How Do Plant Pipe Strain Problems Affect My Pumping Systems?

In today's economic climate, it has become increasingly important to reduce processing costs. Premature pump failures can easily lead to thousands of dollars in maintenance and operations losses. Site surveys conducted in numerous process plants across North America have concluded that 70 percent of all pump failures are attributed to some form of misalignment. Detailed failure evaluations performed at specific plant sites have revealed that the cause of more than 80 percent of chronic failures involved pipe strain.

Piping should not impose excessive forces and moments on the pump to which it is connected. Pipe flanges must be brought squarely together before the bolts are installed and tightened. Suction and discharge piping, along with all associated valves, strainers, etc., should be adequately supported and anchored near to and independent of the pump to prevent strain from being transmitted to the pump casing.

It is widely accepted in the pump industry that pipe strain leads to unreliable equipment operation. With such emphasis placed on eliminating bending moments in high-speed centrifugal pumps, it is important to define pipe strain, consider the effects it has on pumping systems and identify methods of eliminating it.

Defining Pipe Strain

Pipe strain is caused by misalignment between the pump suction and discharge flanges and the corresponding pipe flange connections. Unacceptable pipe strain can be defined as any forces from unanchored piping that will cause equipment deformation of more than .002-in.

Free-bolting is one method that can be used to ensure that no bending moments will be transmitted to the pump. This practice involves confirming that all bolts will slide freely through the holes in both the pump flanges and the pipe flanges without exerting force. A common engineering practice is to specify the bolt holes in flanges to be drilled 1/8-in larger than the diameter of the connecting bolts. This practice is consistent with the alignment specification in

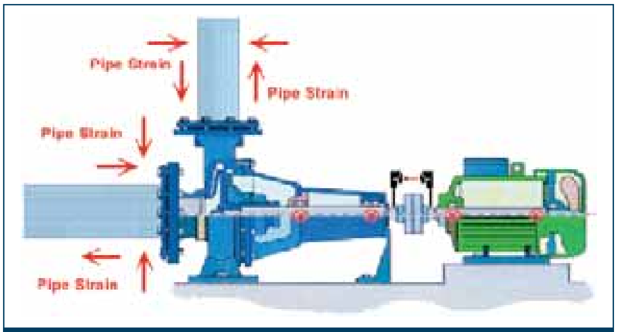

Figure 1. Sources of pipe strain

ANSI/ASME B31.3, which states:

> *"Flanged joints shall be aligned to the design plane within 1/16-in/ft measured across any diameter. Flange bolt holes shall be aligned within 1/8-in maximum offset."*

Effects of Pipe Strain on Pumping Systems

Parallel and angular misalignment of piping flanges at the pump nozzle results in excessive nozzle loads. Excessive nozzle loads create stresses in pump hold-down bolts as well as distortion in pump supports and baseplates. Other than serious unbalance of pump components, there is no single detractor of equipment reliability more significant than poor alignment. Incorrect alignment between pump and driver couplings can cause extreme heat in couplings that leads to hub, keyway and grid failure. Reverse bending fatigue creates excessive loads that can bend, crack or break a pump shaft and excessive radial and thrust loads lead to premature radial and thrust bearing failure.

Forcing piping in place for attachment to the pump suction and discharge flanges can easily create excessive loads in pump nozzles that stress materials and produce bending moments. They distort internal moving parts and affect critical radial clearances. Rubbing caused by radial clearance losses between rotating and stationary elements rapidly damages component parts and requires more power to rotate the pump shaft.

Sealing System

Piping misalignment can also be costly from a leakage standpoint. Impending forces are placed on piping components that will relieve compression on casing gaskets as well as gaskets that seal between the suction and discharge flanges and the corresponding pipe flanges. Damage from piping misalignment can also cause failures of supports, expansion joints and fittings. Eccentricity of the pump shaft to the bore of the stuffing box or seal chamber caused by pipe strain will also impact performance of packing and mechanical seals. This is of utmost importance given the tremendous interest placed on reducing dilution and waste associated with flushing fluid and eliminating costly product leakage to the atmosphere.

Packing

The choice of using packing versus mechanical seals to control leakage is largely based on the end user's process conditions and requirements. If slight leakage can be tolerated, or it is undesirable to pull the pump off-line, then packing may be the preferred choice for sealing the stuffing box. Sealing water-based slurries and water at elevated process temperatures are examples. Packing relies on radially expanding soft flexible materials to control leakage by filling the annulus between the rotating shaft/sleeve and the bore of the stuffing box.

To achieve cost-effective leakage control with packing, it becomes increasingly important to ensure leakage is consistently maintained at allowable rates for the application conditions and the type of packing used. If the pump shaft does not remain concentric with the bore of the stuffing box, the radial gap is compromised, preventing equal compression on the packing. This condition then leads to product dilution, leakage to the atmosphere and dramatically increased process costs.

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. *This month's Sealing Sense was prepared by FSA Member Tommy Seales.* 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 technology issues on rational total Life Cycle Cost (LCC) principles.

The **Compression Packing** and **Mechanical Seal Divisions** are two of six with specific product technology focus. As part of their educational missions they develop publications such as the new joint FSA/ESA *Compression Packing Technical Manual*, the *Pump & the Valve Packing Installation Procedures* pamphlet and the *Mechanical Seal Handbook*. These are intended to complement the more detailed manufacturer's documents produced by the member companies. The latter handbook also served as the basis for joint development of the more comprehensive **Hydraulic Institute** publication: *Mechanical Seals for Pumps: Application Guidelines*. Joint mechanical seal publications also include the *Seal Forum*, a series of case studies in pump performance, as well as the *Life Cycle Cost Estimator*, a web-based software tool for determination of pump sealing system total Life Cycle Costs.

The following members companies sponsor this *Sealing Sense*:

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Mechanical Seals

Investments in mechanical seals are cost justified based on consistent, long-term reliability. Ensuring "leak-free" operation of a mechanical seal at maximum performance levels relies on preventing destructive heat build-up while maintaining compression on secondary seals and providing control of the parallel gap at the primary seal interface.

Radial clearance losses between rotating and stationary seal components created as a result of pipe strain can cause seal components to rub, producing excessive heat and severe mechanical damage. Radial contact between rotating and stationary seal and pump components will also prevent the seal faces from aligning and adjusting for seal face wear, leading to leakage, premature failure and costly replacement. As noted in the March 2008 *Sealing Sense*, the stationary spring design better compensates for pipe strain misalignment than does the rotating design.

Eliminating Pipe Strain

As with any problem, a complete understanding of the root cause(s) will lead to an effective solution(s). Training is one of the most effective methods to ensure that equipment installation problems that create misalignment and pipe strain can be addressed. Care should be taken to provide training program formats that include methods of prevention, understanding and recognition. All maintenance personnel including millwrights, maintenance supervisors and management personnel need to be included in the training process so everyone understands the time required and the importance of installing pumps correctly.

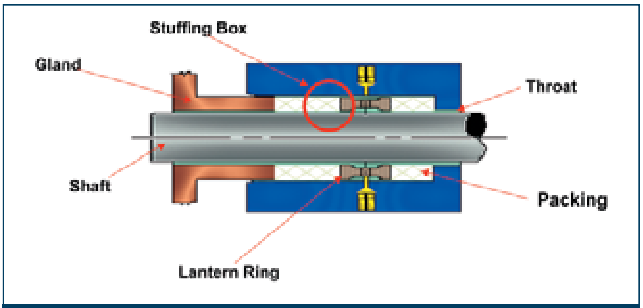

Figure 2. Typical stuffing box

Identification of repeat offenders through performance tracking, coupled with detailed failure analysis of components, will help determine the cause of failure and the corrective action required to fix the problem. In addition, there are a couple of practices that can be considered for positively identifying and correcting pipe strain and equipment misalignment. Vibration analysis provides data that will help identify specific

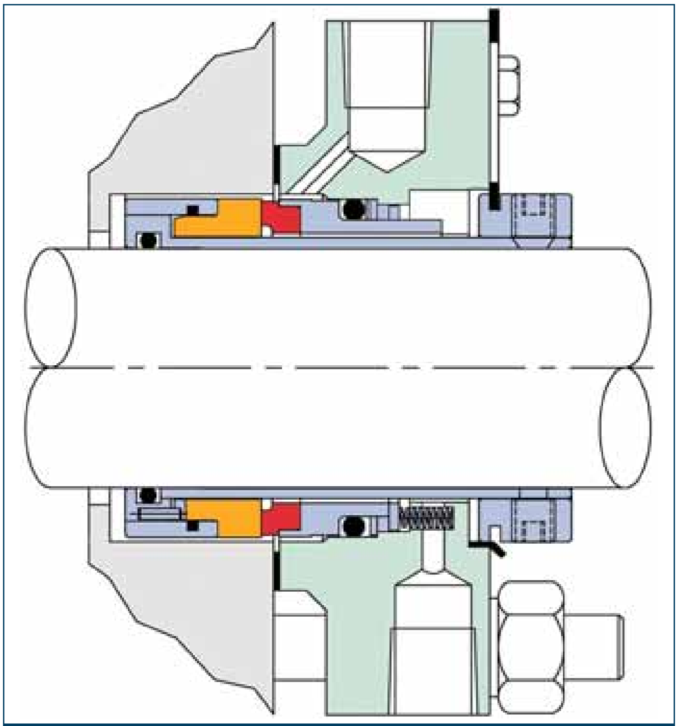

Figure 3. Typical stationary design mechanical seal

installation problems and the severity of the problem. Pipe strain can be measured with shaft laser alignment tools in the same way that *soft foot* can and should be considered an integral tool for precisely aligning pump and driver couplings within .002-in T.I.R.

Conclusion

It is important to understand that pipe strain is one of the leading causes of premature pump failure. Pipe strain can cause "failure" of the packing or mechanical seal since they are both sensitive to misalignments introduced by pipe strain. Pipe strain must be eliminated to extend reliability of pumping systems and prevent costly repairs and downtime from repetitive failures. Elimination of pipe strain should be a critical part of the alignment process during pump installation. This will eliminate one source of pump component failure including that for packing and mechanical seals.

Next Month: *How can the capabilities of primary seal materials be improved?*

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.