Strategies for Optimizing Pump Efficiency and LCC Performance

Process pumps are the largest consumers of energy in a typical pulp and paper mill—boosting their efficiency is a new avenue to reduced plant operating costs.

— BY MIKE PEMBERTON

The rapidly changing business environment is forcing paper companies to change many of their traditional business practices. Globalization of markets, regulatory requirements, and shareholder demands require that manufacturers find new avenues to lower operating costs.

In recent years, paper companies have been increasingly using information technology (IT) to improve productivity in functional areas such as enterprise resource planning and supply chain management. But while mills install the latest IT tools for their business systems, they continue to use aged and inefficient motor systems to operate the production process.

Today, inefficient motor systems are a weak link in process management. More specifically, motor driven pump efficiency can play a critical role in optimizing the production process. Although often overlooked, there are significant opportunities to lower energy, maintenance, and material cost through the use of motor efficient technologies.

Typically, the largest consumers of industrial motor energy are the pumps moving fluid throughout the pulp and paper process. Optimizing system efficiency has the potential to achieve 20% to 50% improvements in energy and maintenance cost, while improving pump and process reliability. In addition to hindering overall operating efficiency, poor pump performance can contribute to lower product quality, lost production time, collateral damage to equipment, and inordinate maintenance costs.

Bigger Is Not Always Better

Overall plant performance has always been tied to the proper selection, sizing, installation, and maintenance of pumping systems. Standard industrial practice has been to oversize the pump to ensure adequate supply during peak demand periods. That practice was acceptable in the past when mills had standing orders for all of their forest based products.

Today, however, it's a different story. Globalization of markets has resulted in high market pulp inventories and excess capacity. Now that the table has turned, oversized pumps should be viewed differently

In 1996, a Finnish Technical Research Center report titled *Expert Systems for Diagnosis and Performance of Centrifugal Pumps* revealed that the average pumping efficiency across 20 plants and 1,690 pumps studied was less than 40%, with 10% of pumps operating below 10%. Pump over-sizing and throttled valves were identified as the two major contributors to this sizeable efficiency loss.

Strategies to Improve Pumping Efficiency

The initial price of a process pump is typically less than 15% of the cost of ownership. The life cycle cost (LCC) of a 50-hp pump, which includes the costs to install, operate, maintain, and decommission the system, is several times the initial purchase price. In general, energy will accounts for about 30% of LCC costs, with maintenance reaching as high as 40%. Over a 20-year period, combined energy and maintenance costs may exceed 10 times the initial pump purchase price. Pump system operating cost can be dramatically reduced through efficiency improvements.

PUMPING SYSTEM PERFORMANCE IS AFFECTED BY SEVERAL FACTORS:

- Efficiency of pump and system components
- Overall system design
- Efficient pump control

- Efficiency of drives
- Appropriate maintenance cycles.

Millwide assessments help qualify and quantify the best opportunities to improve pumping system efficiency.

THE FOLLOWING SYSTEM MODIFICATIONS OFFER THE MOST POTENTIAL FOR EFFICIENCY IMPROVEMENTS:

- Motor efficiency *via* new replacement or upgrade
- Best match between component size and load requirement
- Reduced load on the motor through improved process and systems design
- Use of speed control instead of throttling or bypass mechanisms.

Also, when performing system assessments, the following pump symptoms are good indicators of potential opportunity—throttled valve; bypass line normally open; multiple parallel pump system with same number of pumps always operating; constant pump operation in a batch environment, and presence of cavitation noise.

Intelligent Flow Control

The growing use of variable frequency drives (VFDs), particularly intelligent drives for pump control, is a major departure from the standard operating practice of using control valves as the final control element for fluid flow. Historically, VFDs are used in pump applications where conventional control strategies did not work well or for the purpose of lowering energy usage. In fact, the term intelligent pump is somewhat of a misnomer as the intelligence actually resides in the drive's microprocessor.

Intelligent drives allow the pump to operate near its best efficiency point (BEP) and will protect the pump from mechanical damage when it moves away from BEP. Recent studies reveal that pump operation near the BEP

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provides dramatic improvements in pump efficiency and operating reliability. Table 1 compares pump flow demand with control valve dP setting and VFD RPM setting.

VFDs allow pumps to run at slower speeds with trimmed impellers for further contributions to pump reliability and significant improvement in mean-time-between-failure (MTBF). In new applications, variable speed drives are often less expensive to purchase and install than flow control valves. Subsequently, when combined with lower energy and maintenance cost, the total LCC of a given pumping system can be significantly reduced.

WHEN EMPLOYED, INTELLIGENT VARIABLE SPEED DRIVE TECHNOLOGY PROVIDES THE FOLLOWING ADAPTATIONS:

- Automatically adjusts to process changes
- Automatically adjusts to pump system changes
- Protects pump from system upsets
- Provides on-line condition monitoring.

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Table 1. Flow Demand vs. Required Control Valve or VFD Settings

FLOW RATE (GPM)	DUTY CYCLE (% OF TIME)	CONTROL VALVE DP SETTING (PSID) & PUMP % OF BEP		VFD RPM SETTING & PUMP % OF BEP	
400	10	1	86%	1750	87%
280	30	17	31%	1225	86%
120	50	30	26%	508	90%
80	10	31	17%	315	95%

Source: ***Pumps & Systems Magazine***, November 2002, *Optimizing Pumping Systems to Maximize First or Life Cycle Cost*; Judy Hodgson, DuPont, and Trey Walters, Applied Flow Technology.

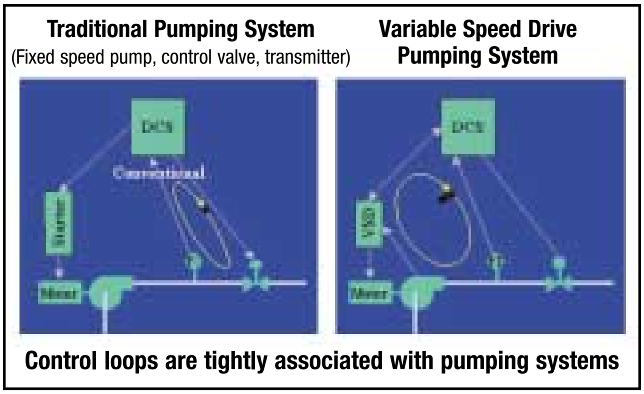

Figure 1. Pumping System Elements

Figure 1 compares elements of a traditional pumping system with a variable speed pumping system.

Calculate the Savings

As shown in Table 2, pumps in the pulp and paper industry consume a very high percentage of total motor energy. The energy intensive nature of process pumps, in particular, make them prime energy optimization candidates.

Process pumps, depending on type, have mechanical designs that allow high efficiency operation. When applied, the design goal is to size the pump to operate near its BEP under normal operating conditions. However, there are large swings in process demand and load requirements often change with time. As a result, sizing a fixed speed pump to operate near its BEP is similar to "shooting at a moving target."

INDUSTRY	PUMP ENERGY (% of Total Motor Energy)
Petroleum	59%
Pulp & Paper	31%
Chemical	26%

Table 2. Pumping Systems are Energy Intensive Source: Bureau of Economic Analysis, 1997.

Among all rotating assets in pulp and paper mills, process pumps typically have the overall best potential for electrical energy savings. Variable frequency drives, by controlling the speed of a motor in real-time, are able to adjust energy use according to need. By varying motor speed to meet the exact process demand, VFDs eliminate excess energy used when running a motor at fixed speed.

By optimizing pump performance, case studies have shown up to 50% or greater reductions in energy use. Also, the excess energy in fixed-speed systems, not used for moving fluid, is often dissipated into the infrastructure and can contribute to lower equipment reliability.

In addition to energy cost reduction, a top priority is to solve and eliminate recurring operating problems experienced by mill 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 increase productivity.

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Enhanced Asset Management

A successful predictive maintenance strategy should include the application of intelligent drives for on-line condition monitoring of motor driven systems. This information is communicated to asset management software, integrated into the process control system, or to the computerized maintenance management system (CMMS) for alarming and historization.

Historically, asset information has been collected manually and filed or, less frequently, manually entered into the CMMS. Automated condition monitoring systems have grown in use over the years, especially on large rotating assets such as turbines, but are infrequently used for predictive maintenance. Manufacturers typically rely on scheduled preventative maintenance checks and, when necessary, corrective maintenance.

By developing a predictive maintenance capability, maintenance can verify and update equipment status on a continuous basis. Real-time analysis of asset data pro-

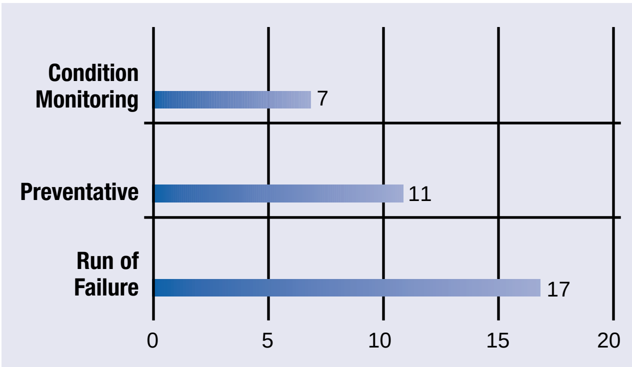

Figure 2. Predictive maintenance—potential savings. Source: SKF, P&P Maintenance, 1994

vides tangible information to plan and schedule maintenance activities rather than perform maintenance based on a predetermined time schedule since the last shutdown. Major benefits from predictive maintenance include increased uptime, operating flexibility, and significantly lower maintenance. Figure 2 illustrates that the cost of predictive maintenance is significantly lower than preventative or corrective maintenance programs.

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

Conclusion

Historically, the papermaking process makes extensive use of process instruments to measure physical and chemical properties, although the use of sensors to monitor process equipment such as pumps, compressors, and other rotating assets has been limited to high capital cost items. Today, with the growing use of intelligent devices and digital communication, traditional process control and asset management functions are seamlessly merging into one process management system.

The emergence of intelligent pumps is a critical step forward in the evolution of process management. With embedded intelligence, the VFD not only provides control, but also offers pump condition monitoring and protection in a single electronics platform.

In spite of the financial and operating benefits, paper companies face many hurdles when implementing motor efficient technologies. Among the major barriers is the lack of awareness among the managers, engineers, and their distributors of new technologies and strategies to improve pump performance.

When understood, the perceived risk from changing long established operating practices often delays decisions and project implementation. Additionally, generally low levels of staffing in maintenance, operations, and engineering departments limits the time available for evaluating and commissioning new technologies. Considering these constraints, there's a common attitude among plant staffs that "if it ain't broke, don't fix it".

Alternately, on the supplier side of the equation, there are conflicting incentives for promoting efficient systems and practices. For example, pump distributors may have greater incentive to sell additional pumps to meet demand growth, rather than advise customers on how to manage load growth through more efficient pump operation. Interestingly, even when the distributor identifies opportunities and quantifies the potential benefits, many end-users continue to make buying decisions based on initial cost rather than spend the incremental capital required for achieving long-term savings.

To capture the many benefits of pump optimization, end-users, manufacturers and distributors, as well as design engineers, must work together. Millwide assessments provide an effective methodology to identify and quantify the best opportunities for project justification. Once implemented, the next best few applications can be identified, providing a steady stream of high value projects that will contribute to the goal of continuous improvement.

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