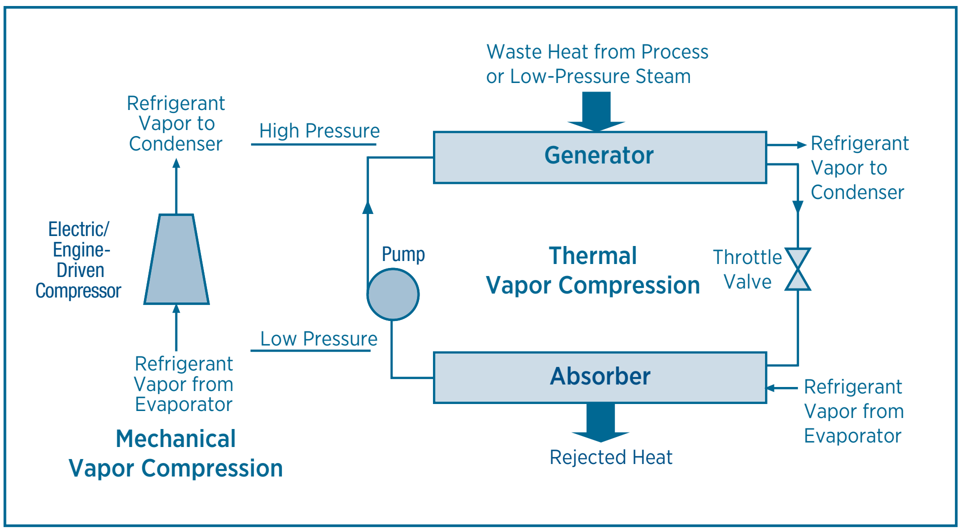
Use Low-Grade Waste Steam to Power Absorption Chillers

Absorption chillers use heat, instead of mechanical energy, to provide cooling. The mechanical vapor compressor is replaced by a thermal compressor (see figure) that consists of an absorber, a generator, a pump, and a throttling device. The refrigerant vapor from the evaporator is absorbed by a solution mixture in the absorber. This solution is then pumped to the generator where the refrigerant is revaporized using a waste steam heat source. The refrigerant-depleted solution is then returned to the absorber via a throttling device. The two most common refrigerant/absorbent mixtures used in absorption chillers are water/lithium bromide and ammonia/water.

Comparison of Mechanical and Thermal Vapor Compression Systems*



*The evaporator and the condenser, required for both systems, are not shown in the figure.

Compared to mechanical chillers, absorption chillers have a low coefficient of performance (COP = chiller load/heat input). Nonetheless, they can substantially reduce operating costs because they are energized by low-grade waste heat, while vapor compression chillers must be motor- or engine-driven.

Low-pressure, steam-driven absorption chillers are available in capacities ranging from 100 to 1,500 tons. Absorption chillers come in two commercially available designs: single-effect and double-effect. Single-effect machines provide a thermal COP of 0.7 and require about 18 pounds of 15-pounds-per-square-inch-gauge (psig) steam per ton-hour of cooling. Double-effect machines are about 40% more efficient, but require a higher grade of thermal input, using about 10 pounds of 100- to 150-psig steam per ton-hour.

Suggested Actions

Determine the cost-effectiveness of displacing a portion of your cooling load with a waste-steam absorption chiller by taking the following steps:

- Conduct a plant survey to identify sources and availability of waste steam.
- Determine cooling load requirements and the cost of meeting those requirements with existing mechanical chillers or new installations.
- Obtain installed cost quotes for a waste-steam absorption chiller.
- Conduct a life-cycle cost analysis to determine if the waste-steam absorption chiller meets your company's cost-effectiveness criteria.

Example

In a plant where low-pressure steam is currently being exhausted to the atmosphere, a mechanical chiller with a COP of 4.0 is used 4,000 hours per year (hr/yr) to produce an average of 300 tons of refrigeration. The cost of electricity at the plant is $0.06 per kilowatt-hour (kWh).

An absorption unit requiring 5,400 pounds per hour of 15-psig steam could replace the mechanical chiller, providing annual electrical cost savings of:

Annual Savings = 300 tons x (12,000 Btu/ton / 4.0) x 4,000 hr/yr x $0.06/kWh / 3,413 Btu

= $63,287

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

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.

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