HB Products

ENERGY EFFICIENT PUMPED SYSTEMS

Energy efficient pumped systems.

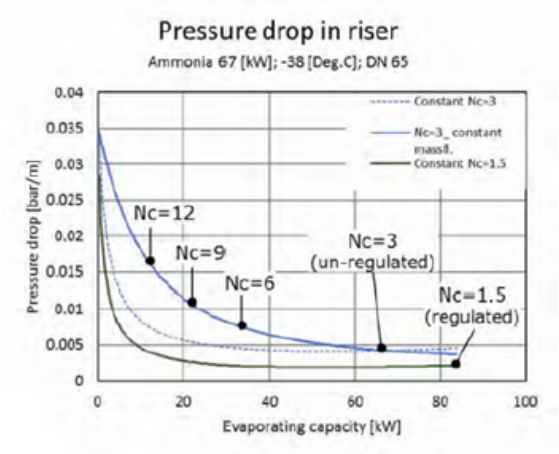
Refrigeration systems utilizing pumped refrigerant technology are widely adopted and known for their reliability. However, their energy efficiency can often be improved, particularly in poorly designed systems or when operating at partial load. When multiple evaporators are connected to a compressor, the suction pressure is determined by the evaporator or process with the lowest pressure demand. Typically, it is a single evaporator that defines the suction pressure, and under exceptional circumstances.

To reduce energy consumption in pumped systems, it is necessary to increase the suction pressure. Although this will decrease the capacity, the benefits are significant. For every Kelvin increase in pressure, the coefficient of performance (COP) improves by approximately 4%.

Most refrigeration systems are designed for full capacity but operate mainly at partial load. If the circulation rate is not actively controlled, it tends to increase during partial load conditions when less heat is supplied to the evaporators. This growing circulation ratio results in increased pressure loss in risers and lower suction pressure to maintain the functionality of the risers. The accompanying image illustrates how pressure drop increases with the circulation ratio with and without regulating the circulation ratio.

Circulation rate control

Control of the circulation rate can be achieved through a liquid valve or frequency control of the liquid pumps. The control mechanism should be based on vapor quality measurement or mass flow metering. The lowest energy consumption is achieved when the circulation rate is minimized, and most evaporators can operate with a circulation number as low as 1.5. However, at such a low circulation number, the liquid distribution might be inadequate, and the capacity may be reduced.



If evaporators operate with circulation numbers above 3, they typically become inefficient due to excessive liquid content, preventing proper boiling and evaporation of the refrigerant. This reduces gas flow and hampers the transportation of liquid back to the pump separator. In such cases, reducing the suction pressure is often used as a temporary fix, but it leads to increased energy consumption in the compressors.

Reduced refrigerant charge

In several countries a large ammonia charge is problematic due to safety and large quantities of HFOs are expensive so there is a general interest in reduction of the charge. A reduction of the circulation rate can reduce the needed charge because you don't need to have refrigerant filling the suction pipes. For many systems, it has been possible to extend the system with additional evaporators without increasing the charge just by controlling the circulation rate.

What is Vapor Quality control?

Vapor Quality Control involves measuring the amount of liquid present in the gas leaving an evaporator. The sensor used for this purpose is essentially a level sensor designed for two-phase flow measurement. It provides an analog signal (4-20 mA) sent to the PLC/controller. Based on this measurement, the liquid feed can be adjusted to maintain a consistent liquid content in the gas.

Liquid feed management can be accomplished by controlling the pump capacity or by incorporating a valve between the pump and the evaporator. In larger systems, valves are usually required since each evaporator necessitates its own control system unless they are identical and experience identical loads.

Batch process systems

Batch process systems pose a challenge for control, particularly batch freezers, plate freezers, and other batch processes. These processes require maximum capacity at the beginning when a significant amount of heat is extracted from the goods that need to be frozen, resulting in high heat transfer rates. Towards the end of the process, heat transfer decreases, and only the center part of the goods remains unfrozen. Consequently, the liquid feed should be minimized to prevent overfilling the evaporator with liquid. When Vapor Quality Control is used, you can reduce freezing time and control the last part of the batch process as direct expansion. This will eliminate the slug flow you usually have in the riser and improve the efficiency significantly because no reduction in suction pressure is required.

To achieve energy savings

It is crucial to balance the system so that all evaporators require the same suction pressure. The challenge lies in maintaining this balance when the system capacity fluctuates. By utilizing a Vapor Quality Sensor to measure the liquid leaving the evaporator and controlling the liquid flow based on this measurement, the riser can avoid excessive liquid accumulation, thereby reducing the required suction pressure.

Therefore, when an uncontrolled pump system operates at partial load, efficiency is significantly diminished since an increased amount of liquid needs to be transported back to the separator, requiring the compressors to work harder to maintain a sufficiently low suction pressure. By reducing the liquid feed, the system continues to operate effectively, allowing the suction pressure to be maintained or even increased, resulting in lower energy consumption.

Hence, a balanced system coupled with circulation rate control can yield substantial energy savings, particularly during partial load conditions by enabling an increase in suction pressure.

Where is the Vapor Quality Sensor installed?

The Vapor Quality Sensor must be installed directly after the evaporator, typically within the cold room. Placing the sensor on top of the riser would render it ineffective during partial load conditions when the riser becomes filled with liquid.

Don't install the Vapor Quality Sensor on the top of a riser. In a part load situation, the gas velocity will not be sufficient to carry the liquid upwards. This means the sensor will measure dry gas, but the sensor will not be able to see the difference between a riser filled with liquid and a dry riser. When the liquid feed is controlled based on this measurement you will end up with a system blocked by liquid.

When installed just after the evaporator the sensor can be used to control the liquid feed and secure a riser which is working.

If you install a drop leg after the sensor you protect it against liquid trapped in the sensor when the system is stopped. This is important for DX systems but can be skipped in overfeed systems.

HB Products

We develop sensors for energy efficient evaporator control, level measurement, leak detection, and oil regulation.

HB Products is a family-owned Danish company, which has specialized in the development and production of sensors for industrial and commercial refrigeration as well as for heat-pump systems since 2002. We are dedicated to supplying optimal solutions for energy-efficient evaporator control, level control, and oil management.

We remain at the forefront of innovation, utilizing cutting-edge technologies and supplying solutions based on years of specialized experience, technical know-how, and expertise in design and optimization. This enables us to develop and produce high-quality and durable products with high operational reliability, guaranteed by rigorous product testing.

We put emphasis on providing high flexibility, short lead time, and quick delivery to meet the needs of our customers and the global refrigeration and heat industry.

Over the past 25 years, HB Products has established a strong global presence with distributors operating in more than 60 countries. We cater to a diverse range of customers, from leading OEMs to small contractors.