Select an Energy-Efficient Centrifugal Pump

Overview
Centrifugal pumps handle high flow rates, provide smooth, nonpulsating delivery, and regulate the flow rate over a wide range without damaging the pump. Centrifugal pumps have few moving parts, and the wear caused by normal operation is minimal. They are also compact and easily disassembled for maintenance. The design of an efficient pumping system depends on relationships between fluid flow rate, piping layout, control methodology, and pump selection. Before a centrifugal pump is selected, its application must be clearly understood.

Centrifugal Pump Performance
Centrifugal pumps are generally divided into three classes: radial flow, mixed flow, and axial flow. Since they are designed around their impellers, differences in impeller design allow manufacturers to produce pumps that can perform efficiently under conditions that vary from low flow rate with high head to high flow rate with low head. The amount of fluid a centrifugal pump moves depends on the differential pressure or head it supplies. The flow rate increases as the head decreases.

Manufacturers generally provide a chart that indicates the zone or range of heads and flow rates that a particular pump model can provide.

Before you select a pump model, examine its performance curve, which is indicated by its head-flow rate or operating curve. The curve shows the pump’s capacity (in gallons per minute [gpm]) plotted against total developed head (in feet). It also shows efficiency (percentage), required power input (in brake-horsepower [bhp]), and suction head requirements (net positive suction head requirement in feet) over a range of flow rates.

Pump curves also indicate pump size and type, operating speed (in revolutions per minute), and impeller size (in inches). It also shows the pump’s best efficiency point (BEP). The pump operates most cost effectively when the operating point is close to the BEP.

Pumps can generally be ordered with a variety of impeller sizes. Each impeller has a separate performance curve (see Figure 1). To minimize pumping system energy consumption, select a pump so the system curve intersects the pump curve within 20% of its BEP, and select a midrange impeller that can be trimmed or replaced to meet higher or lower flow rate requirements. Select a pump with high efficiency contours over your range of expected operating points. A few points of efficiency improvement can save significant energy over the life of the pump.

Resources
DOE and Hydraulic Institute, Improving Pumping System Performance: A Sourcebook for Industry.

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.

**Example**

A process requires 15,000 gpm at a total operating head of 150 feet. Assume the centrifugal pump will be powered by a 700-hp motor, operate for 8,000 hours annually, and transport fluid with a specific gravity of 1.0. One candidate pump has an efficiency ($\eta_1$) of 81% at the operating point; a second is expected to operate at 78% efficiency ($\eta_2$). What are the energy savings given selection of the first pump?

Reduced Power Requirements (bhp) = \(\{(\text{Head} \times \text{Flow} \times \text{SG}) / 3,960\} \times (100/\eta_1 - 100/\eta_2)\)

where

- Head = head at operating point in feet
- Flow = pump discharge at operating point
- SG = fluid specific gravity

bhp Reduction = \(\{(150 \text{ feet} \times 15,000 \text{ gpm} \times 1.0) / 3,960\} \times (1/0.81 - 1/0.78) = 27 \text{ bhp}\)

Assuming an efficiency of 96% for the pump drive motor, the annual energy savings are:

Energy Savings = 27 bhp x 0.746 kW/bhp x 8,000 hours/year / 0.96 = 167,850 kWh/year

These savings are valued at $8,393 per year at an energy price of 5 cents per kWh. Assuming a 15-year pump life, total energy savings are $125,888. With an assumed cost differential between the two pumps of $5,000, the simple payback for purchasing the first pump will be approximately 7 months.

**References**

Centrifugal Applications (ANSI/HI 1.3-2000), Hydraulic Institute, 2000.