PUMP OPERATION WITH VFD CONTROLLED MOTORS

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February 2010 for USCID Newsletter

There are numerous reasons to consider using a VFD (variable frequency drive) controller with pumps in irrigation and drainage. These include:

1. Proper matching of the pump characteristics with the system. Reasonable engineers and salespersons will almost always overdesign pumps. It is very simple – if the pump is too small, there will be complaints. If, on the other hand, the pump delivers a bit more pressure than needed, there is rarely a complaint. Reasons to overdesign include:
    a. Pumps eventually have wear, and the impellers are in effect "trimmed" over time.
    b. Pumps rarely have certified performance. The pumps curves are accurate within some plus/minus accuracy. A designer must err on the side of caution.
    c. The hydraulics of the system are not precisely known. Losses through various fittings can be quite different from theoretical values, and often the as-built system includes valves, fittings, etc. of different models than what were specified. Even good designers typically add a certain pressure loss in their calculations for "miscellaneous".
    d. Source water levels change with time. River levels go up and down. Aquifer depths change from year to year, and throughout the year. There is no one "correct" lift value; the designer must design a pump for the maximum condition.

2. Flow rate requirements may change with time. When the flow rate requirement for a system decreases, the operators must either bypass the extra flow, or dissipate the extra pressure developed by the pump at the lower flow rate. Both situations require more power consumption by the pump than what would ideally be needed. In these cases, a VFD-controlled pump can often save energy during periods of low flow.

3. Precise control of water levels or pressures requires the ability to fine-tune flow rates. VFDs provide that capability. For automatic control of canal water levels, for example, ITRC frequently uses VFD-controlled pumps. Power saving is only a secondary concern in those cases.

4. Minimization of water hammer. The slow start and slow stop capability helps to minimize water hammer when flow begins or ends.

5. Increasing the longevity of well life. Single speed well pumps always start with very high flow rates because the total dynamic head during startup is low. This causes a rapid drawdown within the well casing – exceeding the drawdown rate outside of the well casing. The differential pressure weakens old pipe quickly, and incidentally tends to draw out a lot of sand on startup.

The three biggest problems I have noticed with VFD applications are:

1. The need for excellent air conditioning of the VFD cabinet is not understood or is ignored. Good VFD controllers are very efficient – 98% to 99% efficient. But for a 100 KW panel,

this is equivalent to a 1-2 KW heater operating inside the cabinet. Heat is death on VFD controller electronics.

2. VFD controllers are sometimes undersized. A rule of thumb is to upsize the controller by one size above the motor rating. A motor may be 90 – 94% efficient, and often motors are overloaded. It's simple math – with a 5% overload on a 100 HP motor that's 94% efficient, the VFD controller needs to supply 100 HP/.94/.95 = 112 HP. A 100 HP VFD controller can't do it. Although VFD controllers are rated in terms of volts and amps, think "125 HP controller for a 100 HP motor".

3. Low quality VFD controllers have numerous problems including low efficiency, noise, dirty power quality, and even such simple things as not being able to supply a power cable longer than 10 feet between the controller and the motor.

Another common error is thinking that the affinity laws are easy to use for predicting power savings. The affinity laws for pumps that relate power, head, and flow are only useful for drawing new pump curves at various RPMs. They cannot be used, by themselves, to estimate power savings. To estimate power savings, one must overlay the system curve on the family of pump curves, as seen in Figure 1. Figure 1 illustrates several points about VFD control of pump motors that can be useful to know for automation projects.

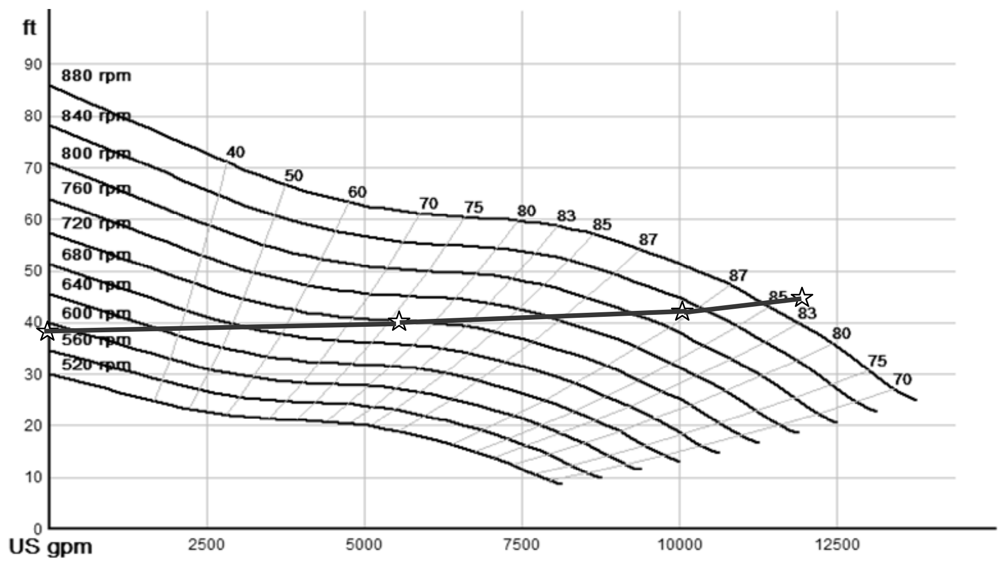

Figure 1. System curve overlain on pump curves of various RPMs. Pump curves were developed in software available from Goulds Pump.

Points from Figure 1 include:

1. Figure 1 illustrates a common irrigation district situation in which there is a static lift from the source to the discharge. In this case, it is about 40'.

2. The RPM at zero flow rate is not zero. Rather, in this case it is about 590 RPM, which is 67% of the maximum (880 RPM) shown on the pump curves. This is important, because the fan that cools the motor should still be effective at 67% speed.

3. The change in GPM per 40 RPM change in speed is quite variable. For control, this means that the required change in pump speed to accomplish a change of flow of, say 200 GPM, is quite different depending upon what the RPM is.
4. The system curve extends past the 880 RPM curve. VFD controllers are capable of operating a motor at higher-than-nominal speed, as well as at a lower-than-nominal speed. This, of course, requires sufficient sizing of the VFD controller.

For low lift installations that use mixed and axial flow pumps, one must always examine the pump curve all the way to zero GPM. Most pump suppliers will only supply curves that show the upper 50% of the flow range. With a system for which the majority of the pressure requirement is elevation lift rather than friction, there can be problems if the pump curve has a dip. If the pump and system curves do not have one unique point of intersection, the flow rate can suddenly shift and damage the system.