Consider Steam Turbine Drives for Rotating Equipment

Steam turbines are well suited as prime movers for driving boiler feedwater pumps, forced or induced-draft fans, blowers, air compressors, and other rotating equipment. This service generally calls for a backpressure non-condensing steam turbine. The low-pressure steam turbine exhaust is available for feedwater heating, preheating of deaerator makeup water, and/or process requirements.

Steam turbine drives are equipped with throttling valves or nozzle governors to modulate steam flow and achieve variable speed operation. The steam turbine drive is thus capable of serving the same function as an induction motor coupled to an inverter or adjustable speed drive. Steam turbine drives can operate over a broad speed range and do not fail when overloaded. They also exhibit the high starting torque required for constant torque loads such as positive displacement pumps.

Steam turbines are inherently rugged and reliable low-maintenance devices. They are easy to control and offer enclosed, non-sparking operation suitable for use in explosive atmospheres or highly corrosive environments. Steam turbines provide fast, reliable starting capability and are particularly adaptable for direct connection to equipment that rotates at high speeds. Steam turbine drives may be installed for continuous duty under severe operating conditions, or used for load shaping (e.g. demand limiting), standby, or emergency service.

Steam turbine performance is expressed in terms of isentropic efficiency or steam rate (the steam requirement of the turbine per unit of shaft power produced). Steam rates are given in terms of pounds per horsepower-hour (lb/hp-hour) or lb/kWh.

Example

A 300-hp steam turbine has an isentropic efficiency of 43% and a steam rate of 26 lb/hp-hour given the introduction of 600 psig/750°F steam with a 40 psig/486°F exhaust. What steam flow is necessary to replace a fully-loaded 300-hp feedwater pump drive motor?

Steam flow = 26 lb/hp-hr x 300 hp = 7,800 lb/hr

An examination of the ASME steam tables reveals that this steam turbine would utilize 103 Btu/lb of steam or 0.80 MMBtu of thermal energy per hour. Given a natural gas cost of $5.00/MMBtu and a boiler efficiency of 80%, the fuel-related cost of steam turbine operation is (0.80 MMBtu/hr/0.80 x $5.00/MMBtu) = $5.00/hr.

In comparison, a 300-hp motor with a full-load efficiency of 95% would require:

\[
\frac{300 \text{ hp} \times (0.746 \text{ kW/hp})}{0.95} = 235.6 \text{ kWh/hr}
\]

In this example, the steam turbine drive would provide energy cost savings when the price of electricity exceeds:

\[
\frac{5.00/\text{hr} \times 100 \text{ cents/}$}{235.6 \text{ kWh/hr}} = 2.12 \text{ cents/kWh}
\]

The total annual energy savings are strongly dependent upon the facility energy cost and the hours per year of feedwater pump operation. Annual energy savings are given in Table 1 for various electrical rates and pump operating schedules. In addition to operating cost savings, steam turbine maintenance costs should be compared with electric motor maintenance expenses.
The Office of Industrial Technologies (OIT), through partnerships with industry, government, and non-governmental organizations, develops and delivers advanced energy efficiency, renewable energy, and pollution prevention technologies for industrial applications. OIT is part of the U.S. Department of Energy’s Office of Energy Efficiency and Renewable Energy.

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

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

OIT and its BestPractices program 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.oit.doe.gov/bestpractices or by contacting the OIT Clearinghouse at 800-862-2086 or via email at clearinghouse@ee.doe.gov.

### Table 1. Annual Energy Savings when Using a Steam Turbine Feedwater Pump Drive

<table>
<thead>
<tr>
<th>Electricity Costs, $/kWh</th>
<th>Feedwater Pump Annual Operating Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2,000</td>
</tr>
<tr>
<td>0.03</td>
<td>$4,105</td>
</tr>
<tr>
<td>0.05</td>
<td>13,525</td>
</tr>
<tr>
<td>0.075</td>
<td>25,305</td>
</tr>
</tbody>
</table>

Savings are based upon operation of a 300-hp steam turbine drive with a steam rate of 26 lbs/hp-hr. A natural gas cost of $5.00/MMBtu is assumed.

BestPractices is part of the Office of Industrial Technologies’ (OIT’s) Industries of the Future strategy, which helps the country’s most energy-intensive industries improve their competitiveness. BestPractices brings together the best-available and emerging technologies and 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:

Peter Salmon-Cox
Office of Industrial Technologies
Phone: (202) 586-2380
Fax: (202) 586-6507
Peter.Salmon-Cox@hq.doe.gov
www.oit.doe.gov/bestpractices

OIT Clearinghouse
Phone: (800) 862-2086
Fax: (360) 586-8303
clearinghouse@ee.doe.gov

Please send any comments, questions, or suggestions to webmaster.oit@ee.doe.gov

Visit our home page at www.oit.doe.gov

Office of Industrial Technologies
Energy Efficiency and Renewable Energy
U.S. Department of Energy
Washington, DC 20585-0121

DOE/GO-102002-1475
Revised February 2002
Steam Tip Sheet #21