The Myth Regarding the Use of Ammonia in a DX Designed refrigeration system

The desire to use the world's most energy-efficient refrigerant, ammonia, in DX-designed refrigeration systems has led to many challenges and has rightfully earned the reputation of being a poor solution that does not always work well. There have been many problems, and over time, many attempts have been made without any significant breakthroughs. It was necessary to compromise the normal DX design and install liquid separators before the compressors and set superheating very high in order to avoid liquid flood-back and potential compressor damage. High superheating, and inefficient/non-dynamic evaporators combined with ammonia's high latent heat of vaporization have caused most of the challenges. Altogether, this has led to very poor energy efficiency. It is also a fact that water content in ammonia changes the boiling point and thus the regulation of superheating, which is calculated based on pressure and temperature; 1% water increases the bubble point by around 5K towards the end of the evaporation process. In DX evaporators, the water concentration in the ammonia will increase as evaporation progresses. Gradually this leads to an increase in bubble point, which conventional superheat control will identify as a "false" superheat signal and react accordingly. In addition, the water content in an ammonia refrigeration will reduce the refrigeration capacity and hence reduce coefficient of performance (COP).

Thanks to new sensor technology, new evaporator designs with new liquid distributors, as well as new practical experiences it`s now possible to design an ammonia DX system with all the advantages of a DX system design. The advantages consist of low charge refrigerant, no wet suction lines/pipes, and thus a high level of energy efficiency, smaller suction and liquid pipes, and in particular, much lower refrigerant inventory and reduced system capital costs particularly for large expansive plants.

Recommendations:

- **Use of a gas quality sensors "HBDX"**, which measure the liquid amount in the gas flow and can be calibrated to the desired sensitivity as "X" degree of dryness (regulation is now not dependent on the boiling point).
- Use of liquid separators designed as small tanks/pots without pressure drop (Küba design/Colmac Coil tank distributor).
- Dynamic evaporator design with high gas velocity, i.e. smaller evaporator pipes leads to a small delta T.
- Use of modulating compressor capacity control, where the capacity is changed steeples.
- Water and oil can be removed by draining from the collecting pipe at the bottom of the liquid separator.
- Innovative defrosting, where the draining of the condensate is controlled by the gas quality sensor, which conducts the condensate back and controls the opening of a pulse modulating magnetic solenoid valve (AKVA valve), which can save many kg of refrigerant.
- **The use of the defrost sensor "HBDF" (Defrost on Demand)**, which measures the ice thickness on the evaporator surface and leads to savings up to 10% energy.
- Gas outlet at the top of the receiver for hot gas defrost will minimise oil fouling in the evaporators, and defrosting can be carried out without increasing the condensing pressure (condenser pressure falls during defrost).

You can find a description of a new energy-efficient ammonia DX system from Melbourne, Australia, on the HB Products website: www.hbproducts.dk

You can also greatly benefit from using the same measurement principle for optimising and improving the efficiency of flooded and pump circulation evaporators as well as for minimising and controlling refrigerant amount in riser pipes. E.g. a pressure drop of 0.3 bar at -40 °C would result in increased power consumption of min. 25 %. An experiment with the measurement and control of four risers is performed at Claus Sørensen in Vejle, in collaboration with DTI (Danish Technological Institute).

By Michael Elstrøm, HB Products A/S, Bøgekildevej 21, DK-8361 Hasselager