Low-charge Ammonia Systems with High Efficiency

Controlling the liquid feed enables reduced ammonia charge

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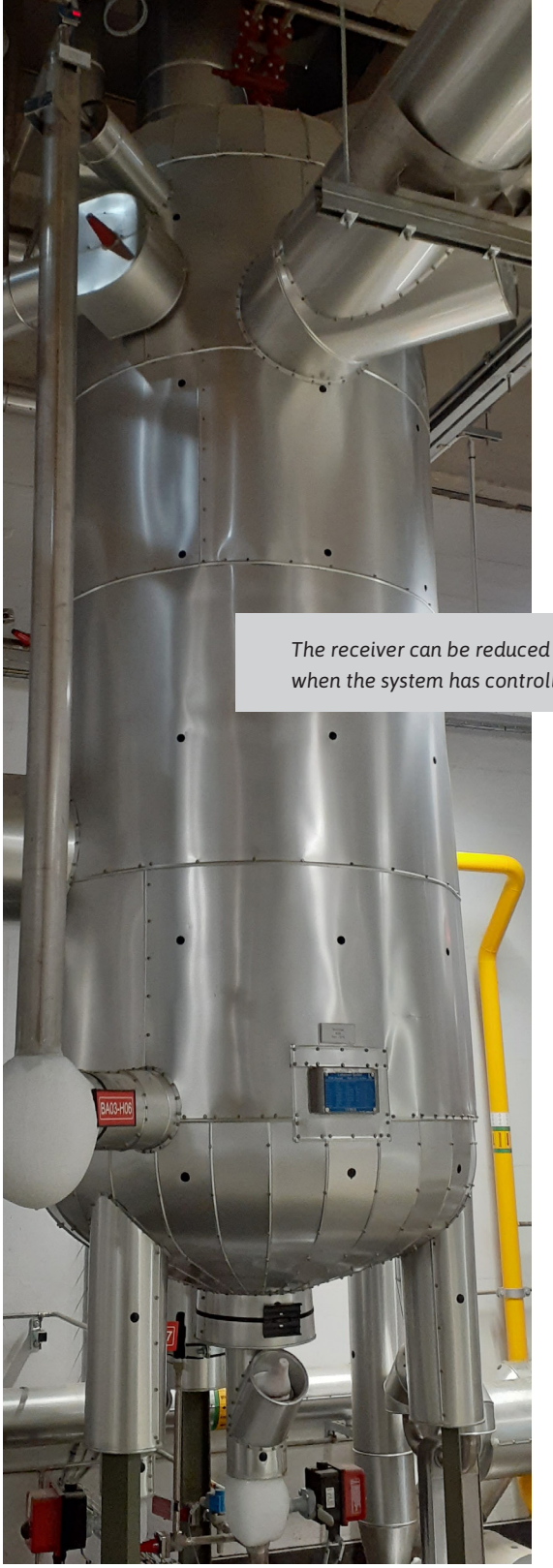
Ammonia plants are simple and energy efficient. However, due to its toxicity, and local legislation in many areas, it is essential to reduce the ammonia charge. A low-charge system can also be more energy efficient than traditional designs.

Here are some of the most important requirements, when aiming to reduce the ammonia charge in pumped systems.



The receiver can be reduced significantly when the system has controlled circulation

CONTROLLING THE LIQUID FEED

When cooling systems run at partial loads, which they often do, circulation rates tend to increase as less heat is supplied to the evaporators; with the compressors then having to work harder to maintain sufficiently low suction pressure. The lowest energy consumption is therefore achieved when the circulation rate is minimized. However, if the circulation drops too low, the liquid distribution might be inadequate, and the capacity of the system may be reduced.

This dilemma can be solved by installing a vapor quality control sensor, which measures the amount of liquid present in the gas leaving the evaporator.

To maintain a consistent liquid content in the gas, the circulation rate can be adjusted by installing a valve between the pump and the evaporator, or with frequency control of the liquid pumps.

Reducing the liquid feed allows the suction pressure to be maintained or even increased, resulting in lower energy consumption. A reduction of the circulation rate reduces the needed charge because you don't need to have refrigerant filling the suction pipes.

EVAPORATOR

Traditional evaporators contain a lot of liquid and the bottom acts as distributor. With low liquid circulation rates, a high-quality evaporator with good liquid distribution is essential. A poor distribution will reduce the overall efficiency and capacity of the evaporator.

REFRIGERANT QUALITY

In Europe most installed systems have a charge of approx. 5kg NH3/kW. This can be reduced to less than 1.5 kg/kW by controlling the circulation ratio as mentioned above. Such systems will still have hot gas defrost, but requires a clean refrigerant without water and air.

If your refrigerant is of poor quality, the ammonia evaporates first, leaving water and oil components that cannot evaporate, resulting in poor heat transfer efficiency. In a pump-circulated system, there is a small amount of liquid ammonia left that can carry both oil and water back to the separator, meaning no operational issues. The system will, however, run with lower energy efficiency, as the pumps are working constantly to pump the water around.

For more information about the importance of good liquid distribution and refrigerant purity, see this study from the Danish Technological Institute.

This 100 kW DX ammonia chiller has only 4 kg charge

Low-charge DX Ammonia Systems with High Efficiency

A low-charge DX system where all the refrigerant is evaporated can be as energy efficient as traditional systems. Here are some of the most important design requirements, when aiming to reduce the ammonia charge in DX systems.

CONTROLLING THE LIQUID FEED

DX ammonia systems can have even lower charges than pumped ones because the suction lines are dry. The typical number is around below 1 kg NH3/kW. If hot gas defrosting is not needed the charge can be reduced even more down to 0.04 kg NH3/kW.

DX systems are traditionally controlled based on a superheat measurement, but that is very inefficient. The only alternative way to control DX systems is to use a vapor quality sensor. The sensor detects the liquid content in the gas leaving the evaporator.

The sensor detects all the liquid, including the water in the refrigerant, which does not evaporate. To secure dry gas in the suction pipe the expansion valve is controlled based on the measured vapor quality. This means the sensor protects the compressor, but the system will be inefficient if the ammonia contains water.

The HB Products sensor used for DX and pumped systems is the same, but the DX versions has improved sensitivity. In DX systems, the sensor is normally located at the bottom of the horizontal suction pipe or at the wall of a vertical pipe.

EVAPORATOR

As mentioned above, it is now possible to achieve high efficiency in DX systems with very low ammonia charges, if the superheat is kept close to zero, but these designs are even more sensitive to a good liquid distribution than pumped systems.

Pumped systems start with pure liquid, which is much easier to distribute. In DX systems, a mixture of liquid and gas needs to be distributed. Therefore, you need a special distributor to ensure the gas doesn't bypass the partly liquid-filled channels, which would reduce the cooling power, with only the liquid-free channels contributing.

REFRIGERANT QUALITY

DX ammonia systems are even more sensitive than pumped systems to the purity of the refrigerant. If your refrigerant is of poor quality, the ammonia evaporates first, leaving water and oil components behind. This results in poor heat transfer efficiency. Where a pump-circulated system leaves small amounts of liquid refrigerant that can transport the water and oil back to the separator, DX systems evaporate all the refrigerant, meaning the effect of the impurities is more severe.