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PUMP CLINIC 15

MECHANICAL SEAL DESIGN, OPERATION AND MAINTENANCE PROBLEMS

"In my seminars I teach that mechanical seals fail prematurely because:

- The lapped faces open
- A seal component becomes damaged

In the following paragraphs we will learn how these failures can be separated into:

- Design problems
- Operation problems
- Maintenance problems

The purpose of this paper is to give you an overview of the subject, and assist you in your troubleshooting function.

MECHANICAL SEAL DESIGN PROBLEMS

Problems with the Seal Faces:

- Wrong carbon or hard face selected. The material is not compatible with the fluid you are sealing, and the cleaner or solvent used to clean or flush the system

Face flatness problems:

- The face cross-section is too narrow causing temperature or pressure distortion problems
- The material modulus of elasticity is too low
- The face is not hard enough
- All clamping forces must be "equal and opposite" to prevent face distortion. In many designs they are not
- The differential expansion between the seal face and its holder can cause the face to go out of flat
- The faces were not lapped at a cryogenic temperature and the seal is being specified for cryogenic service
- Bad packaging

Poor heat conductivity

- Carbon is a poor conductor of heat compared to most hard faces
- Many ceramics are not good conductors of heat
- Plated or coated faces can "heat check" due to a differential expansion rate between the coating and the base material
- The seal face is sometimes insulated by a gasket or elastomer
- Low expansion steel face holders are not usually corrosion resistant
- No vibration damping has been provided to prevent "slip stick" vibration problems. This is a major problem with metal bellows seals
- Unbalanced seal designs require excessive flushing or cooling to remove unwanted heat

- The carbon must be dense enough to prevent entrained air pockets from expanding and causing pits in the carbon face. An "unfilled carbon" with four impregnates is the best

The Springs or bellows:

- Springs in the fluid can clog easily, especially the small springs
- Stainless steel springs and bellows are sensitive to chloride stress corrosion problems
- A single spring can be wound in the wrong direction
- Thin bellows plates and small cross section springs are sensitive to abrasive wear
- Rubber bellows experience a catastrophic failure mode when the bellows ruptures
- Stressed metal corrodes faster. Springs and metal bellows are subjected to high stress
- Too much spring or bellows movement will cause an early fatigue of the metal

The Dynamic Elastomer (the one that moves):

- Some elastomers do not move to a clean surface as the face wears
- Spring loaded elastomers stick to the shaft or sleeve and are sensitive to the shaft diameter and finish
- Elastomers positioned in the seal face are subject to the heat generated between the seal faces
- Dynamic elastomers are very sensitive to the shaft tolerance and finish

Operating conditions too severe for the design:

- Elastomers and some seal faces are sensitive to temperature extremes
- Excessive pressure can distort seal faces causing them to go out of flat
- Excessive pressure can cause elastomer extrusion
- High speed can separate the seal faces in rotating seal designs
- High speed can cause excessive heat at the seal faces
- Excessive shaft movement separates faces also
- Hard vacuum can "out gas" an elastomer causing it to leak

Dual seals:

- Rotating "back to back" designs
- Centrifugal force throws solids into the inner faces
- Inner seal blows open if barrier fluid pressure is lost
- Inner stationary face is not positively retained to prevent movement if the pressure is lost between the faces
- When the outboard seal fails the inboard will fail also due to the pressure drop between the faces
- The inner seal has to move into the sealing fluid as the face wears. This is a major problem if the fluid contains solids
- Failure to use "two way" hydraulic balance causes the inner faces to open with a reversal in barrier fluid pressure

Design problems that cause excessive shaft movement:

- An elbow is installed too close to the pump suction inlet
- The mass of the foundation is not five times the mass of the pump and its driver
- Wrong size pump was specified because of safety factors and, as a result, the pump is operating off the B.E.P

- The pump was selected oversize in anticipation of a future need
- A "centerline" design should have been selected when the operating temperate exceeded 200°F (100°C)
- The shaft L^3/D^4 is too high

The pump is cavitating due to a design problem:

- Too high a N.P.S.H. is required. You need a double suction pump
- The suction specific speed number is too high
- You are using too low a specific speed impeller
- A reducer has been installed up side down, letting an air pocket into the suction
- The impeller to cutwater clearance is too low
- There is too much suction resistance due to excessive piping
- Too much suction lift for the fluid temperature

Other design problems:

- Some seal designs cannot compensate for thermal shaft growth or impeller adjustment. Cartridge versions are needed for this feature
- The pumping fluid is located at the inside diameter of the seal faces
- Solids will be thrown into the lapped faces destroying some face materials
- Solids will pile up in front of the movable faces, preventing them from compensating for wear
- Most seal faces are weak in tension
- Hysteresis (delay) problems caused by the seal mass and sliding elastomers
- Poor packaging that allows face damage during shipment and storage
- Designs that frett (damage or groove) the shaft or sleeve
- High speed requires the use of stationary seal designs. Centrifugal force can open rotating designs above 5000 fpm. (25 m/sec.)
- The seal is positioned too far from the bearing housing
- Lack of a self-aligning feature is causing excessive face movement
- A tapered stuffing box can cause face damage
- No vent has been provided to vent the stuffing box in a vertical application
- Hardened shafts and sleeves can cause the seal set screws to slip
- A discharge recirculation line is aimed at the lapped faces, causing them to wear, and interfering with the seal movement

Problems caused by the product you are sealing:

- The fluid can flash or vaporize between the faces
- Viscous fluids open seal faces as they restrict seal movement
- Products that solidify will open and damage seal faces
- Crystallizing products restrict seal movement and open the faces
- Film building products cause the faces to open. Hot oil is typical
- The fluid can attack one of the seal components, especially the elastomer
- All chemicals have the potential for corroding a seal component. It is just a mater of time

Some fluids are poor lubricants:

- This can cause excessive wear
- Color contamination problems as the carbon wears
- "Slip stick" vibration problems
- Slurries clog up the sliding seal components and open the faces
- Cryogenic fluids can attack some carbon faces and most elastomers
- High temperature fluids attack elastomers and change the state of the fluid you are sealing
- Some fluids can cause the formation of ice outboard the seal, restricting seal movement as the face wears
- Agitation can cause some fluids to change their viscosity
- Cleaners or solvents are attacking a seal component

OPERATION PROBLEMS

Operations that cause excessive shaft movement that will open or damage the seal faces:

- Opening and closing valves in the suction and/or discharge causing the pump to operate off the B.E.P, and the shaft to deflect
- Pumping the supply tank dry, causing excessive vibration and heat
- Series or parallel pump operation can cause shaft deflection
- Running at a critical speed will cause the shaft to defect

Cavitation problems:

- Low N.P.S.H
- Air getting into the system through packing
- A stuffing box, suction recirculation line is heating the incoming fluid
- A discharge bypass line is heating the suction fluid
- A discharge recirculation line is aimed at the seal face restricting its movement
- Water hammer is opening or damaging the lapped faces
- The piping system has been altered since the pump was installed
- The pump is being started with the discharge valve shut or severely throttled
- Starting a pump with the discharge valve open is just as bad

Operations that cause excessive heat and corrosion problems:

- Cleaners or solvents used in the lines can attack a seal component, especially the elastomer
- A product concentration change will affect corrosion
- A change of product
- Either a temperature or pressure change in the system will affect both

Operations that cause the seal faces to open:

- The seal is seeing frequent reversing pressures
- Loss or lack of an environmental control
- Flush not working
- Quench is shut off
- Barrier fluid not circulating

- Loss of heating or cooling
- Heating jacket clogged
- Pressure drop in the stuffing box
- Flushing with a dirty product
- Quenching with shop water leaves solids outboard of the seal that will cause a hang-up as the seal moves forward to compensate for wear
- The quenching steam pressure is too high. It is getting into the bearings

MAINTENANCE PROBLEMS

- The pump and driver are not aligned & emdash; causing excessive seal movement
- Pipe strain
- Thermal growth
- Bad installation techniques that can injure a seal component
- The wrong lubricant was put on the dynamic elastomer
- The impeller clearance was set after the seal installation
- The face is inserted backwards, only one side is lapped
- The seal is set at the wrong installation length
- The sleeve moved when the impeller was tightened to the shaft
- A lubricant was put on the seal face that froze when the product evaporated across the lapped faces
- The rotating assembly is not dynamically balanced
- The shaft is bent
- The sleeve is not concentric to the shaft
- Impeller clearance is not being maintained, causing vibration problems
- The impeller is positioned too close to the cutwater
- The seal has been set screwed to a hardened shaft
- No seal or gasket between the shaft sleeve and the solid shaft. This is a big problem with double ended pumps
- The seal environmental control is not being maintained
- Flushing fluid is being restricted or shut off
- Quenching steam is shut off
- The barrier fluid tank level is too low
- The convection tank is running backwards
- The cooling jacket is restricted due to a calcium build up
- You are running both a discharge recirculation line and a cooling jacket
- Out of tolerance shaft dimensions will restrict seal movement
- The impeller clearance was made without re-adjusting the seal face load
- The shaft sleeve was removed to accommodate a smaller diameter seal. The sleeve was providing corrosion resistance
- A gasket is protruding into the stuffing box restricting the seal movement.“