

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 noncondensing 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, nonsparking 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-hr) or pounds per kilowatt-hour (lb/kWh).

Example

A 300-hp steam turbine has an isentropic efficiency of 43% and a steam rate of 26 lb/hp-hr given the introduction of 600-pounds-per-square-inch-gauge (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?

$$\begin{aligned}\text{Steam Flow} &= 26 \text{ lb/hp-hr} \times 300 \text{ hp} \\ &= 7,800 \text{ lb/hr}\end{aligned}$$

An examination of the ASME steam tables reveals that this steam turbine would utilize 103 Btu/lb of steam or 0.80 million Btu (MMBtu) of thermal energy per hour. Given a natural gas cost of \$8.00/MMBtu and a boiler efficiency of 80%, the fuel-related cost of steam turbine operation is $(0.80 \text{ MMBtu/hr} / 0.80 \times \$8.00 / \text{MMBtu}) = \$8.00/\text{hr}$.

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

$$300 \text{ hp} \times (0.746 \text{ kW/hp}) \times 100/95 = 235.6 \text{ kWh/hr}$$

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

$$\frac{\$8.00/\text{hr}}{235.6 \text{ kWh/hr} \times \$/100 \text{ cents}} = 3.4 \text{ cents/kWh} (\$0.034/\text{kWh})$$

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 (e.g., 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.

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 the table below 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.

Annual Energy Savings when Using a Steam Turbine Feedwater Pump Drive*, \$

Electricity Costs, \$/kWh	Feedwater Pump Annual Operating Hours				
	2,000	4,000	6,000	7,000	8,760
0.04	2,830	5,650	8,480	9,900	12,380
0.05	7,540	15,080	22,620	26,390	33,020
0.075	19,320	38,640	55,960	67,620	84,620

*Savings are based upon operation of a 300-hp steam turbine drive with a steam rate of 26 lb/hp-hr. A natural gas cost of \$8.00/MMBtu is assumed.

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.

Steam Tip Sheet information adapted from material provided by the TurboSteam Corporation and reviewed by the AMO Steam Technical Subcommittee.

Resources

U.S. Department of Energy—DOE’s software, the *Steam System Assessment Tool* and *Steam System Scoping Tool*, can help you evaluate and identify steam system improvements. In addition, refer to *Improving Steam System Performance: A Sourcebook for Industry* for more information on steam system efficiency opportunities.

Visit the Advanced Manufacturing Office website at manufacturing.energy.gov to access these and many other industrial efficiency resources and information on training.



Energy Efficiency & Renewable Energy

Advanced Manufacturing Office
 Energy Efficiency and Renewable Energy
 U.S. Department of Energy
 Washington, DC 20585-0121
manufacturing.energy.gov

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