Thermally Driven Heat Pump Runs Hot and Cold for Food and Beverage Industries

The Problem

The food and beverage industry uses a great deal of energy, costing an annual average of $643,000 per plant in the United States—mostly for heating and cooling. These plants typically use gas-fired water heaters or boilers to produce hot water and electrically driven mechanical refrigeration systems for cooling. There has been no cost-effective way to lower energy consumption using conventional technology.

The Solution

A newly commercialized heat pump (see **Figure 1**) driven by thermal energy from a range of possible sources—fuel, steam, solar heat, or waste heat—efficiently produces both hot and cold water at the same time. Called the ThermoSorber™, the system operates at high efficiency thanks to a new design that uses an ammonia-water absorption cycle and proprietary heat and mass exchangers (see **Figure 2**). In many applications, the resulting energy savings yield a two-year-or-less payback period. The ThermoSorber is now available as a commercial product from Energy Concepts Co.

Features and Benefits

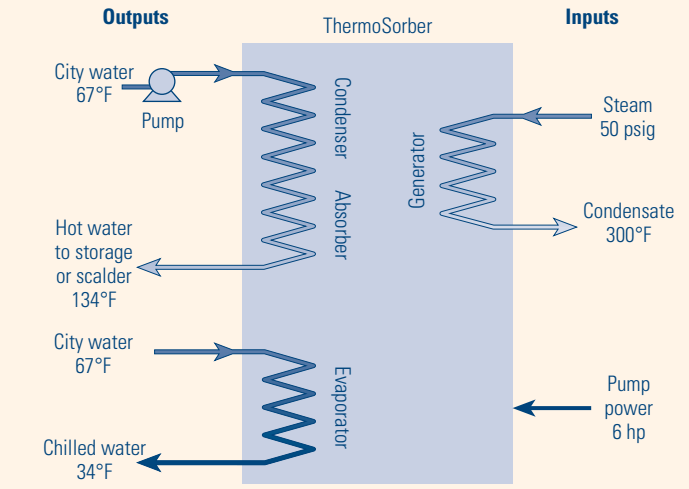
The key to the efficiency of the ThermoSorber is a modified ammonia-absorption cycle, which begins when a solution of ammonia in water is pressurized and heated to generate ammonia gas and desorbed liquid. The gas is condensed to a liquid state, which releases heat, and is expanded to low pressure to produce a vapor and a cooling effect. The resulting ammonia vapor is then absorbed back into the desorbed liquid to produce a solution and more heating. Finally, this solution is pumped back to the generator. The ThermoSorber modifies this well-known cycle by altering the solution flow path and adding proprietary heat and mass exchangers. The result is heat rejection at temperatures high enough to produce hot water that can be used in food processing plants and other applications.

Figure 1: ThermoSorber installed at a poultry processing plant

This 100-ton ThermoSorber uses natural gas to produce hot water for scalding and cold water for chilling. It is composed of proprietary heat exchangers, refrigeration cycle components, a solution pump, and controls.

Figure 2: ThermoSorber produces hot and cold water at the same time

From inputs of steam and a small amount of electricity to power the ammonia solution pump, the ThermoSorber efficiently produces both hot and cold water.



Note: F = Fahrenheit; hp = horsepower; psig = pounds per square inch gauge.

The ThermoSorber boasts a number of beneficial attributes:

- *Efficient.* When both heating and cooling effects are fully utilized, the ThermoSorber can reduce consumption of natural gas by 34 percent and electricity by 80 percent over conventional processes (see **Figure 3**, next page).
- *Robust.* The system features only one moving part—the pump for the ammonia solution. The design also makes the ThermoSorber immune to freeze-up problems that can plague other absorption systems.
- *Compact and lightweight.* The ThermoSorber replaces both boiler and chilling equipment yet weighs just 40 pounds per ton of cooling capacity. A 25-ton unit has a footprint of only 3 by 3 feet.
- *Environmentally friendly.* Ammonia does not harm atmospheric ozone. The technology requires a minimum

ammonia charge of only 1.5 pounds of ammonia per ton of chilling capacity, which minimizes concerns about ammonia toxicity.

- *Fuel flexible.* ThermoSorber can be fired with natural gas, propane, steam, fuel oil, solar heat, or waste heat.

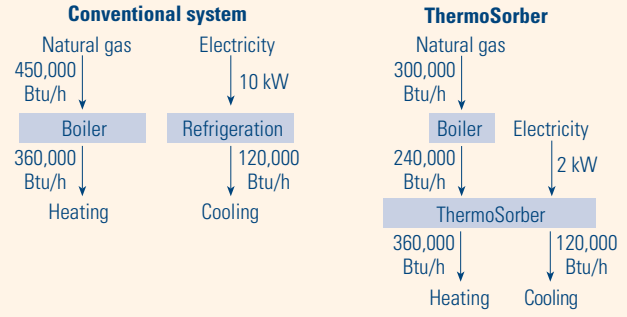
The California Energy Commission Food Industry Energy Research program sponsored the first demonstration of the ThermoSorber at a Central California poultry processor. Since 2003, the 10-ton unit has operated successfully, cutting energy use while delivering hot water at approximately 140° Fahrenheit (F) and cold water at 35°F. The system is driven by steam heat at 300°F, generated specifically for the ThermoSorber. In 2006, a 100-ton unit was installed in a larger poultry-processing application. Results from monitoring show that the total energy cost savings amount to more than $100,000 per year. Because the installation cost was $180,000, the energy savings yield a simple payback of approximately 1.8 years.

Applications

To achieve its full savings potential, ThermoSorber technology can be used at industrial and commercial sites where a combination of hot water, at temperatures in the range of 110°F to 160°F, and some chilling capacity is required. The types of sites that meet these conditions include: food-processing plants, dairies, breweries, restaurants, laundries, commercial kitchens, hospitals, apartment buildings, motels, gymnasiums, and indoor swimming pools. The ThermoSorber product is available in sizes ranging from 240 kilowatts (kW) of water heating (90 kW chilling) to 1,800 kW (700 kW chilling).

Figure 3: High-efficiency ThermoSorber cuts energy consumption

A ThermoSorber can supply as much heating and cooling as a conventional system while reducing natural gas consumption by 34 percent and electricity by 80 percent.



Notes: Btu/h = Btu per hour; kW = kilowatt.

California Codes and Standards

Because the use of the ThermoSorber reduces consumption of both natural gas and electricity, it yields a substantial decrease in carbon dioxide (CO_2) emissions. This reduction will help California meet its global-warming-related CO_2 reduction mandate. Those savings also reduce the emissions of atmospheric pollutants such as nitrogen oxide, thus enhancing air quality and especially benefiting non-attainment areas.

The technology also qualifies for efficiency incentives at some publicly owned California utilities, as well as for a low-interest loan program through the Commission.

What's Next

The Commission plans to hold at least one workshop to familiarize the food and beverage industry with this technology. To show the ThermoSorber's performance benefits when incorporated into different types of industrial processes, Energy Concepts will continue to install and monitor demonstration projects. The company is also working with several organizations to market the ThermoSorber and with others that are incorporating it in combined cooling, heating, and power systems.

Collaborators

The organizations involved in this project are Energy Concepts Co., Pacific Gas and Electric Co., and the National Energy Technology Laboratory.

For More Information

Reports documenting this project and providing more details may be downloaded from www.energy.ca.gov /pier/final_project_reports/CEC-500-2005-094.html.

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About PIER

This project was conducted by the California Energy Commission's Public Interest Energy Research (PIER) Program. PIER supports public-interest energy research and development that helps improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

Arnold Schwarzenegger, *Governor*

For more information see www.energy.ca.gov/pier

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