Pump ED 101

Why the Left Can Be Dangerous – A Conservative's Viewpoint

Joe Evans, Ph.D http://www.pumped101.com

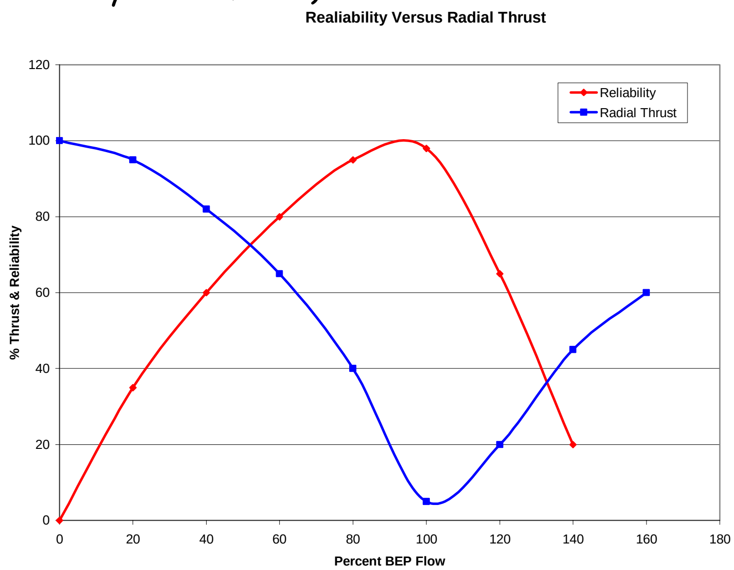
Some of you may question if this is an appropriate topic for a pump magazine. I do admit that I am a staunch conservative but this column is not about the political left. Instead, it addresses a very different left - - the left side of a centrifugal pump's performance curve. When it comes to centrifugal pump politics, I believe that both the far left and far right should be avoided! Personally, I am a card carrying member of the BEP party - - which is a bit to the right of center.

Most pump manufacturers will usually specify how far, on either side of BEP, one of their pumps can be operated without subjecting it to some type of short term damage. Often it will be stated as a percentage (80 – 120% of BEP) but it can take the form of a simple angled line on the right and left side of the performance curve. Their purpose is to insure the proper application of that particular pump. If you ignore these "stop signs" and operate outside the recommended minimum and maximum flows, you run the risk of severely damaging the pump. But, even if you follow their rules, you can still experience long term damage if the operating point is too far to the left.

The damage that can occur due to operation on the left side of the performance curve can arise from several sources. Let's take a quick look at each and then review a real life example.

Mechanical (Radial Forces)

At low flows, the primary forces acting upon an impeller are radial in nature and act perpendicular to the shaft. Although the pressures that develop around the impeller of an end suction, single volute pump are seldom equal, they tend to be relatively uniform at its design point (BEP). At all other points on the capacity curve these pressures are unbalanced and some resultant radial force will act upon the periphery of the impeller. This net radial force increases dramatically as flow decreases and is proportional to the total head, the diameter of the impeller, and the width of the impeller vanes. In other words larger, higher head impellers will see a greater radial force than smaller, low head designs. High head wastewater pumps can be especially vulnerable due to the large vane widths that are needed to pass solid material. Figure 1 shows some API data that compares pump reliability to the level of radial thrust. Radial thrust is lowest at BEP and increases to its maximum at shut off while pump reliability is greatest at BEP and reaches its minimum at shut off. Note that reliability decreases rapidly to the left of the intersection of the two curves (approximately 50% of BEP).



These unbalanced radial forces can result in excessive shaft deflection and, left unchecked, can lead to bearing, mechanical seal, and wear ring damage. In extreme cases deflection can cause the shaft to break. (Note to self: A wear ring is not intended to be a secondary shaft bearing.)

Abrasion

If a liquid contains solids or other abrasives, they should flow through the pump continuously at a relatively high volume. When flow approaches shut off head, internal circulation of these substances can cause increased seal wear and erosion of the volute, impeller, shaft, and wear rings. (Note to self: Sandblast pump only after it is disassembled.)

Thermal

Some pumps, with smaller impellers, can operate at or near shut off head with little or no damage that can be attributed to radial forces. The damage that can occur is often due to the elevated temperature that results from the increased friction between the pumpage and the impeller. If a bypass is not installed on pumps that run at or near shut off head for extended periods, water may well reach its boiling point. If it does, the mechanical seal can lose its source of lubrication and fail. Increased temperature can also have an effect on the corrosiveness of certain liquids (water included) which can result in increased erosion. (Note to self: There are more economical methods of heating water.)

Hydraulic

Even if a pump's shaft is designed to accommodate the higher radial forces that occur during far left operation, it is almost impossible to eliminate recirculation. A very small amount of recirculation from the impeller vane exits back to the suction via the wear ring is typical and usually does not cause problems. As flow is reduced this secondary flow will increase and cavitation can arise. If excessive shaft deflection is also present the result will be increased wear ring wear, and an even greater recirculation flow. Another type of low flow recirculation, known as discharge recirculation, occurs when water changes direction at the vane exit and reenters the vane. This will lead to cavitation that erodes the low pressure side of the vane. Wastewater pumps are especially prone to discharge recirculation due to the lack of vane overlap on most two vane impellers. (Note to self: A reasonable volume of water should exit the volute when the pump is running.)

Lets take a look at a real life example of what can happen when a pump is misapplied and ends up operating well to the left of BEP. A 4" non-clog with an 11.5" impeller has a manufacturer approved minimum flow of 250 GPM. The application specified a flow of 600 GPM @ 125' - - which is about 70% of BEP flow. Unfortunately a design error resulted in a head miscalculation. At start up, a flow meter indicated a flow of just 340 GPM - - or about 40% of BEP. Since the specified flow of 600 GPM would not be needed until build out was complete, the sewer district decided to allow the pump to remain installed. It was pulled approximately 13 months later for inspection.

Figure 2 shows the impeller that was removed from this pump during inspection. The front shroud exhibited severe erosion due to cavitation that arose from excessive recirculation from the vane exits back to the suction. Erosion was also found on the volute wear ring. In addition, severe erosion was found on the inside of the shrouds and the low pressure side of the vanes at the vane exit. This cavitation was due to discharge recirculation. Both forms of recirculation and the resulting cavitation were caused by operation too far to left side of the curve even though the actual flow was above the approved minimum.

Joe Evans is responsible for customer and employee education at PumpTech Inc, a pumps & packaged systems manufacturer & distributor with branches throughout the Pacific Northwest. He can be reached via his website www.PumpEd101.com. If there are topics that you would like to see discussed in future columns, drop him an email.