



Variable Frequency Drive Application Surveys

Why use VFDs?

Increased process efficiency and reduced production costs are the ultimate goals of process optimization. High process variability compromises the economic performance through off-quality product, higher raw material costs, and reduced efficiency. Variability reduction programs have been credited with improving operating efficiency by 2 to 10%. One important source of variability is the control loop itself. Numerous studies have concluded that control loops increase process variability in over 50% of all loops. Poor control valve performance is the single biggest source of controller-induced variability.

Energy is an important production cost. Motor energy consumption in a typical paper machine is approximately \$15/tonne (3% of all operating costs). Pumping systems account for 35% of all motor energy use (approximately 1% of all operating costs). A recent study concluded that the average pumping efficiency is *less than 40%*. There is much room for improving energy efficiency in pumping systems.

Variable Frequency Drive (VFD's) technology has matured and presents an attractive optimization option. VFDs not only provide energy savings but the potential for vastly improved control performance and lower process variability.

Current Design Practise

In a conventional flow control loop, the control valve is throttled to regulate the process variable to target. The fixed speed centrifugal pump adds pressure energy to the fluid, according to the pump Head vs Flow performance curve. The control valve provides a variable restriction to flow, absorbing any excess energy added by the pump.

A high percentage of centrifugal pumps are oversized. This is due to anticipated production increases and generous allowances for unknowns such as pipeline fouling and scaling. The result is that the pump adds too much energy to the fluid, which is wasted at the control valve. The oversized pump operates far away from its Best Efficiency Point (BEP), increasing both maintenance and energy costs.

The majority of control valves are also oversized. Unknowns such as pump performance, pipe-line fouling, and future production rate increases all bias towards over-sizing. The majority of control valves operate at less than 50% open.

Impact of over-sizing on control performance/variability

The tendency to oversize results in a high-pressure drop across the control valve, with the valve operating at a relatively closed position and over a narrow range. This not only compromises control resolution but results in process dynamics that are highly non-linear over the operating range of the loop. These non-linear dynamics can result in overly sluggish response during some operating conditions and oscillation during other conditions. Process variability is higher due to the magnified impact of valve tracking non-linearities such as backlash and stiction.

Impact of over-sizing on Life Cycle Costs

An over-sized pump will obviously increase energy costs. In addition, the oversized pump operates well below the BEP, where maintenance costs are higher due to increased wear on seal, bearings and shafts. The purchase price of a pump is typically less than 15% of the life cycle cost, which includes the cost to operate and maintain the pump.

What is a VFD

The use of a control valve is analogous to operating an automobiles engine at full speed and using the brake to control speed. Conversely, using a VFD is analogous to operating the car with the brake completely released and the speed of the engine used to control the vehicles speed.

A VFD is a device used to vary the speed of a 3-phase induction motor. It works by adjusting the frequency of the power supply to the motor. The motor speed is directly proportional to the power frequency. The motor speed affects the pump performance according to the affinity laws.

$$Q_2 = Q_1 \left(\frac{N_2}{N_1} \right) \quad H_2 = H_1 \left(\frac{N_2}{N_1} \right)^2 \quad BHP_2 = BHP_1 \left(\frac{N_2}{N_1} \right)^3$$

Advantages of VFDs – Control Performance and Energy Consumption

The principle advantages of VFDs can be summarized as follows:

- Reduced process variability, due to elimination of the control valve and improved control performance. The VFD is faster, more linear and is invulnerable to backlash and stiction.
- Reduced Energy consumption. The pump supplies only enough energy to overcome the system head. The energy wasted across the control valve is eliminated.
- Reduced maintenance costs, since the pump will operate close to the BEP over the entire operating range. Reliability and efficiency are complementary.

Pulp and Paper Applications

There are many good applications for VFDs in the Pulp and Paper industry. The symptoms are easy to identify. Control valves that operate in a relatively throttled position, cavitation at the pump or valve and high pump/valve maintenance costs are indicators of poor controllability, and excessive energy consumption. In the paper machine process area *BW Flow Control, Whitewater Header Pressure Control, and Stock Blending Flow Control* are important process systems where VFDs should be applied. In these systems, the reduction in energy costs is secondary to the benefits that would be realized from reduced process variability.

One reason that this technology is under utilized is the widespread belief that VFDs are unreliable. In fact, since the VFD was first introduced in the early 1980's, performance and reliability have steadily improved. Nowadays, reliability and reduced maintenance requirements are often stated as a *primary benefit*. The cost of VFDs has dropped by an average 5% per year over the last 10 years.

The cost of a VFD becomes particularly easy to justify under some conditions.

1. Valve replacement is necessary due to inadequate performance. The replacement cost may be comparable to the VFD cost.
2. A tightened quality specification requires a reduction in process variability.
3. Production upgrade project requires upgrading of pumps and valves.

HOW CAN PRONAMICS HELP?

ProNamics Control is a pulp and paper process optimization company located in Vancouver, BC. The principals have an in-depth knowledge of pulp and paper processes, control performance requirements, and process variability reduction techniques.

The objectives of the ProNamics VFD applications survey are to identify and quantify opportunities for energy cost savings and process variability reductions. An analytical approach is taken to identifying the best opportunities. The pumping systems are documented and then pre-screened to identify the best candidates for detailed analysis. The pre-screening is based on a process importance rating, size of motor, and secondary screening symptoms such as control valve position, presence of cavitation, by-pass valve position and other factors.

More detailed data is gathered on the pumping systems that survive the pre-screening process. ProNamics data acquisition equipment and portable instrumentation will be used to collect online data where required. The system analysis will include the following:

- Estimating the *actual* pump flow and head and comparing against the *required* flow and head.
- Comparing the pump efficiency with the BEP.
- Estimating the control valve pressure drop to determine wasted HP at the valve
- Calculating the process linearity of the loop over the operating range.
- Measurement of control valve non-linearities such as backlash and stiction to estimate improvement in control resolution.

Finally, a life cycle cost comparison of alternative solutions (impeller trimming, installation of a new pump/motor, and installation of VFD) is prepared to justify the recommendations. The detailed report includes a VFD implementation plan. ProNamics will assist in developing control strategies and controller tuning to ensure that the potential benefits are realized.



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