Energy Tips – Pumping Systems

Pumping Systems Tip Sheet #11 • January 2007

Industrial Technologies Program

Suggested Actions

Consider using adjustable speed drives in pumping applications that range from 1 to 1,000 horsepower (hp).

Resources

Improving Pumping System Performance: A Sourcebook for Industry, U.S. Department of Energy, 2006

Variable Speed Pumping: A Guide to Successful Applications, Hydraulic Institute, 2004

Hydraulic Institute—HI is a non-profit industry association for pump and pump system manufacturers; it provides product standards and a forum for the exchange of industry information for management decision-making. In addition to the ANSI/HI pump standards, HI has a variety of energy-related resources for pump users and specifiers, including training, guidebooks and more. For more information, visit www.pumps.org, www.pumplearning.org, and www.pumpsystemsmatter.org.

U.S. Department of Energy—DOE's Pumping System Assessment Tool (PSAT) can help you assess pumping system efficiency and estimate energy and cost savings. PSAT uses pump performance data from Hydraulic Institute standards and motor performance data from the MotorMaster+ database.

Visit the BestPractices Web site at www.eere.energy.gov/industry/bestpractices to access these and many other industrial efficiency resources and information on training.

Adjustable Speed Pumping Applications

Most pumps operating today were selected to meet a maximum system demand, or potential future demands. This means that most pumps are oversized, rarely operating at their full design capacity. In addition, pumps are often installed in systems with multiple operating points that coincide with process requirements. A throttling valve is usually employed when the process flow requirement is less than the flow at the pumping system's natural operating point.

Throttling valves control flow by increasing the system's backpressure or resistance to flow. This increase in pressure or head requirements shifts the pump's operating point to the left along its performance curve, and, typically, away from its best efficiency point. The result is a loss in efficiency.

Adjustable speed drives (ASDs) provide an efficient flow control alternative by varying a pump's rotational speed. These drives are broadly classified as mechanical (fluid or eddy current) drives and variable frequency drives (VFDs). Today, the VFD is the most frequently specified type of ASD, and pulse-width-modulated VFDs are the most commonly used.

In centrifugal applications with no static lift, system power requirements vary with the cube of the pump speed. Small decreases in speed or flow can significantly reduce energy use. For example, reducing the speed (flow) by 20% can reduce input power requirements by approximately 50%.

In addition to energy savings, VFDs offer precise speed control and a soft-starting capability. Soft-starting reduces thermal and mechanical stresses on windings, couplings, and belts. Also, VFDs reduce voltage fluctuations that can occur in starting up large motors. Induction motors with across-the-line starting draw as much as six times the full-load current during start-up. During acceleration, a VFD-controlled motor's locked rotor current is limited to one and one-half times the full-load current.

Operating at reduced speeds results in other benefit, as well, such as lower bearing loads, reduced shaft deflection, and lower maintenance costs.

Estimating Performance

We can use the affinity laws to predict the performance of a centrifugal pump with little or no static head at any speed, if we know the pump's performance at its normal operating point. The affinity law equations are as follows:

$$
\begin{aligned}
Q_2 / Q_1 &= N_2 / N_1 \\
H_2 / H_1 &= (N_2 / N_1)^2 \\
P_2 / P_1 &= (H_2 Q_2) / (H_1 Q_1) \\
&= (N_2 / N_1)^3
\end{aligned}
$$

where

Q = fluid flow, in gallons per minute (gpm)
N = pump rotational speed, in revolutions per minute (rpm)
H = head, in feet
P = brake horsepower (hp)
Q_1, H_1, P_1, N_1 = pump performance at normal (initial) operating point
Q_2, H_2, P_2, N_2 = pump performance at final operating point

The affinity laws show that the pump head decreases significantly when the pump speed is reduced to match system flow requirements (see figure). Pump shaft horsepower requirements vary as the product of head and flow or as the cube of the pump's speed ratio. Note, however, that the affinity laws will not provide accurate results for systems with static head. In that case, constructing a system curve to calculate new duty points is essential.

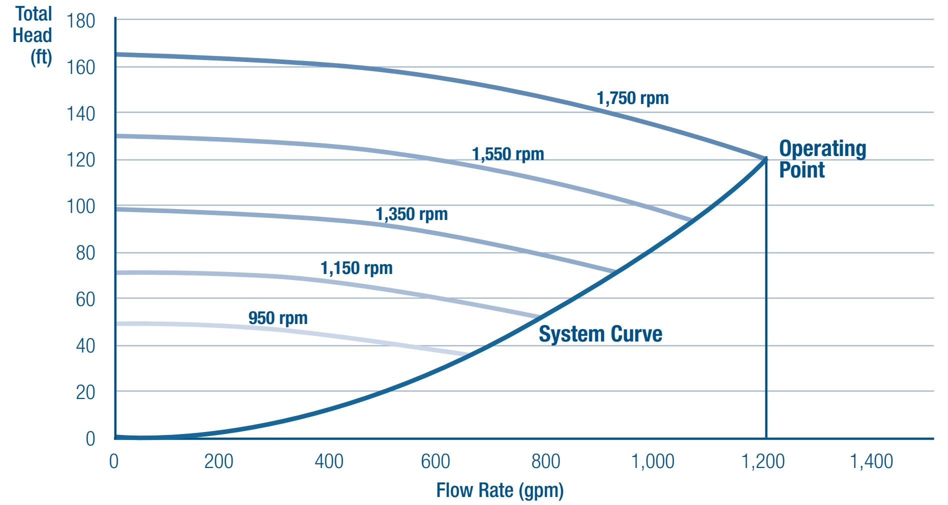

Figure 1. Variation in the centrifugal pump head capacity curve with pump speed

Potential Applications

ASDs are ideally suited for variable-torque loads from centrifugal pumps, fans, and blowers when the system load requirements (head, flow, or both) vary with time. Conditions that tend to make ASDs cost-effective include the following:

- ***High horsepower*** (greater than 15 to 30 hp)—The higher the pump horsepower, the more cost-effective the ASD application.
- ***Load type***—Centrifugal loads with variable-torque requirements (such as centrifugal pumps or fans) have the greatest potential for energy savings. ASDs can be cost-effective on positive displacement pumps, but the savings will generally not be as great as with centrifugal loads.
- ***Operating hours***—In general, ASDs are cost-effective only on pumps that operate for at least 2,000 hours per year at average utility rates.
- ***High utility rates***—Higher utility energy charges provide a more rapid payback on an investment in an ASD.
- ***Availability of efficiency incentives***—Where they are available, electric utility incentives for reducing energy use or installing energy-saving technologies will reduce payback periods.
- ***Low static head***—ASDs are ideal for circulating pumping systems in which the system curve is defined by dynamic or friction head losses. They can also be effective in static-dominated systems—but only when the pump is carefully selected. A thorough understanding of pump and system interactions is critical for such applications.

BestPractices is part of the Industrial Technologies Program (ITP) Technology Delivery strategy, which helps industry save energy and increase competitiveness. Through this strategy, ITP brings together state-of-the-art technologies and energy management best practices to help companies improve energy efficiency, environmental performance, and productivity right now.

BestPractices focuses on key plant energy systems where significant efficiency improvements and savings can be achieved. Energy Savings Assessments are encouraged for the largest energy-consuming plants. In addition, the Industrial Assessment Centers help small- and medium-size manufacturers identify opportunities in their operations. Industry gains easy access to near-term and long-term solutions for improving the performance of steam, process heating, compressed air, and motor systems.

FOR ADDITIONAL INFORMATION, PLEASE CONTACT:

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DOE/GO-102007-2229
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