

VILTER INDUSTRIAL HEAT PUMP SOLUTION

Kraft Foods relies on industrial heat pump for sustainable operations

Innovative ammonia heat pump plant uses heat extracted from refrigeration for energy saving heating and cooling system.

Ammonia heat pump system delivers

- Annual operating savings of \$267,407
- 14,000,000 gallons of water saved annually
- Waste heat recovery of 7.0 MMBtuh (2.1 MW)
- 6.51 coefficient of performance (summer)
- 4.23 coefficient of performance (winter)
- Ammonia refrigerant with 0 ODP & 0 GWP
- 15% higher efficiency than comparable technologies
- Design for +20 years service without costly maintenance

Challenge

The Kraft Foods plant in Davenport, Iowa, made significant investments in energy conservation. With a focus on energy savings, the plant installed high efficiency boilers and invested to capture and recover boiler stack heat. Yet, like many food processing plants, Kraft Foods was paying for electrical energy to remove heat from their refrigerated spaces with an ammonia refrigeration system and rejecting that heat to the atmosphere. Also, they were paying for natural gas to add heat to hot water used for the hygienic cleaning of the plant.

If the rejected heat could be captured and used to provide water heating, substantial energy would be saved. The highest pressures and temperatures in the refrigeration system (compressor discharge gas) provided the best source for heat to be transferred to the sanitation clean-up water. But, as ammonia refrigeration practitioners who have employed "heat reclaim" practices have noted, ammonia at typical condensing

pressures, while possessing large quantities of heat energy, condenses at fairly low temperatures [75-95°F (24-35°C)]. The transfer of this energy to city water, through conventional heat exchangers, to create 145-185°F (63-85°C) wash down water, is only effective for limited pre-heating of the cold water supply.

If the refrigeration system compressor discharge gas, at fairly high pressures [180 psig (13.2 atm)] could be fed directly into the suction of a "heat pump" compressor and compressed to even higher pressures [i.e. 450-800 psig (32-55 atm)], condensing this higher pressure ammonia with cold water in a heat exchanger would capture much larger quantities of heat energy than heat reclaim and elevate the cold water supply from 60°F (15°C) up to the 145°F (63°C) required for wash down.

The requirement of the plant to have the wash down water classified as a potable supply presented another challenge, as local codes prohibit potable water to be in direct heat exchange with ammonia. Using such an ammonia heat pump system would require a secondary loop, thereby lowering the efficiency of heat transfer.

Given the need for sustainable projects to clear the same internal rate of return hurdle as non-sustainable projects, the challenge was to define and justify the project. The project costs would include tapping into the ammonia refrigeration system, adding and installing a custom ammonia heat pump system and employing the electrical energy to operate the high pressure ammonia heat pump system.

Solution

The ammonia heat pump system delivers hot water at 145°F using heat extracted from refrigeration and features Vilter single screw compressors. The inherent high pressure capability of the single screw compressor allows for full acceptance of the highest operating discharge pressure from the host system, even in excess of 180 psig, without the risk of rotor deflection and excessive bearing thrust loads, which can result in accelerated degradation, or the loss of efficiency due to over-compression.

With the lower 60°F (15.6°C) incoming cold water temperature during winter, the estimated heating capacity of the heat pump during winter conditions was estimated at 5.738 MMBtuh (1,682 kW), providing 135 GPM (30.7 m³/h) of continuous 145°F (62.8°C) hot water flow. The heat pump was estimated to provide an average year-round heating capacity of 7.013 MMBtuh (2,056 kW), heating 170 GPM (38.6 m³/h) from 62.5°F (16.9°C) to 145°F (62.8°C).

Since commissioning, the plant is heating 170 gallons per minute of water. And this hot water is delivered far more efficiently than from their natural gas hot water heater. The ammonia heat pump solution has cut heat energy cost by over \$250,000 each year and saves fourteen million gallons of water per year because of the reduced load on the evaporative condensers.

By using ammonia, Copeland's compressor technology solution offers a refrigerant with a good environmental profile (non-ozone depleting and zero global warming impact), delivers higher temperatures and provides superior performance benefits from its consumed resources than competing technologies. Also, the balanced radial and axial force design of the single screw compressor lowers stress on the unit's bearings, resulting in low operating and maintenance costs while delivering a performance unachievable with any other type of compressor.