shaft seal. Both packing and mechanical seals use dynamic sealing, whether it being a shaft rotating in stationary packing or the seal faces rotating against a stationary face. Magnetically driven (Mag Drive) pumps use no dynamic seals. They have zero leakage and provide the most reliable seal for hazardous or difficult-to-contain liquids. Magnets mounted radially around the pump drive set up a magnetic field. When the drive shaft rotates, the field compels the pump shaft to rotate. The canister wall is not penetrated by either shaft and is statically sealed at its interface with the pump housing.

Magnetic drive pump applications include corrosive liquids such as sodium hydroxide, hazardous liquids such as sulfuric acid, difficult to seal liquids such as isocyanate, and critical sealing applications such as pipeline sampling of oil. However, these certainly are not the only applications, seal-less pumps once made up just a small fraction of the total pump market but are now the fastest growing area across several markets.



Viking® Mag-drive Internal Gear Pump Pump

Benefits

- Mag Drive pumps are a truly seal-less design which ensures zero leakage of liquid or emissions, making them ideal for hazardous, toxic, corrosive, flammable, or expensive liquids.
- Extremely reliable for maximum insurance against seal leakage and maximum seal life

Drawbacks

- More expensive than most shaft seal options.
- Typically limited to about 500°F / 260°C maximum temperature (heat can permanently damage the magnets).

1.4 Comparison between Mechanical Seal and Gland Packing

Parameters	**Mechanical Seal**	**Gland Packing**
Leakage	Extremely small or none	Certain leakage is necessary for lubrication and to avoid seizure
Life	Long with appropriate design and material	Comparatively short
Power consumption	Negligible friction between seal component and shaft / sleeve. Comparatively less power consumption.	High friction due to surface contact. Packing generates …mately six times as …at as a balanced …cal seal.
Applica…		…pplications for …zardous fluids. Not …r vacuum …s.
Cost		…s low. But …t is high.
Spares		…rface contact of …haft / sleeve …ssibility of shaft …ge, resulting …consumption … maintenance
Maintenanc…		…ning …st be …of shaft or …xcessive. …monitoring … of equipment.
Meet API star… requirements		Can't be used where API standards are insisted.