Holistic Pump System Designs

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A pump system that is well-designed not only maximizes overall system efficiency, it can also be adapted to changing process demands in the future. In the long run, it means low life cycle cost and high return on investment for end users. To achieve optimum system efficiency and life cycle performance, we need to adopt a holistic approach in designing the pump system with your overall operation.

Thinking Outside Traditional Process Design

When deciding to build a new facility or modernize an existing one, initial design considerations are focused on sizing the major capital equipment items. Once mass balances are determined, the reactors, vessels and other capital equipment items are selected. The next phase typically includes sizing the pipes and motor driven systems—like centrifugal pumps—to meet production targets.

In anticipation of future load growth, the end user, supplier and design engineers routinely add 10 to 50 percent "safety margins" to ensure the pump and motor can accommodate capacity increases. Near the final design phase, when the piping isometrics and pump sizing are completed; process control engineers select the instruments and valves needed to implement process control strategies. As each design phase progresses, the various engineering disciplines rarely collaborate on the subtleties associated with pump, pipe and valve sizing in order to consider their overall impact on operating performance. As a result, optimum process control is seldom achieved at plant start-up. Furthermore, as control loop performance is known to decay over time, the performance gap will continue to widen during the life of the plant, unless it is addressed.

Table 1. Typical pump populations in the process industries (*Source: ITT Industrial Process*)

Industry	Pumps
Pulp & Paper Mill	100 – 1000
Petroleum Refinery	500 – 5000
Chemical Plant	100 - 8000

In 1996, a Finnish Technical Research Center report entitled "Expert Systems for Diagnosis and Performance of Centrifugal Pumps" revealed that the average pumping efficiency, across the 20 plants and 1,690 pumps studied, was less than 40 percent, with 10 percent of pumps operating below 10 percent. Pump over-sizing and throttled 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.

The majority of pumping systems run far from their best efficiency point (BEP) for reasons ranging from a lack of accurate design data when the system was new to overly conservative design as well as decades of incremental process change. As a result, most pumps, pipes and control valves are incorrectly sized. Therefore, the pump system does not operate with the economy, reliability and control inherently available from these finely engineered individual components.

Design Considerations for Improve Pumping Efficiency

In the process industries, the purchase price of a centrifugal pump is often 5 to 10 percent of the total cost of ownership. Typically, considering current design practice, the life cycle cost (LCC) of a 100 hp pump system, including the costs to install, operate, maintain and decommission, will be more than 20 times the initial purchase price. Centrifugal pumps consume between 20 and 60 percent of plant electrical motor energy depending on the industry segment (see Table 2).

Table 2. Pumping systems are energy intensive (*Source: Bureau of Economic Analysis, 1997*)

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

Based on current design practice, energy accounts for about 35 percent of life cycle costs (LCC), with maintenance averaging around 25 percent. In poorly designed systems, maintenance may reach as high as 40 percent of LCC, even more. Initial process design considerations help identify opportunities to improve pump system efficiency. The following criteria offer the highest 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. In addition, the excess energy in fixed-speed systems, not used for moving fluid, is often dissipated into the infrastructure and contributes to noise, vibration and lowers equipment reliability, i.e., encompassing all major categories of process equipment such as instruments, valves, pipes and the pumps themselves.

Table 3. Techniques for lower pump energy consumption (*Source: DOE Office of Industrial Technology, United States Motor Systems, Market Opportunities Assessment, 1998)*

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 vessels	10 – 20%
Replace motor with a more efficient model	1 – 3%
Replace pump with a more efficient model	1 – 2%

In addition to energy cost reduction, a top priority is 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 as the fault that causes the highest downtime and maintenance cost. Pump system optimization helps minimize unscheduled downtime and contributes to productivity improvement.

Greenfield and Modernization Project Benefits

In the future, pumps should be considered part of the automation architecture, along with the valves and instruments that are considered to be fundamental elements of process control systems. Plant management often views process automation as a key to competitive advantage. During the past 30 years, with the advent of the information technology revolution, process automation has dramatically enhanced the operation of plant processes. Tighter monitoring and control has reduced cost while providing important productivity and quality gains.

The revolution is not complete, however. While process automation has produced a wide range of benefits, integrating the pumping system—through the use of variable frequency drives, condition monitoring technology and embedded chips, among other information rich tools—offer quantum leaps in performance. To compete in a global economy, pump automation will provide the needed advances in technical and economic performance. While these enabling technologies are readily available, however, they are not being readily adopted.

Plant management has often overlooked the need to invest in new automation strategies to improve asset efficiency and productivity. Surveys suggest that plant management is not convinced that automation technology has fully delivered on past promises of large cost reductions. As a result, there has been a lack of spending on process automation and many plants now have aged control systems that are technologically, if not functionally, obsolete. Future investment in process control systems, when considering functional design enhancements, must ensure the pump system as an integral component of the system.

To remain competitive in global markets, continuous process plants must become more innovative in pump system design and ensure these systems are part of process automation strategies. New plant designs must incorporate the latest process control and asset management technologies and strategies that will allow them to produce the highest value product and the absolute lowest possible operating cost.

Conclusion

An important step in improving capital effectiveness is to rethink process design and the role of pumping systems. Optimal design provides major opportunities to integrate all the elements of pumping, control and asset management systems for improvements in operator effectiveness. The growing body of pump optimization knowledge will support effective system design and operation.

Despite the financial and operating benefits of these design changes, paper and other process companies face many obstacles when implementing motor efficient technologies. Among the major barriers is the lack of awareness among staffs, suppliers and design engineers of new technologies and strategies to improve pump and process performance. The perceived risk from changing long established operating practices often delays decisions and project implementation. In addition, plants have reduced staffing levels in maintenance, operations and engineering that limit the time available for evaluating and commissioning new technologies.

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 life cycle savings.

To capture the many benefits of pump optimization, the process industries, their fluid handling equipment suppliers and design engineers must work together to improve process design and capture the significant capital and operating cost savings that are readily available?

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