Energy Tips – Steam

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Industrial Technologies Program

Use Vapor Recompression to Recover Low-Pressure Waste Steam

Low-pressure steam exhaust from industrial operations such as evaporators or cookers is usually vented to the atmosphere or condensed in a cooling tower. Simultaneously, other plant operations may require intermediate-pressure steam at 20 to 50 pounds per square inch gauge (psig). Instead of letting down high-pressure steam across a throttling valve to meet these needs, low-pressure waste steam can be mechanically compressed or boosted to a higher pressure so that it can be reused.

Vapor recompression relies upon a mechanical compressor or steam jet ejector to increase the temperature of the latent heat in steam to render it usable for process duties. Recompression typically requires only 5% to 10% of the energy required to raise an equivalent amount of steam in a boiler.

Energy Required for Steam Recompression

Inlet Pressure, psig	Compressor Work, Btu/lb of Steam Produced				
	Compression Ratio				
	1.2	**1.4**	**1.6**	**1.8**	**2.0**
0	17.8	33.2	46.8	58.8	69.6
15	18.6	34.7	48.7	61.2	72.6

Assuming adiabatic compression with a compressor efficiency of 75%. Water at 80°F is sprayed into the steam to eliminate superheat.

Example

Consider a petrochemical plant that vents 15-psig steam to the atmosphere. At the same time, a process imposes a continuous requirement on the boiler for 5,000 pounds per hour (lb/hr) of 40-pounds-per-square-inch-gauge (psig) steam. If 15-psig waste steam is recompressed to 40 psig by an electrically driven compressor, the compression ratio is:

Compression Ratio = (40 + 14.7) / (15 + 14.7)
= 1.84

Interpolating from the table above, the compressor requires 63.5 Btu/lb of delivered steam. Assuming that electricity is priced at $0.05/kWh, the annual cost of driving the compressor is:

Compressor Operating Cost = [63.5 Btu/lb x 5,000 lb/hr x 8,760 hr/yr x $0.05/kWh] / 3,413 Btu/kWh
= **$40,750**

If an equivalent quantity of 40-psig steam (enthalpy for saturated steam is 1,176 Btu/lb) were to be supplied by an 80% efficient natural-gas-fired boiler, the steam

Suggested Actions

A vapor recompression project analysis consists of matching recovered waste heat with the need for low-pressure steam for process or space heating. To perform this analysis:

- Conduct a plant audit to identify sources of low-pressure waste steam.
- Estimate the heat recovery potential.
- Inventory all steam-utilizing equipment and list pressure requirements, energy consumption, and patterns of use.
- Estimate the cost-effectiveness of installing recompression equipment and connecting piping.

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 BestPractices Web site at www.eere.energy.gov/industry/bestpractices to access these and many other industrial efficiency resources and information on training.

production costs with fuel priced at \$8.00 per million Btu (\$8.00/MMBtu) and 70°F feedwater (enthalpy is 38 Btu/lb) are:

Steam Production Costs = [5,000 lb/yr x (1,176 – 38) Btu/lb x 8,760 hr/yr x \$8.00/MMBtu] / (0.80 x 10^6 Btu/MMBtu)
= **\$498,440**

Annual Vapor Recompression Cost Savings = \$498,440 – \$40,750
= \$457,690

Conduct a Pinch Analysis

Based on the actual application, there may be other options to vapor recompression. The industry best practice is to conduct a pinch analysis on the steam system to reveal cost-effective alternatives and optimize steam use by eliminating inefficiencies.

Vapor Recompression Limits

Vapor recompression is limited to applications where the compressor inlet pressure is above atmospheric and the compression ratio is less than two per stage.

System Pressure Boosting

Vapor recompression can be used in steam distribution systems to boost system pressures that have dropped to unacceptably low levels.

Adapted from an Energy TIPS fact sheet that was originally published by the Industrial Energy Extension Service of Georgia Tech.

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