Pump ED 101

Two Steps To Longer Pump Life – (Part One) The As Built Operating Point

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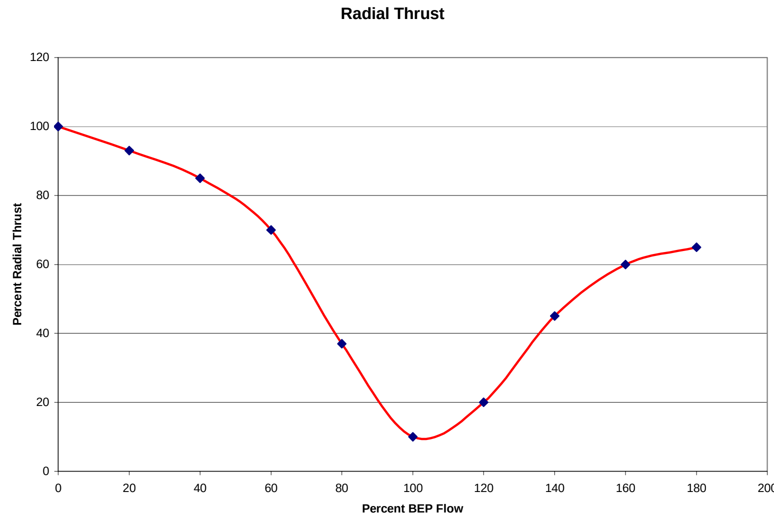
This is the first of a two part column that addresses two of the major causes of premature pump and motor failure. Although it specifically addresses submersible wastewater pumps, it applies to any end suction, single volute pump and all three phase motors.

The overall system in which a pump operates can have a tremendous impact on its life span. The system, which consists of hydraulic, electrical, and mechanical components, has the power to extend or decrease useful life. In one of my seminars, (The Two Most Important Preventive Maintenance Steps), I cover two separate system issues that can lead to premature failure. The first addresses the original system design versus the actual operating point of the pump on its H/Q curve. The second discusses the electrical side and the effect of voltage unbalance on motor life. Both of these issues are dynamic and, even though they may have been in an acceptable operating range at start up, they could be unacceptable today.

Radial Thrust

The intensity of the radial forces that form about the periphery of an impeller, due to uneven volute geometry, is a function of the total head and the width and diameter of the impeller. They are relatively balanced at or near BEP but unbalance can increase quickly as operation moves to the left or right. Higher head wastewater pumps, including smaller 3" & 4" models, can be particularly vulnerable due to the large vane widths that are required for the passage of non deformable solids. This unbalanced radial thrust acts perpendicularly to the shaft and can result in excessive shaft deflection. Increased deflection will reduce mechanical seal, wear ring, and bearing life and, in some cases, it can cause the shaft to break.

Figure 1 plots the percent radial thrust versus percent BEP flow for a typical single volute pump (data source Pump Handbook 2nd Edition). As you can see, unbalanced radial thrust is lowest near BEP and increases to its maximum at shut off. It also rises significantly as flow moves to the right of BEP. Similar plots of pump reliability versus BEP flow show reliability reaching its maximum at BEP and then falling sharply as flow moves to either side. Although other off BEP components such as axial thrust and recirculation can have an effect upon reliability, it turns out that unbalanced radial thrust is the most problematic.



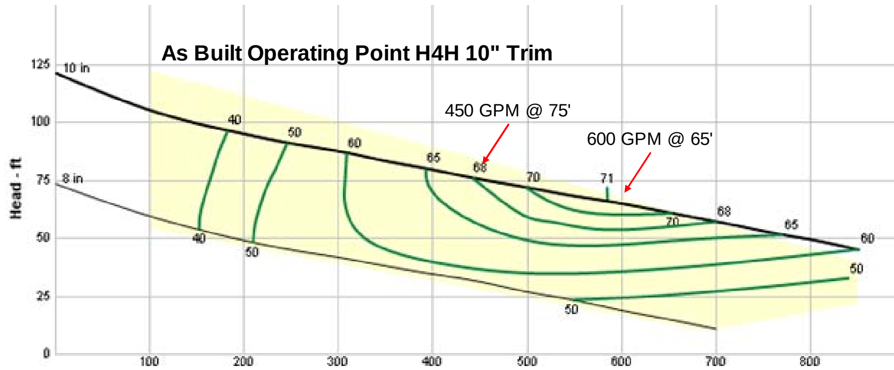
I have mentioned in previous columns that some systems are better designed than others and that "as built" systems do not always mirror the actual design. Often a system is simply over designed for the conditions and sometimes the actual conditions are different than expected. In some cases cost saving measures, taken during construction, can change those conditions. Even systems that adhere to the original design can undergo changes over time. For example the addition of new lift stations to an existing force main will increase system head and may force some pumps to operate well to the left of BEP. Because of these potential system changes it is important that you determine the actual operating point of the pump on its H/Q curve and take corrective action if that point is too far off BEP.

Determining the Point of Operation

In a typical wastewater pump down application, the most accurate way to do this is with a calibrated flow meter. Record the flow rate at the beginning and end of the pump down cycle and you now know the operating range on the H/Q curve. If a flow meter is not available there are two alternative methods that can be pretty accurate as long as you exercise reasonable care.

The first involves recording the time to pump the wet well down one foot from its "pump on" (highest) level. Since there is usually a relatively small flow reduction with one foot of pump down, the calculated average flow will be pretty close to the actual starting flow. To obtain the average flow in GPM, divide the volume per vertical foot by the pump down time in minutes. For example a 10 foot diameter wet well contains approximately 587 gal per vertical foot. If it takes 58 seconds (0.966 min) to pump down the first foot, the average flow is about 600 GPM.

The second uses a high quality pressure gauge to measure the pump operating pressure at the "pump on" (highest) level. Pressure is typically measured outside of the wet well and must be in a section of the discharge piping that is flowing full. To obtain the actual pump pressure, convert the measured pressure to feet and add the vertical distance from the gauge location to the "pump on" water level in the wet well. For example, if the measured pressure is 24 PSI (55 ft) and the distance from the gauge to the water level is 10 feet, the total head is 65 feet.



Once any one of these measurements is obtained it is simple to find that point on the H/Q curve. Figure 2 shows the as built starting point for the examples above. As you can see each of the alternative measurement methods will provide very similar results. The average pumping rate of 600 GPM corresponds very closely with the total head of 65 feet measured at start. The "minimum" ending flow point can be determined by adding the pump down elevation, in feet, to the pump head generated at the starting point. For example, if the pump down is 10 feet, the minimum ending flow for our example is 450 GPM. Since this method does not factor in the reduction in friction, actual ending flow could be slightly higher.

Ideally, pumps should operate in a flow range of 90 – 110% of BEP. In a pump down application we can often stretch that envelope to 70 – 115% of BEP since, by definition, the pump will not operate continuously at some single flow point. The starting and ending flows should always occur within this range. This increased range will not apply to every pump, so it is a good idea to check with the manufacturer for the recommended flow range for a particular model.

Fixes

If starting flow is found to be too far to the right of BEP, fixing the problem is pretty straightforward. For a constant speed pump, trim the impeller to a diameter that will allow an acceptable starting flow. If the pump is operated by a VFD, reducing the maximum allowable operating speed will produce the same results. If the wet well volume will allow a lower "pump on" level, a change of just 2 feet can have a significant impact on flatter pump curves.

It can be more difficult to fix the problem if starting flow is too far to the left of

BEP. The best approach is to try to determine what is causing the problem. If you are really lucky there could be some restriction is the piping system that is fixable. Maybe the impeller was over trimmed based upon expected conditions. If available motor HP is adequate, a larger diameter impeller may be the fix. Increasing the "pump on" level in the wet well may have an acceptable impact on flatter curves. But, if none of the above work and the pump is under sized for the actual conditions you have two choices. Either replace the pump or be prepared for some additional "predictive" maintenance!

Next month we will take a look at the impact of voltage unbalance on motor life.

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