



Energy savings in ammonia chillers and heat pumps with plate heat exchangers

Industrial chillers are widely used in many industries ranging from HVAC, general manufacturing, food processing, pharmaceutical and industrial applications such as cold storage and logistics centers.

The condenser and evaporator of the chiller can either be of an air heat exchanger type or be cooled/heated by e.g. glycol, brine or water. By utilizing the later technology, the refrigerant charge can be kept to a minimum and the complete refrigeration system can be placed in one machine room connected to air coolers, energy wells, dry-coolers through secondary systems using a less sensitive media such as water, glycol or even CO₂.

The energy consumption of a chiller is highly dependent on the design and performance of the associated heat exchangers, mainly the evaporator and condenser. In a traditional chiller with one evaporator and one condenser, the energy efficiency can be increased in three ways by change of the heat exchanger designs:

1. Increase the evaporation temperature
2. Decrease the condensation temperature
3. Increasing the subcooling

Selection of evaporators

The fluid temperatures on the secondary side are normally set by the process requirement; could be an industry process or the requirement for the indoor climate in a building.

By selecting the evaporation temperature, this defines the size of the heat exchanger. The evaporation temperature is directly connected to the evaporation pressure set by the physical data for the refrigerant. The higher the evaporation temperature, the higher the evaporation pressure. By having a higher evaporation pressure, the less the compressor needs to lift the pressure to reach the condensation pressure.

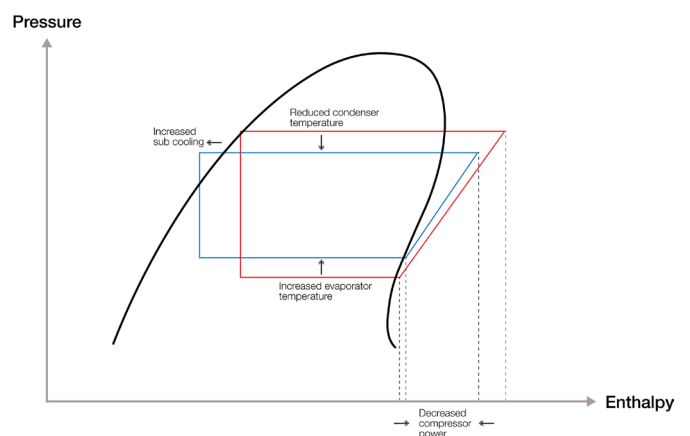
By utilizing a semi-welded plate heat exchanger a higher evaporation temperature, for instance 5°C instead of 2°C for a typical HVAC refrigeration application; cooling water from 12°C to 7°C, a substantial lower electricity consumption for the compressor can be achieved. The small extra investment in a larger heat exchanger can be paid back in a short time.

Selection of condensers

The principal for selecting condensers for a refrigeration system follows the process for evaporators, but the other way around. The condensation temperature follows the condensation pressure, and the lower the condensation pressure the less lift is necessary in the compressor. To maximize the energy efficiency of a refrigeration system, the condensation temperature should therefore be kept as low as possible.

By utilizing plate heat exchangers, a very close temperature approach (difference between leaving glycol/water and evaporation temperature in the heat exchanger) can be achieved, and thereby the condensation temperature can be kept low. In fact, using a plate heat exchanger with a superheated gas entering the condenser, the leaving water temperature can be higher than the condensation temperature.

By introducing subcooling, cooling of the liquid condensate, into a refrigeration system, more “free energy” can be taken up from the secondary media. As the subcooling increases, less mass flow is needed for the same capacity, which will result in less flow to the compressor and less energy consumption. By using a plate heat exchanger, the de-superheater, condenser and subcooler can be combined into one single heat exchanger, something which often requires three separate heat exchangers using a different technology.



Payback period for sustainability

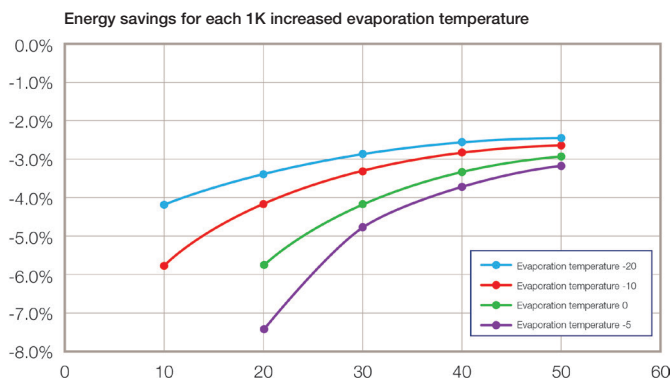
Chillers and heat pumps are one of the highest consumers of electricity in utilities part of plants and buildings, often running for extended time periods. By paying close attention to the selection of heat exchangers for condensation and evaporation we can help sustainability by saving our natural resources, as well as reduce costs over time.

How much energy there is to be saved depends mainly on the limits for the condensation and evaporation temperature.

Example: An Ammonia chiller is designed to cool 2,000 kW of water from 12°C to 7°C with a condensation temperature of 35°C.

If a heat exchanger is selected for an evaporation temperature of 2°C the nominal compressor power (assuming a compressor isentropic efficiency of 100%) is 274 kW. If the heat exchanger is selected for an evaporation temperature of 5°C, the nominal compressor power is reduced to 244 kW.

If the system runs 5,000 hours per year with an electricity price of 0,1 euro/kWh, the annual savings are 15,274 euros or 11% of the total cost of running the chiller.



Maintenance

Over time any heat exchanger might be subject to fouling caused by impurities on the water side as well as compressor oil fouling on the refrigerant side, mainly in the evaporator. Fouling might severely reduce the heat transfer performance resulting in increased condensation temperature as well as reduced evaporation temperature.

By designing an oil return system, the risk of oil fouling can be reduced. By selecting a semi-welded plate heat exchanger, the secondary side is openable for easily cleaning of the water/ brine side.

▼ PRACTICAL TIPS

1. Specify what evaporation and condensation temperature you want based on the secondary temperature. For an industrial ammonia system, a temperature difference between leaving water temperature and evaporation temperature of 2K often gives an efficient system. For condensers a temperature difference between leaving water temperature and condensation temperature of 0 to 1K gives a good balance between initial investment and operational cost.
2. Oil fouling might severely reduce the heat transfer performance, especially in evaporators. An oil fouling film of as little as 0.3 mm thickness can reduce the capacity with 33%. By installing a compressor oil return system this risk can be reduced substantially.