

PLANT ENGINEERING[®]

December 2003

plantengineering.com

32

Physical analogy for
ac electrical power

38

Maintenance Tips &
Tricks winners

40

Limiting noise from
conveyor rollers

54

Wrenches

58

Compressed air systems

61

Benchmarking
maintenance
effectiveness

Plus:

11

Human Side

23

Management Side

25

Plant Electronics

**Intelligent
pumping**

28

Intelligent variable speed pumping

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Key Concepts

- Optimizing pumping systems improves plant performance.
- Variable speed pumps save energy and reduce maintenance.
- Intelligent pumps automatically adjust to system changes.

In today's business environment, process industries are looking for new strategies to enhance plant performance. An easy and often overlooked means to make a dramatic impact on plant performance is through maximizing pumping system efficiency.

Centrifugal pumps are rarely considered an integral part of the process control architecture. Other than graphical screens to change the on/off status of the pump, there has been little, if any, real-time information on pump or motor performance.

Historically, the fundamental building blocks of process control systems have been sensors and control valves, with little consideration given to the role of pumps (Fig. 1).

Overall plant performance has always been tied to

the proper selection, sizing, and installation of pumping systems. A Finnish Technical Research Center report entitled, "Expert Systems for Diagnosis and Performance of Centrifugal Pumps," revealed that the average pumping efficiency across 20 plants and 1690 pumps studied was less than 40%, with 10% of the pumps operating below 10% efficiency.

Pump oversizing and throttling valves were identified as the two major contributors to this sizeable efficiency loss. Besides hindering overall plant efficiency, poor pump performance results in lower product quality, lost production time, collateral damage to process equipment, and inordinate maintenance costs.

Once a pump is installed, its efficiency is determined predominately by process conditions. The major factors affecting performance include efficiency of the pump and system components, overall system design, efficient pump control, efficient drives, and appropriate maintenance cycles.

To achieve the efficiencies available from mechanical designs, pump manufacturers must work closely with end users and engineers to consider all of these factors when specifying pumps. Pump selection and sizing should be considered in the context of the overall system, not just the efficiency of the individual components.

Improving pumping efficiency

In process industries, the purchase price of a centrifugal pump is often less than 15% of the total cost of ownership. Typically, the life cycle cost (LCC) of a 50-hp pump, including costs to install, operate, maintain, and final disposal, can be more than 20



Fig. 1. Pumps that become a part of process control systems can improve plant operations.

Techniques to lower pump energy consumption

Energy savings method	Savings
Replace throttling valves with speed controls	10-60%
Reduce speed for fixed load	5-40%
Install parallel system for highly variable loads	10-30%
Equalize flows using surge tanks	10-20%
Replace motor with a more efficient model	1-3%
Replace pump with a more efficient model	1-2%

times the initial purchase price.

Centrifugal pumps consume, depending on the industry, between 25% and 60% of electrical motor energy. In general, energy accounts for about 30% of LCC, with maintenance averaging around 20%. In poorly designed systems, maintenance can be more than 40%.

Plant design considerations help identify the best opportunities to improve pumping system efficiency. The following criteria offer the most potential for efficiency improvements:

- Reduced load on the motor through optimum process design
- Best match between component size and load requirement
- Use of speed control instead of throttling or bypass mechanisms.

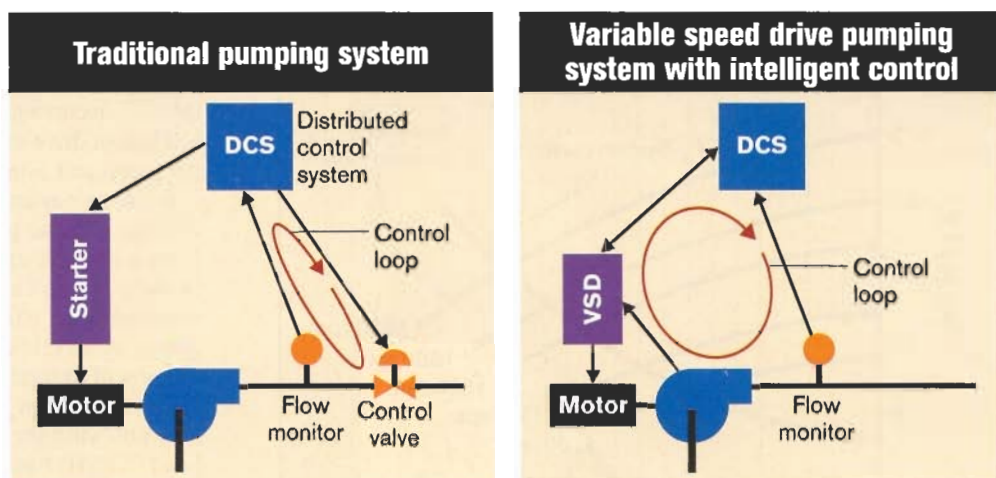
Among all rotating assets in a process plant, centrifugal pumps typically have the best overall potential for electrical energy savings. The excess energy in fixed-speed systems, not used for moving fluid, is often dissipated into the infrastructure and can contribute to lower reliability of instruments, valves, pipes, and the pumps themselves.

In addition to energy cost reduction, a top priority should be to solve and eliminate recurring operating problems experienced by plant production, maintenance, and engineering departments. Typically, the asset group with the highest failure rate is centrifugal pumps, with seal leakage being the fault that causes the highest downtime and maintenance cost. Pumping system optimization helps minimize unscheduled downtime and contributes to productivity improvement.

Intelligent pumps

A good example of pump manufacturers thinking outside the flange to improve pump performance is the emergence of intelligent pumps with variable-speed drives (VSD) and algorithms to monitor and control pump performance. In recent years, automation suppliers have introduced smart sensors and valves (Fig. 2).

A smart pump is the next logical step in the evolution of intelligent field architecture. With the growing use of digital field buses to communicate device data to asset management software, intelligent pumps can now be seamlessly integrated into the process control system architecture, merging process control and asset management into one system for process management.



Pump oversizing causes the pump to run far to the left of its best efficiency point (BEP) on the pump curve. Intelligent drives allow the pump to operate near its BEP and protect the pump from mechanical damage when it moves away from BEP, enhancing mechanical reliability beyond using a standard VSD.

Excessive valve throttling is expensive, contributes to higher energy costs and lower pump reliability, and can impair control loop performance. Employing a throttled control valve less than 50% open on the pump discharge can also prematurely damage valve components and further increase maintenance costs.

Pump oversizing can increase valve friction, slowing valve response. As a result of increased friction and backlash, operators may lose confidence in valve performance and switch the control loop to manual.

VSDs allow pumps to run at slower speeds with trimmed impellers for further contributions to pump reliability and significant improvement in mean-

Fig. 2. Traditional pumping systems control the flow downstream from the pump.

Integrated control and condition monitoring benefits

- Early detection of changes in pump performance
- Savings from reducing pump over-maintenance
- Reduction in scheduled and unscheduled downtime
- Increased throughput and reduced off-spec production
- Higher productivity of plant maintenance and reliability staffs
- Prevention of failure by identifying faults at the component level
- Improved communication between specialists (vibration, oil analysts, operations, maintenance planning, etc)
- Identification of improper operation to allow procedural changes, prevent equipment damage, and increase MTBF

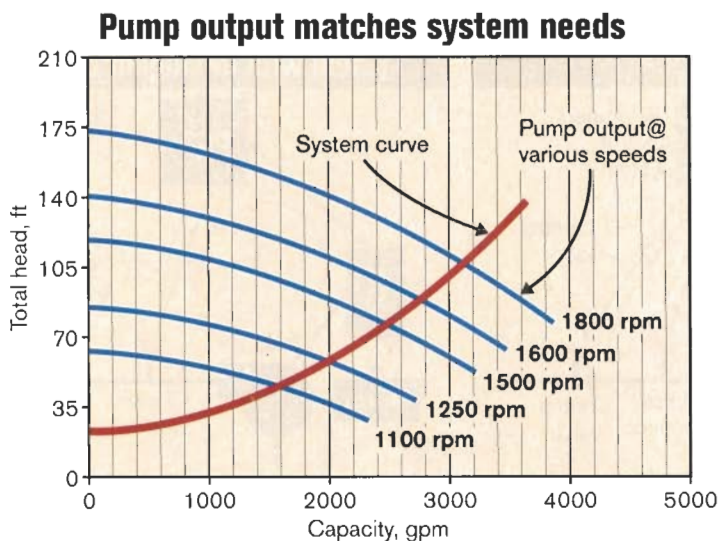


Fig. 3. Intelligent pump controls maintain BEP as system requirements change.

time-between-failure (MTBF). In new applications, variable speed drives are often less expensive to purchase and install than flow control valves and motor starters. Considering total energy and maintenance cost savings, the total LCC of a given pumping system can be significantly reduced.

Intelligent variable-speed drive technology provides the following benefits:

- Automatically adjusts to process changes
- Automatically adjusts to pump system changes
- Protects pumps from system upsets
- Provides online condition monitoring.

Intelligent pumping systems with embedded sensors and controls provide for smoother startups and production changes with tighter control during continuous operation. They also can deliver a fast diagnosis of potential system problems before product quality or process operation is negatively affected.

Intelligence and reliability

Intelligent pumps provide value beyond a traditional VSD. While similar energy savings can be achieved by employing a standard VSD, there is no assurance of decreasing the various failure modes of a centrifugal pump. An intelligent drive utilizes variable speed as a method for delivering enhanced pump reliability.

For example, assume variable speed is being used for flow control. A flow meter provides a process value to either an intelligent drive or standard drive to adjust speed to deliver 100 gpm. Now, assume a control valve is closing on the discharge side. What happens? The standard drive speeds up to compensate for increased resistance. An intelligent drive will do the same.

What happens when the valve closes to a point where 100 gpm cannot be delivered? A standard drive

will continue to run at full speed against a closed valve. How is this better than a fixed speed pump? An intelligent drive can identify that a detrimental condition is occurring and notify the user. In addition, the intelligent drive can intervene to slow down or stop the pump and avoid premature failure.

In another example, the pump is operating in flow control. Assume the suction pressure from the fluid level in the tank starts to decrease to a point that causes the pump to cavitate. If suction pressure drops, a standard VSD will speed up to continue delivering 100 gpm. In this case, increasing speed while cavitating will exacerbate the situation.

The intelligent pump can avoid this problem by first notifying the user that the net positive suction head (NPSH) has decreased to the point that cavitation exists. The intelligence can also decrease pump speed to allow the NPSH to increase to the point that cavitation does not occur, then resume normal operation (Fig. 3).

Both of these scenarios demonstrate that process upsets can cause mechanical faults when utilizing a standard VSD, just as they can similarly occur when operating in fixed speed mode.

In a predictive maintenance environment, tangible information concerning equipment status replaces guesswork, allowing plants to plan and schedule maintenance activities only when there is a change in equipment condition. Plants no longer have to perform maintenance on equipment that has already failed. Maintenance, which was once an art form based on past performance, experience, and intuition, can become a scientific process of fault identification.

Modernization benefits

Process automation is often viewed as the key to competitive advantage. Over the past 25 yr, process automation has dramatically changed the operation of industrial plants. Tighter control of critical processes has reduced cost while producing important productivity and quality gains.

While process automation has produced a wide range of benefits for the process industries, integrating motor-driven pumps into the control architecture has the potential to make quantum leaps in process economics. Yet, available control technologies are not being used to their fullest capacity. In part, this is due to downsizing and, in some cases, complete elimination of corporate and plant process control staffs.

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More Info:

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