Test for Pumping System Efficiency

A pump's efficiency can degrade as much as 10% to 25% before it is replaced, according to a study of industrial facilities commissioned by the U.S. Department of Energy (DOE), and efficiencies of 50% to 60% or lower are quite common. However, because these inefficiencies are not readily apparent, opportunities to save energy by repairing or replacing components and optimizing systems are often overlooked.

Suggested Actions

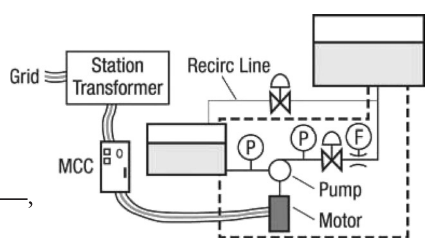
- Survey the priority pumps in your plant and conduct efficiency tests on them.
- Identify misapplied,oversized, or throttled pumps, or those that have bypass lines.
- Identify pumps with operating points below the manufacturer's pump curve (if available); estimate energy savings of restoring the system to its original efficiency.
- Identify pumps with flow rates of 30% or more from the BEP flow rates, or with system imbalances greater than 20%.
- Determine the cost effectiveness of each improvement.

Define Pumping System Efficiency

System efficiency incorporates the efficiencies of the pump, motor, and other system components, as shown in the area of the illustration outlined by the dashed line.

Pumping system efficiency (η_{sys}) is defined as follows:

$$\eta_{sys} = \frac{Q_{req} \times H_{req} \times SG}{5308 \times P_e},$$



where
Q_{req} =required fluid flow rate, in gallons per minute
H subscript req =required pump head, in feet
SG =specific gravity
P_e =units for electrical power input.

Only the required head and flow rates are considered in calculating system efficiency. Unnecessary head losses are deducted from the pump head, and unnecessary bypass or recirculation flow is deducted from the pump flow rate.

Conduct Efficiency Tests

Efficiency tests help facilities staff identify inefficient systems, determine energy efficiency improvement measures, and estimate potential energy savings. These tests are usually conducted on larger pumps and on those that operate for long periods of time.

Flow rates can be obtained with reliable instruments installed in the system or preferably with stand-alone tools such as a sonic (Doppler-type) or "transit time" flow meter or a Pitot tube and manometer. Turbulence can be avoided by measuring the flow rate on a pipe section without fittings at a point where there is still a straight run of pipe ahead. For details, see Hydraulic Institute Standards ANSI/HI 1.6-2000, Centrifugal Pump Tests, and ANSI/HI 2.6-2000, Vertical Pump Tests.

Improve System Efficiency

Internal leaks caused by excessive impeller clearances or by worn or misadjusted parts can reduce the efficiency of pumps. Corrective actions include restoring internal clearances and replacing or refurbishing worn or damaged throat bushings, wear rings, impellers, or pump bowls. Changes in process requirements and control strategies, deteriorating piping, and valve losses all affect pumping system efficiency.

Tip Sheet

Tip Sheet

Potential energy savings can be determined by using the difference between actual system operating efficiency (η_o) and the design (or optimal) operating efficiency (η_a), or by consulting published pump curves, as available, for design efficiency ratings.

Software tools like DOE's Pumping System Assessment Tool (PSAT) also provide estimates of optimal efficiency. When the required head and flow rate, as well as actual electrical data, are input into the software, PSAT will account for artificial head and flow losses.

The equation for calculating potential energy savings is as follows:

$$\text{Savings} = kW_{in} \times t \times (1 - \eta_a / \eta_o),$$

where

Savings = energy savings, in kilowatt-hours (kWh) per year

kW_{in} = input electrical energy, in kilowatts (kW)

t = annual operating hours

η_a = actual system efficiency,calculated from field measurements

η_o = optimal system efficiency.

Example

Efficiency testing and analysis indicate that a 300-horsepower centrifugal pump has an operating efficiency of 55%. However, the manufacturer's pump curve indicates that it should operate at 78% efficiency. The pump draws 235 kW and operates 6,000 hours per year. Assuming that the pump can be restored to its original or design performance conditions, estimated energy savings are as follows:

$$\text{Savings} = 235 \text{ kW} \times 6{,}000 \text{ hours/year} \times [\, 1 - (0.55/0.78)] = 415{,}769 \text{ kWh/year.}$$

At an energy cost of 5 cents per kWh, the estimated savings would be $20,786 per year.

References

Centrifugal Tests (ANSI/HI 1.6 -2000), Hydraulic Institute, 2000.

Vertical Pump Tests (ANSI/HI 2.6-2000) Hydraulic Institute, 2000.

Conduct an In-Plant Pumping System Survey, DOE Pumping Systems Tip Sheet, 2005.

Match Pumps to System Requirements, DOE Pumping Systems Tip Sheet, 2005.

Trim or Replace Impellers on Oversized Pumps, DOE Pumping Systems Tip Sheet, 2005.

References may be found at the Pump Systems Matter web site, www.PumpSystemsMatter.org.

RESOURCES

Hydraulic Institute (HI). Hydraulic Institute, the largest association of pump producers in North America, serves member companies and pump users worldwide by developing comprehensive industry standards, expanding knowledge by providing education and training, and serving as a forum for the exchange of industry information. In addition to the ANSI/HI pump standards, HI has a variety of resources for pump users and specifiers, including Pump LCC and VSP guidebooks, "7 Ways To Save Energy" training program and more. To download FREE executive summaries of HI's "Pump Life Cycle Costs", "Variable Speed Pumping", and an index to ANSI/HI Standards, visit www.Pumps.org and www.PumpLearning.org.

Pump Systems Matter™ (PSM). Developed by the Hydraulic Institute, PSM is an educational initiative created to assist North American pump users gain a more competitive business advantage through strategic, broad-based energy management and pump system performance optimization. PSM's mission is to provide end-users, engineering consultants and pump suppliers with tools and collaborative opportunities to integrate pump system performance optimization and efficient energy management practices into normal business operations.

PSM is seeking the active support and involvement of energy efficiency organizations, utilities, pump users, consulting engineering firms, government agencies, and other associations. For more information on PSM, to become a sponsor, or to download PSM's *FREE Pump System Improvement Modeling Tool*™ (PSIM), an educational tool designed to show pump systems engineers how modeling tools can reduce cost and conserve energy, visit www.PumpSystemsMatter.org.

U.S. Department of Energy (DOE). DOE's Industrial Technologies Program (ITP), through partnerships with industry, government, and non-governmental organizations, develops and delivers advanced energy efficiency, renewable energy, and pollution prevention technologies for industrial applications. ITP has launched the **Save Energy Now** initiative to help the nation's manufacturing facilities continue to thrive during a time of diminished energy supplies and rising costs. As a part of this initiative, ITP is sending DOE Energy Experts to the nation's most energy-intensive manufacturing facilities to conduct 200 Energy Savings Assessments. See www.eere.energy.gov/industry for additional information on DOE's energy efficiency activities.

BestPractices emphasizes opportunities for savings in plant systems such as motor, steam, compressed air, and process heating systems. BestPractices is a part of the Industrial Technologies Program, and offers a variety of resources addressing ways to reduce energy and maintenance costs in industrial process systems. This includes training workshops, software tools, a series of sourcebooks, case studies, tip sheets, and other materials, including several which focus on opportunities in pumping systems. For example, the Pumping System Assessment Tool (PSAT) aids in the assessment of pumping system efficiency and estimating energy and cost savings.

For more information, please contact: EERE Information Center; 1-877-EERE-INF (1-877-337-3463); www.eere.energy.gov/industry/bestpractices.