Energy Tips – Pumping Systems

Pumping Systems Tip Sheet #3 • October 2005

Industrial Technologies Program

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

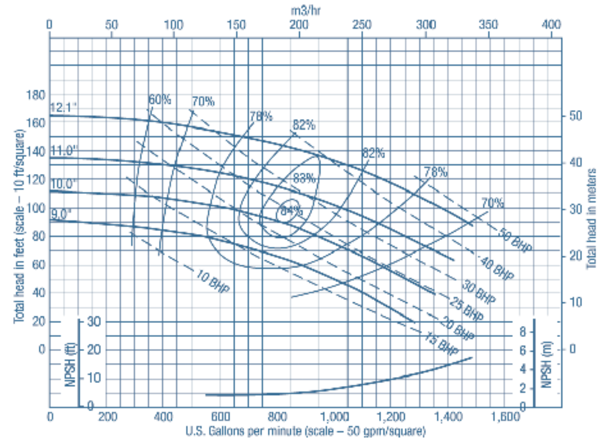
Centrifugal pumps are generally divided into three classes: radial flow, mixed flow, and axial flow. Since they are designed around their impellers, differences in impeller design allow manufacturers to produce pumps that can perform efficiently under conditions that vary from low flow rate with high 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.

Figure 1. End Suction Centrifugal Pump Performance Curve



Suggested Actions

- Develop an accurate system curve (see tip sheet "Pump Selection Considerations").
- Select a correctly sized pump and drive motor.
- Select the pump with the highest efficiency over the range of expected system operating points.
- Develop an index. A useful index for comparing pumps in the same application involves calculating the gallons of fluid pumped per kilowatt-hour of electrical energy used (gal/kWh). This index illustrates the fluid transported per unit of energy expended. Calculating the inverse—kWh/gal—is equally useful, and provides the basis for an energy cost comparison.

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.

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/bestpractices for more information on PSAT and for upcoming training in improving pumping system performance and in becoming a qualified pumping system specialist.

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 (η_1) of 81% at the operating point; a second is expected to operate at 78% efficiency (η_2). What are the energy savings given selection of the first pump?

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

where

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

bhp Reduction = {(150 feet x 15,000 gpm x 1.0) / 3,960} x (1/0.81 – 1/0.78) = 27 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.

About DOE's Industrial Technologies Program

The Industrial Technologies Program, through partnerships with industry, government, and non-governmental organizations, develops and delivers advanced energy efficiency, renewable energy, and pollution prevention technologies for industrial applications. The Industrial Technologies Program is part of the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy.

The Industrial Technologies Program encourages industry-wide efforts to boost resource productivity through a strategy called Industries of the Future (IOF). IOF focuses on the following eight energy and resource intensive industries:

- Aluminum
- Chemicals
- Forest Products
- Glass
- Metal Casting
- Mining
- Petroleum
- Steel

The Industrial Technologies Program and its BestPractices activities offer a wide variety of resources to industrial partners that cover motor, steam, compressed air, and process heating systems. For example, BestPractices software can help you decide whether to replace or rewind motors (MotorMaster+), assess the efficiency of pumping systems (PSAT), compressed air systems (AirMaster+), steam systems (Steam Scoping Tool), or determine optimal insulation thickness for pipes and pressure vessels (3E Plus). Training is available to help you or your staff learn how to use these software programs and learn more about industrial systems. Workshops are held around the country on topics such as "Capturing the Value of Steam Efficiency," "Fundamentals and Advanced Management of Compressed Air Systems," and "Motor System Management." Available technical publications range from case studies and tip sheets to sourcebooks and market assessments. The Energy Matters newsletter, for example, provides timely articles and information on comprehensive energy systems for industry. You can access these resources and more by visiting the BestPractices Web site at **www.eere.energy.gov/ industry/bestpractices** or by contacting the EERE Information Center at **877-337-3463** or via email at **www.eere.energy.gov/informationcenter/.**

BestPractices is part of the Industrial Technologies Program Industries of the Future strategy, which helps the country's most energy-intensive industries improve their competitiveness. BestPractices brings together emerging technologies and best energy-management practices to help companies begin improving energy efficiency, environmental performance, and productivity right now.

BestPractices emphasizes plant systems, where significant efficiency improvements and savings can be achieved. Industry gains easy access to near-term and long-term solutions for improving the performance of motor, steam, compressed air, and process heating systems. In addition, the Industrial Assessment Centers provide comprehensive industrial energy evaluations to small- and medium-size manufacturers.

FOR ADDITIONAL INFORMATION, PLEASE CONTACT:

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A Strong Energy Portfolio for a Strong America

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DOE/GO-102005-2157
October 2005
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