13 Common Factors that Affect Pump Life

Common Pumping Mistakes, by Jim Elsey. Extraido revista Upstream Pumping

End users frequently ask me, “How long will the pump operate?” Of course, my answer is, “It depends.”

As an engineer for a large pump manufacturer in the late 1970s, I was troubleshooting a pump issue at a Midwest power plant, where a broken cast steel piece required replacement. The user was upset because the part was not covered under warranty.

With the exception of a few overhauls for wear rings and bearings every 10 years, the pump had been operating 24/7 for more than 45 years. The pump was designed to operate for a long time, and the user operated and maintained the pump in a manner that resulted in a half-century of trouble-free operation.

In the overall equation for reliable pump life expectancy, almost every factor is dependent on the end user—specifically, how the pump is operated and maintained. As an example, a standard L-frame American National Standards Institute (ANSI) pump can be expected to operate for 15 to 20 years—and in many cases longer than 25 years—if it is properly maintained and operated near the best/design operating point. A high-horsepower multistage diffusor pump in boiler feed service can be expected to deliver 40 years of service or more.

For a given pump design, what are some of the factors that end users can control to prolong a pump’s life?

While this is not an exhaustive list, the following 13 notable factors are important considerations for extending pump life.

1. Radial Force

Industry statistics indicate that the biggest reason centrifugal pumps are pulled from service is the failure of bearings and/or mechanical seals. The bearings and seals are the "canaries in the coal mine"—they are the early indicators of pump health and the harbingers of what is happening inside the pumping system.
Anybody who has been around the industry very long probably knows that the No. 1 best practice is to operate the pump at or near its best efficiency point (BEP). At the BEP, the pump by design will experience the lowest amount of radial force. The resultant force vectors of all the radial forces initiated from operating away from the BEP manifest at 90-degree angles to the rotor and will attempt to deflect and bend the shaft.

High radial force and the consequential shaft deflection are a killer of mechanical seals and a contributing factor to bearing life reduction. If high enough, the radial force can cause the shaft to deflect, or bend. If you stop the pump and measure the runout on the shaft, nothing would appear to be wrong because it is a dynamic condition, not a static one.

A bent shaft (deflecting) operating at 3,600 revolutions per minute (rpm) will deflect twice per one revolution, so it is actually bending 7,200 times per minute. This high-cycle deflection makes it difficult for the seal surfaces to stay in contact and maintain the fluid layer required for proper seal operation.

2. Oil Contamination

For ball bearings, more than 85 percent of bearing failures result from the ingress of contamination, either as dirt and foreign material or as water. Just 250 parts per million (ppm) of water will reduce bearing life by a factor of four.

Oil service life is critical. Operating a pump can be similar to operating a car continuously at 60 miles per hour. At 24 hours per day, seven days a week, it does not take long to put some miles on the odometer—1,440 miles per day, 10,080 miles per week, 524,160 miles per year.

For more information on lubrication issues, refer to my columns on lubrication in the April (read it here) and June (read it here) 2015 issues of *Pumps & Systems*.

3. Suction Pressure

Other key factors for bearing life are suction pressure, driver alignment and, to some degree, pipe strain.

For a single-stage horizontal overhung process pump such as an ANSI B 73.1 model, the resultant axial force on the rotor is toward the suction, so a counteracting suction pressure—to some degree and with limits—will actually reduce the axial force, which decreases the thrust bearing loads, contributing to longer life. For example, a standard S-frame ANSI pump with a suction pressure of 10 pounds per square inch gauge (psig) can typically expect a bearing life of six to seven years, but at a suction of 200 psig, the expected bearing life will improve to more than 50 years.

4. Driver Alignment

Misalignment of the pump and the driver overloads the radial bearings. Radial bearing life is an exponential factor when calculated with the amount of misalignment. For example, with a small misalignment of just 0.060 inches, end users can expect some sort of bearing or coupling issues at three to five months of operation; at 0.001 inches of misalignment, however, the same pump will likely operate for more than 90 months.

5. Pipe Strain

Pipe strain is caused by misalignment of the suction and/or discharge pipe to the pump flanges. Even in robust pump designs, the resultant pipe strain can easily transmit these potentially high forces to the bearings and their respective housing fits. The force (strain) causes the bearing fit to be out of round and/or incongruent with the other bearings so that the centerlines are in different planes.

6. Fluid Properties

Fluid properties (the fluid's personality) such as pH, viscosity and specific gravity are key factors. If the fluid is acidic or caustic, the pump wetted parts such as the casing and impeller materials need to hold up in service. The amount of solids present in the fluid and their size, shape and abrasive qualities will all be factors.

7. Service

The severity of the service is another major factor: How often will the pump be started during a given time?

I have witnessed pumps that are started and stopped every few seconds. Pumps in these services wear out at an exponentially higher rate than pumps that operate continuously under the same conditions. In these cases, the system design is in dire need of change.

Pumps with a flooded suction will operate more reliably than a pump in a suction lift scenario at the same conditions. The lift condition requires more work and offers more opportunities for air ingestion or worse—running dry. See my *Pumps & Systems* articles on submergence (April 2016, read it here) and self-primer problems (September 2015, read it here).

8. $NPSH_{A/R}$ Margin

The higher the margin of net positive suction head available ($NPSH_A$) is over net positive suction head required ($NPSH_R$), the less likely the pump will cavitate. Cavitation will create damage to the pump impeller, and resultant vibrations will affect the seals and bearings.

9. Pump Speed

The speed at which the pump operates is another key factor. For instance, a 3550 rpm pump will wear out faster than a 1,750-rpm pump by a factor of 4-to-8.

10. Impeller Balance

An unbalanced impeller on an overhung pump or on some vertical designs can cause a condition known as shaft whip, which deflects the shaft just as a radial force does when the pump operates away from the BEP. Radial deflection and whip can occur at the same time. I always recommend the impeller be balanced at least to International Organization for Standardization (ISO) 1940 grade 6.3 standards. If the impeller is trimmed for any reason, it must be rebalanced.

11. Pipe Geometry

Another important consideration for extending pump life is the pipe geometry, or how the fluid is "loaded" into the pump.

For example, an elbow in the vertical plane at the pump's suction side will induce fewer deleterious effects than one with a horizontal elbow. The impeller is hydraulically loaded more evenly, so the bearings are also loaded evenly.

Suction-side fluid velocity should be kept below 10 feet per second. I recommend keeping velocities below 8 feet per second, and 6 is even better (assuming non-slurry fluids). Laminar flow in lieu of turbulent will affect how the impeller is loaded and change the rotor dynamics.

12. Pump Operating Temperature

Whether hot or cryogenic, the pump operating temperature—and especially the rate of temperature change—will have a large effect on pump life and reliability. The temperature at which a pump operates is important, and the pump needs to be designed to operate there. More important, however, is the rate of temperature change. I recommend (I am conservative) the rate of change to be managed at less than 2 F per minute. Different masses and materials expand and contract at different rates, which can affect clearances and stresses.

13. Casing Penetrations

While not often considered, the reason casing penetrations are an option rather than a standard on ANSI pumps is the number of pump casing penetrations will have some effect on pump life because these sites are prime for the setup of corrosion and stress risers.

Many end users want the casing drilled and tapped for drains, vents, gauge ports or instrumentation. Every time you drill and tap a penetration in the casing, it sets up a stress riser in the material that becomes an origin source for stress cracks and presents a site for corrosion to initiate.