Energy Tips

Steam

Motors

Compressed Air

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?

$$\text{Steam flow} = 26 \text{ lb/hp-hr} \times 300 \text{ hp} = 7{,}800 \text{ lb/hr}$$

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.

Steam Turbine Flexibility

Equipment redundancy and improved reliability can be obtained by mounting a steam turbine drive and an electric motor on opposite ends of the driven-equipment shaft. You can then select either the motor or turbine as the prime mover by increasing or decreasing the turbine speed relative to the synchronous speed of the motor.

Suggested Actions

Consider replacing electric motors with steam turbine drives if your facility:

- Contains a high-pressure boiler or a boiler designed to operate at a higher pressure than process requirements.
- Has time-of-use (eg. on/off peak, real-time, etc.) energy purchase and resale contracts with periods when electric power costs are substantially higher than fuel costs.
- Has pumps or other rotating equipment requiring variable speed operation.
- Requires continued equipment operation during electrical power supply interruptions.

Steam Tip Sheet information adapted from material provided by the TurboSteam Corporation and reviewed by the DOE BestPractices Steam Technical Subcommittee. For additional information on steam system efficiency measures, contact the OIT Clearinghouse at (800) 862-2086.

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

Electricity Costs, $/kWh	Feedwater Pump Annual Operating Hours				
	2,000	4,000	6,000	7,000	8,760
0.03	$4,105	$8,210	$12,310	$14,365	$17,975
0.05	13,525	27,050	40,570	47,330	59,230
0.075	25,305	50,605	75,910	88,560	110,830

[1] 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.

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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

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Office of Industrial Technologies
Energy Efficiency
and Renewable Energy
U.S. Department of Energy
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