# Energy Tips – Pumping Systems

Pumping Systems Tip Sheet #12 • May 2007

Industrial Technologies Program

## Suggested Actions

- Flow control can be achieved by using ASDs, trimming impellers, installing multiple pumps, or adding a multi-speed motor.
- Consider ASDs as an option when pumps operate at least 2,000 hours per year and process flow rate requirements vary by 30% or more over time.

## 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. Visit www.pumps.org, www.pumplearning.org, and www.pumpsystemsmatter.org.

**U.S. Department of Energy**—DOE's PSAT can help you assess pumping system efficiency and estimate energy and cost savings. PSAT uses pump performance data from HI 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.

## Control Strategies for Centrifugal Pumps with Variable Flow Rate Requirements

In pumping applications with variable flow rate requirements, adjustable speed drives (ASDs) are an efficient control alternative to throttling or bypass methods. ASDs save energy by varying the pump's rotational speed. In centrifugal pumping applications with no static lift, power requirements vary, as the cube of the pump speed and small decreases in speed or flow rate can significantly reduce energy use. For example, reducing the speed (flow rate) by 20% can lower input power requirements by approximately 50%.

Due to drive inefficiencies, however, ASDs do not save energy in applications that operate close to fully loaded most of the time. For example, ASDs are seldom cost-effective in fluid transfer pumping systems with on/off control when static lift is a significant portion of the total head. In moving a fixed volume of fluid, increases in operating hours can offset the power savings resulting from reducing flow rates.

Developing a system curve is the first step in understanding a given pump system's characteristics at various flow rates. Then, process requirements can be displayed in histogram, flow rate duration curve, or load-duty cycle format. The load-duty cycle is a frequency distribution indicating the percentage of time that a pump operates at each system operating point; it can be useful in calculating potential energy savings. You can obtain the load-duty cycle by using historical measurements of fluid flow rates or using a recording watt-meter to monitor the electrical power input to the pump motor (see Table 1).

Table 1. Load-Duty Cycle for an Existing Centrifugal Pump with Throttle Valve Control

| Operating Point | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Operating Time (hours) | 500 | 1,000 | 1,500 | 2,000 | 1,500 |
| Flow Rate (gpm) | 400 | 600 | 800 | 1,000 | 1,200 |
| Head (feet) | 160 | 155 | 145 | 134 | 120 |
| Pump Efficiency (%) | 63 | 76 | 82 | 82.5 | 80 |
| Power (bhp)* | 25 | 31 | 36 | 41 | 45 |

*Brake horsepower.

After establishing values for flow rate and head, you can extract the pump efficiency and shaft horsepower required from the pump curve. Using weighted averages for power at each operating point, factor in the motor's efficiency to calculate weighted input power (see Table 2).

Table 2. Average Power Requirements for a Centrifugal Pump with Throttle Control

| Flow Rate (gpm) | Duty Cycle (%) | Shaft Power (hp) | Weighted Power (hp) | Motor Efficiency* (%) | Weighted Input (kW) |
|---|---|---|---|---|---|
| 1,200 | 23.07 | 45 | 10.38 | 91.4 | 8.47 |
| 1,000 | 30.77 | 41 | 12.31 | 91.6 | 10.02 |
| 800 | 23.07 | 36 | 8.30 | 91.6 | 6.76 |
| 600 | 15.38 | 31 | 4.76 | 91.2 | 3.89 |
| 400 | 7.69 | 25 | 1.92 | 90.9 | 1.58 |
| | | | | Total: | 30.72 |

*Based on a 50-hp, 1,800-rpm, totally enclosed, fan-cooled standard efficiency motor from MotorMaster+ 4.0 data.

Perform similar calculations to obtain the average input power for the same pump when using an ASD to control flow rate. Affinity law equations used in conjunction with the system curve can help you calculate pump shaft horsepower requirements at each flow-rate point. (Affinity laws are valid for circulating water pumping applications or fluid transfer applications with little static head.) Factor in motor and drive efficiency at each operating point to calculate weighted input power (see Table 3).

Table 3. Average Power Requirements for a Centrifugal Pump with ASD Flow Rate Control

| Flow Rate (gpm) | Duty Cycle (%) | Shaft Power (hp) | Drive Efficiency (%) | Motor Efficiency (%) | Weighted Input (kW) |
|---|---|---|---|---|---|
| 1,200 | 23.07 | 45.00 | 95.9 | 91.4 | 8.83 |
| 1,000 | 30.77 | 26.04 | 94.9 | 90.9 | 6.92 |
| 800 | 23.07 | 13.33 | 92.1 | 84.5 | 2.95 |
| 600 | 15.38 | 5.62 | 85.5 | 70.3 | 1.07 |
| 400 | 7.69 | 1.67 | 53.7 | 41.1 | 0.43 |
| | | | | Total: | 20.20 |

## Installation Considerations

- Program drive controllers to avoid operating pumps at speeds which may result in equipment or systems resonances
- Install a manual bypass to keep the motor operating at a fixed speed if the ASD should fail
- Install a single ASD to control multiple pump motors
- Use caution when reducing the flow velocities of slurries.

## Reference


*Adjustable Speed Pumping Applications,* DOE Pumping Systems Tip Sheet, 2007

*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.





**FOR ADDITIONAL INFORMATION, PLEASE CONTACT:**

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