The Benefits of Variable Speed Pumping

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Combining the strength of submersible pumps with the efficiency of variable frequency drives (VFDs) creates a tremendous opportunity for pump users to reduce energy costs, improve performance, and extend equipment life. In this month's SWPA Insight, the team from Mody Pumps shares their collective wisdom on the benefits of variable speed pumping.

When it comes to matching variable frequency drives (VFDs) to pumping applications, how important are drive and pump selection? What are some of the basic keys a submersible pump user should focus on to find the best match?

Variable frequency drives (VFDs) are a commonplace in the submersible pump industry but finding the right drive for your pump can sometimes be a daunting task. A VFD or an adjustable speed drive works on the principle of varying motor input frequency and voltage. In principle, AC power is converted to DC using a converter and this signal is inverted back to AC using pulse width modulation (PWM). Finding the perfect VFD or motor controller for the pumping application can get a little complex because of the number of variables associated with each application and system. The right size VFD will save you money and also make sure that the system is energy efficient. Some of the key factors a user should focus while sizing a VFD are horsepower, Full Load Amps, voltage, RPM and if the motor is inverter duty rated or not.

Knowing the Full Load Amps is perhaps the most critical pieces of information the user needs to gather from the pump manufacturer. Using the FLA rather than horsepower ratings is the proper way to size a VFD. It is important to compare the FLA of the motor with the amp ratings of each VFD you are considering and thus is an area in which being conservative pays off. The user must always size VFDs by allowing an extra cushion with respect to the motor(s) FLA. For example, if the VFD is capable of 250 amps and the motor is rated at 246 amps, choose the next size bigger VFD. Voltage is also an important factor to consider while selecting a VFD. The voltage on the VFD must match the motor(s) voltage on site and this can get a little tricky for a single phase unit. This is primarily because the diode bridge in the VFD is meant to carry current through all three lines. Thus, the rule of thumb for sizing the single phase input on a three-phase drive is to use a VFD rated for 2 times the FLA of the motor. For example, if your motor is a 20 horsepower motor with a FLA of 56 amps, then you would need to select a VFD with an amp rating of 102 amps, which ends up being around 40 horsepower.

Variable speed pumping is a cornerstone of increasing efficiency in pumping applications. For those users just now implementing this technology, how can you best describe the benefits they will see?

The biggest advantage of a VFD is that it matches the amount of work or load on a motor to the amount of energy it needs for that respective load. This makes the system more efficient and also saves the user money by reducing excess energy from being wasted.

When a user implements a VFD in a system benefits are experienced over the life cycle of the pump. On an average 85 percent of a pump's life cycle cost is attributed to its energy consumption and only 15 percent the actual cost of the pump motor. Motors associated with pumps tend to be sized where the pump may to meet peak loads, but not necessarily for normal continuous operation or sized for a duty condition where the pump may no longer be required to operate as result of changes in a given system. In such systems VFDs can have a considerable impact in cost savings. Typically, for every 1 percent reduction in VFD output the user can save 2.7 percent of energy costs. Let us assume that we can operate the motor at 85 percent (51 Hz) of its maximum speed, it is important to note that any reduction pays that reduction cubed. If you cube 85 percent that result be: 0.85 x 0.85 x 0.85 = 0.614. This means the true energy consumption would only be 61.4 percent of total energy consumption. In other words, a 15 percent reduction in speed will result in an approximate 39 percent savings in energy costs. As energy costs continue to rise, it will become more imperative to find ways to cut energy consumption. Variable frequency drives in pumping applications is a key aspect to this effort.

How would you compare the level of control and responsiveness found in a pumping system once a VFD is installed?

The point where the pump curve and the system curve intersect determines the operating point of the system. There are various ways to control the operating point of a pump, one of the most common ways is to control the flow using a throttling valve. This arrangement is very inefficient because it alters the system curve by adding another restriction. VFDs on the hand control the flow with no additional restriction to the piping system, keeping the system curve same. Lowering the speed with a variable frequency drive is synonymous to installing a reduced size impeller on the pump; a new pump curve results.

The level of control and responsiveness of a VFD in comparison to mechanical means of limiting flow is tremendous. A control valve would require time to reposition the plug to change the pressure drop and cause a lag due to the mechanical motion of the valve motor itself. However, using the VFD output the pump will respond within a few cycles of the new frequency to operate at its respective synchronous speed set-point. We know that the flow rate is directly proportional to the rotational speed from pump affinity laws, thus by altering the output frequency of the VFD we can achieve total control of the new pump curve without affecting the system curve. The responsiveness of a pump to the VFD is sometimes so rapid that the speed set-point may need to be ramped to prevent the hammer effect that may occur inside the volute casing. Thus, it is very clear that using a VFD for flow control is more responsive than traditional control valves.

What effect does VFD have on a pump's life-cycle? In what applications do we normally see the most benefits?

Submersible pumps using an electric motor drive are subjected to locked rotor currents at energizing which are 6 to 7 times the full load current values. This is as a result of the high starting torque required to energize the motor from zero speed to the desired speed of operation. Frequent starting and stopping subjects the motor to high mechanical and electrical stresses, shocking damage, stress on the insulation and long term wear on the motor. It is common practice in the industry to limit the number of start/stops per hour to fifteen when the equipment is operated using full voltage starters.

VFDs provide a gradual and smooth ramping up of the motor instead of instant energizing by full voltage starters reducing mechanical and electrical stresses. The maintenance and repair costs drop significantly and the life of the motor and the equipment its coupled to is extended.

The usage of VFDs sees greater benefits in variable torque applications in comparison to constant torque applications. Examples of variable torque loads are centrifugal pumps, fans and other rotating equipment. The submersible wastewater pump falls under this category. When load requirements are less than full speed, a VFD provides means to provide less energy and increase cost savings.

The increased efficiency from VFDs also reduces wear on impellers and other components throughout a pumping system. How does this benefit work and what other savings in maintenance and repairs can pump users expect from incorporating VFDs?

VFDs work on "Affinity Laws" where BHP of the pump is related to the cube of operating speed, with reduction in speed leads to lower resultant pressure on the fluid and hence less consumption of centrifugal energy.

In addition to energy savings, VFDs bring about gradual increase in the rotational speed of the impeller from zero to desired operating speed. This eliminates shock damage caused at the instant of energization when using a full voltage starter. VFDs also facilitate the operation at less than full load which increases the life of the impeller, bearings, seals and other wear components. The wear and tear drops proportionately as the speed of the rotating equipment reduces. This increases the reliability and process performance of the equipment and providing a greater time period between breakdowns and maintenance.

For More Information:

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