How Does Plant Pipe Strain Problems Affect Pumping Systems?

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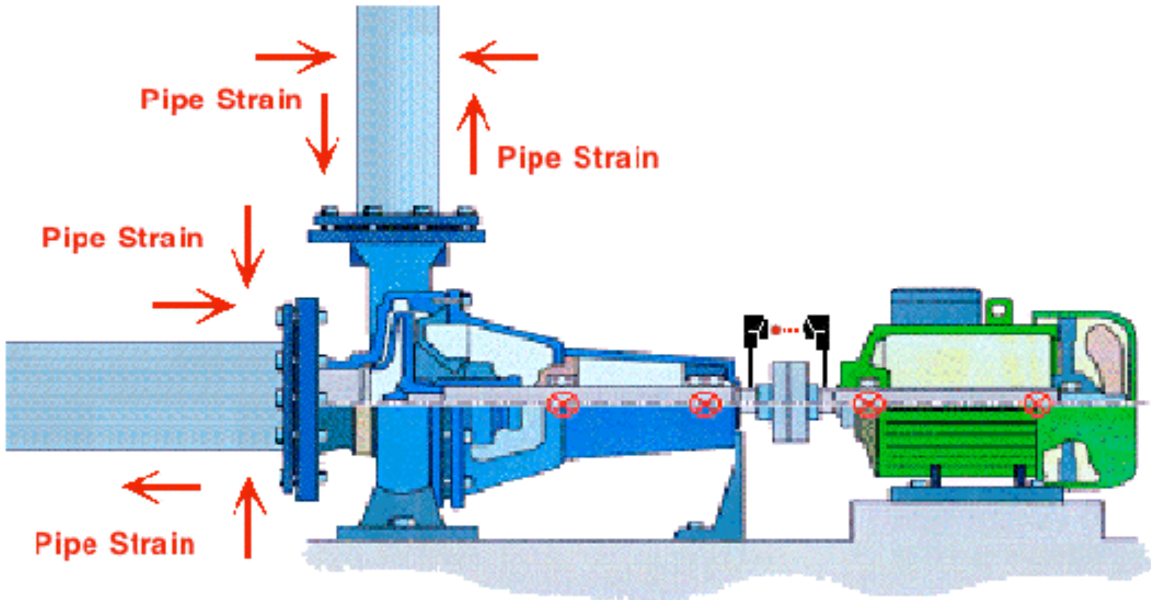
In today's economic climate, it has become increasingly important to reduce processing costs. Premature pump failures can easily lead to thousands of dollars in maintenance and operations losses if left unsolved. Site surveys conducted in numerous process plants across North America have concluded that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

Piping should not impose excessive forces and moments on the pump to which it is connected. Piping 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 is unacceptable if reliable equipment operation is to be expected. With such important emphasis that should be placed on eliminating bending moments in high-speed centrifugal pumps it becomes necessary 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 to the corresponding pipe flange connections. Unacceptable pipe strain can be defined as any forces from piping that when not anchored will cause equipment deformation of more than .002".



“Free-bolting” is one method that can be used to insure that no bending movents will be transmitted to the pump. This practice involves insuring that all bolts will slide through the holes in both the pump flanges and the pipe flanges without having to exert force. A common engineering practice is to specify the bolt holes in flanges to be drilled 1/8” larger than the diameter of the connecting bolts. This lends credibility to the alignment specifications of ANSI 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” maximum offset”.

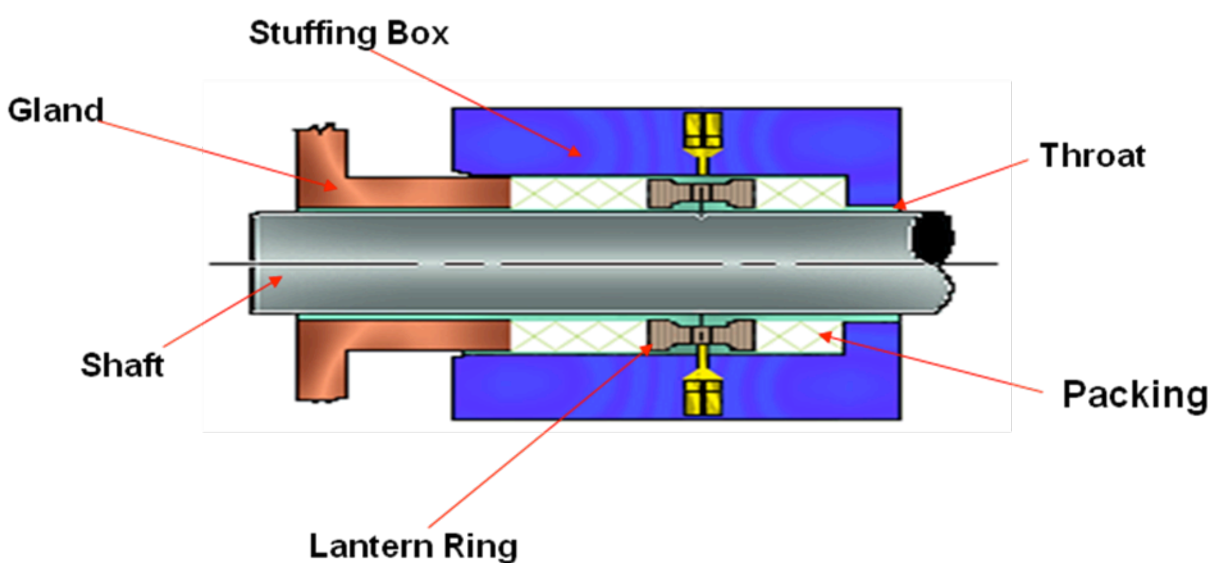
Effects of Pipe Strain on Pumping Systems

Parallel and angular misalignment of piping flanges at the pump nozzle results in component failures that lead to poor equipment reliability, costly repairs, and increased downtime. Excessive nozzle loads create stresses in pump hold-down bolts as well as distortion in pump supports and base plates resulting in severe alignment problems. Other than serious unbalance of pump components, there is no single contributor of deficient equipment reliability more significant than poor alignment. Incorrect alignment between pump and driver couplings can cause extreme heat in couplings that lead 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 load in pump nozzles stressing materials and producing bending moments that distort internal moving parts affecting critical radial clearances. Rubbing caused by radial clearance losses between rotating and stationary elements rapidly damages component parts and requires more electricity to rotate the pump shaft.

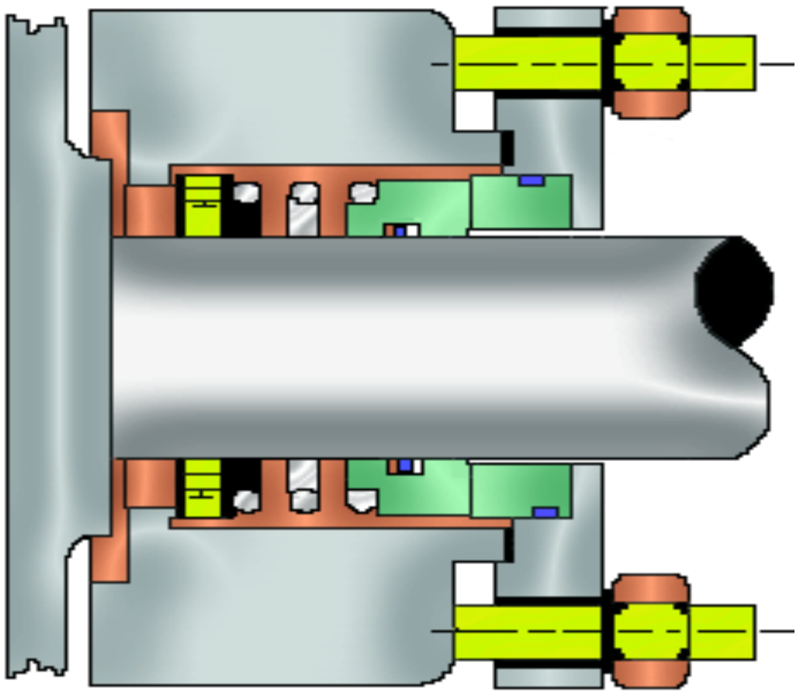
Piping misalignment can also be very costly from a leakage standpoint. Impending forces are placed on piping components that will relieve compression on casing gaskets as well as gaskets that seal between the suction and discharge flanges and the corresponding piping flanges. Damage from piping misalignment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

The choice of using packing versus mechanical seals to control leakage is largely based on end users process conditions and requirements. If slight leakage can be tolerated, water-based slurries and water at elevated process temperatures are being sealed or if it is undesirable to pull the pump off-line, then packing may be the preferred choice for sealing the stuffing box. Packing relies on radially expanding soft flexible materials to control leakage by filling the radial gap between the rotating shaft/sleeve and the bore of the stuffing box. In order to achieve cost-effective leakage control with packing it becomes increasingly important to insure leakage is consistently maintained at allowable leakage rates established by the application conditions and the type of packing being used. If the pump shaft runs out of concentricity to the bore of the stuffing box and the radial gap is compromised preventing equal compression on the packing, product dilution, leakage to the atmosphere, and process costs will increase dramatically.

Packed stuffing box compared with a mechanically sealed seal cavity:



Typical Cross-Section of a Packed Stuffing Box



Mechanically Sealed Seal Cavity

Investments in mechanical seals are cost justified based on consistent, long-term reliability. Producing a leak-free situation with a mechanical seal that reaches maximum performance levels relies on the ability to reduce destructive heat while providing conditions that will maintain compression on secondary seals while adequately providing control of the parallel sealing gap required to affect a seal at the primary seal interface area. Radial clearance losses created between rotating and stationary seal components as a result of pipe strain causes 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 adequately aligning and adjusting for seal face wear causing subsequent leakage resulting in premature failure and costly replacement.

Eliminating Pipe Strain

With any good solution a complete understanding of the cause of a problem along with effective solutions for eliminating the problem need to be identified. Training is one of the most effective methods for addressing equipment installation problems that create misalignment and pipe strain. Care should be taken to insure training program formats include methods of understanding, prevention, and recognition. All maintenance personnel including millwrights, maintenance supervisors, and management personnel need to be included in the training process to insure everyone understands the time required and the importance of installing pumps correctly.

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

In conclusion, it is important to understand that pipe strain is one of the leading causes of premature pump failure. Although it is best to address at the time a new pump is installed, pipe strain must be eliminated to extend reliability of pumping systems that is required to reduce cost and downtime from repetitive failures.

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