Shippensburg Pump Company, Inc.

BOILER FEED • CONDENSATE • DEAERATOR • VACUUM

One Schwenk Drive
P.O. Box 279
Shippensburg, PA 17257-0279

Phone: 717-532-7321
Fax: 717-532-7704
www.shipcopumps.com

December 22, 2005

Re: Why Variable Frequency Drives (VFD's) are not practical in most ***steam system applications***.

What is a Variable Frequency Drive?

Many electric motor-driven devices operate at full speed even when the loads they are serving are less than their capacity. To match the output of the device to the load, some sort of partial load control is in use for the majority of their life. Examples include fans, conveyors, injection molding machines, air compressors, chillers and pumps, depending on the application.

Many part load control strategies waste energy. The most efficient method of part load control, resulting in minimal wasted energy, is the variable frequency drive (VFD). VFD's accomplish part load control by varying electric motor speed.

Essentially, the cost savings promoted from use of VFD's is achieved by reducing the speed of the motor and thereby consuming less energy. Less energy used translates into a lower electric bill and reduced operating costs. When used for *appropriate* applications, energy savings of 50 percent or more can be achieved.

How VFD's Work?

At the heart of an electric motor are the stator and the rotor. The stator and rotor contain pole pairs wound with copper wire. When a current is applied, a magnetic field is generated and the north/south field rotates through the stationary stator as the rotor spins to catch up to the rotating field. The spinning of the rotor provides the torque necessary to drive a load.

An electric motor turns at a given speed depending on the number of poles in the motor and the frequency of the alternating current applied. The motor speed can be adjusted by changing the frequency of the alternating current.

Nearly all VFD's manufactured today are referred to as pulse width modulation drives. These drives contain electronic circuitry that converts the 60 Hertz line power to direct current, then pulses the output voltage for varying lengths of time to mimic an alternating current at the frequency desired.

Electronic motor drives can be grouped into two categories: AC and DC. A motor drive controls the speed, torque, direction and resulting horsepower of a motor. A DC drive typically controls a shunt wound DC motor, which has separate armature and field circuits. AC drives control AC induction motors, and-like their DC counterparts-control speed, torque, and horsepower.

Applications Not Appropriate For VFD's or With Little Energy Saving Potential:

There are number of applications where VFD's offer little energy savings. For example, in some cases a VFD is used to provide a soft start for an electric motor to help prevent equipment damage. Although use of a VFD in this situation will limit a momentary inrush current associated with bringing a motor to full speed almost instantly, there is negligible energy savings and demand savings unless the motor continues to operate at a lower speed during typical operation.

The principle of varying the motor rotational speed has developed into a myriad of complex functions and features that can be confusing and lead people to apply VFD's in applications not suited to varying output. One area where this is true is **steam system applications**.

There are several features of a steam system that make use of VFD's impractical or inappropriate:

- First, a steam system is designed to run at a **constant pressure**. If the operating pressure of the boiler were varied, then the steam traps, steam regulators, and other equipment would need to be resized for different pressures. The time and expense of resizing and replacing would not be practical.
- Second, if an **impeller of a centrifugal pump is trimmed to the design operating** conditions by the manufacturer, the savings from reduced motor horsepower is minimal or non-existent. The savings, cited by VFD proponents, are realized when the pumps used are from manufacturers that do not trim their impellers. The pumps therefore are oversized relative to the design conditions and therefore use excessive energy — *BIGGER IS NOT BETTER IN THIS CASE.*
- Third, on applications using centrifugal pumps, the **required motor horsepower can be lowered simply by balancing (i.e., throttling or choking down) the pump.** Balancing the pump must done either manually by choking the flow rate or automatically by installing an "automatic flow" control valve in the discharge piping without the expense of VFD's. Reducing the flow rate has the additional advantage of lowering the Required Net Positive Suction Head of the pump that prevents pump cavitations.
- Fourth, **condensate units are *ON/OFF applications* where use of VFD's is not applicable. Likewise, VFD's would not be appropriate for ON/OFF boiler feed applications.**
- Fifth, the most common potential application for VFD's in steam applications is on boiler feed and deaerator applications with *continuously running, large horsepower pumps*. **However, these applications typically have a modulating valve in the discharge piping** (i.e., between the pump and boiler) that is controlled by a level control on the boiler. As the water level in the boiler modulates, the boiler level control valve regulates the pump flow rate of the boiler feed pumps thereby automatically adjusting the motor horsepower of the boiler feed pumps. Therefore, less motor horsepower is required at lower flow rates. Finally, on **continuously running boiler feed applications with fractional or small horsepower motors, the** potential savings with a VFD would be negligible relative to the cost of installing VFD's.
- Sixth, for both condensate and boiler feed applications, the **design discharge pressure must be maintained** to ensure the water gets to its intended location**.**

Based on the above factors and our experience, it is our opinion that the best approach for saving money and energy on pump operation in steam applications is to select and size the most appropriate centrifugal pump for the design conditions.

Common VFD Applications:

Due to the decline in costs and the potential for energy savings, VFD's *can be* cost effective in many applications that involve *circulating air and fluids.* The savings potential for these devices is the largest since the theoretical input power varies with the cube of fan/pump speed and volume.

For example, a fan operating at half speed will require only about 13 percent of full speed power. Losses in the variable frequency drive will reduce savings somewhat, but the savings are substantial.

Air and water flow control is accomplished by several methods, including:

- recirculating a portion of the flow,
- throttling,
- variable inlet vanes, and
- variable frequency drives.

Recirculating part of the flow results in the fan or pump operating at full volume all the time. Only a portion of the flow is used for the system or process and the rest is recirculated back to the inlet of the fan or pump. This is the least efficient means of controlling flow.

Throttling essentially chokes the outlet of the pump or fan to decrease flow much like holding your thumb over the end of a garden hose. The pressure increases and the flow decreases. This results in some energy savings over a constant volume recirculating system but is still wasteful.

Variable inlet vanes apply only to fans and compressors, not pumps. Inlet vanes control flow by pre-spinning the air entering a fan wheel or compressor impeller in the direction of rotation, which effectively varies its capacity.

Variable frequency drives can also be applied to what are called constant torque loads. Unlike the fan and pump power which varies with the cube of speed, constant torque applications vary power in direct proportion to speed. This results in lower savings for a given reduction in speed but there are still significant savings available in some applications.

Examples of constant torque systems include conveyors and hydraulically driven injection molding machines. Positive displacement pumps and compressors are also constant torque machines. VFD's provide the most efficient partial load control of rotary screw air compressors, and are gaining market share in the industry.

Variable air volume systems. Variable air volume systems should always have a VFD installed to control volume. A VFD serving a variable air volume system and operating for a typical 3,000 hours per year will pay for itself in two to five years for a return on investment of roughly 20-50 percent. VFD's on larger motors will offer a higher return on investment.

For “custom” applications associated with process fans or pumps, almost any scenario where the flow is being reduced to 90 percent or less of full volume for 4,000 hours per year or more is a good candidate for a VFD. VFD’s installed to reduce flow significantly can easily pay for themselves in under a year for a return on investment of over 100 percent.

Circulating pumps for hot water heating systems. Circulating pumps for hot water heating systems are a good application for VFD’s, provided the hot water temperature is not reset according to building heating loads or outdoor air temperature.

Hot water temperature reset is an automatic lowering of water temperature when the heating loads on the building decrease. When this happens more flow is required to meet the heating demands of the zones in the building. This keeps the required flow higher, which reduces VFD savings. It should be noted though that disabling hot water temperature reset is not advised to achieve pumping savings. Hot water reset results in lower heating costs and allows the temperature controls to work considerably better which provides a more comfortable building.

Chilled water circulating pumps. Chilled water circulating pumps provide good opportunity for savings for VFD’s. Although the cooling season in the Midwest is fairly short, in most cases the pumps run continuously, including during light cooling loads outside normal business hours.

When retrofitting an existing system, there is often an added cost for achieving savings for a chilled water pump application. Typical chilled water systems have three-way control valves at the cooling coils that maintain a constant flow through the pump and chiller. To achieve variable flow savings, the valves will need to be converted to two-way valves so that reduced pumping volume can result during periods of low cooling loads. Additionally, a primary/secondary-chilled water system may have to be established to maintain the required minimum flow through the chiller. Check with the chiller manufacturer.

Geothermal heat pump systems. Almost without exception, VFD’s should be installed on circulating loop pumps for geothermal heat pump systems. The long hours of annual operation, particularly at low heating and cooling loads, provide lots of savings potential even for small pumps less than five horsepower.

Injection-molding equipment. Retrofitting a variable speed drive on hydraulic plastics injection-molding machine requires a controls package that is customized for the application.

Savings are typically in the 33-50 percent range, which over the typical long operating hours of injection molders can quickly generate savings for a high rate of return.

Cooling towers. Cooling towers can be a good application for VFD's. The savings for cooling towers are generated by operating the fan(s) at lower speeds for longer periods of time as opposed to cycling the fans on and off at full speed. This reduces the energy consumption and in some periods may reduce billed demand.

Some chilled water applications that use a cooling tower may have condenser water temperature reset where the condenser water temperature is lowered during periods of low wet bulb temperature (or dew point). This saves chiller energy and although the tower fan will have to run faster to achieve lower condenser water temperature, the chiller savings more than offset the extra tower fan energy.

Shipco® Recommendations:

Shipco recommends use of VFDs' on it products under the following circumstances:

- On On/Off applications, we suggest soft starters or VFD's when motors are 30 HP or higher.
- On Continuous Run applications when motor are 100 HP or higher.

References:

1) D. Polka. "What is a Variable Frequency Drive?", Training Notes, www.joliettech.com, pp 1-4.
2) "Energy Expertise: Energy Efficiency - Variable Frequency Drives", Alliant Energy, www.alliantenergy.com, pp1-4.
3) "Installation, Operation and Maintenance Information: Model D Pumps", Shippensburg Pump Company.

Revised 8/8/06