



RC pump: Grace under pressure
in CO₂ refrigeration system



Alexander Cohr Pachai of OEM contractor Johnson Controls. Pachai designed the modern cascade refrigeration system, as used here at Pastella.

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The world's first pump optimised for the circulation of liquid CO₂ refrigerant is saving money and hassle at a Danish pasta factory, proving its worth to the system supplier, Johnson Controls.

The Grundfos RC pump uses about a third of the energy of the standard, centrifugal pumps that Johnson Controls' Alexander Cohr Pachai has otherwise used in his decade-long development of the "cascade" refrigeration system.

A modern cascade system circulates a natural refrigerant like carbon dioxide (CO₂) to all the evaporators in the low-stage part. Another natural refrigerant like propane is used in the upper-stage part to transfer the heat from the low-stage part to the ambient.

Pachai and Grundfos Product Manager Bjarne Dindler Rasmussen first tested RC pumps in a cascade system for a Danish supermarket in 2007. "These pumps turned out to be very efficient compared to the old ones," says Pachai.

In the pasta factory, the old, cast-iron pumps used 3.6 kW of electricity to run, where the stainless steel RC pump needs only 1.3 kW – using 20,000 kWh less over one year. That's a 64% energy savings.

"The energy consumption really surprised me," Pachai says. "It was so much lower and the pump is very efficient. We see a lot of potential with this new technology."

A cascade system

Since 2000, Pachai has installed several cascade systems around Scandinavia, the UK and New Zealand. "When I started out, they were first of their kind," says Pachai, Business Development Manager at global buildings market supplier Johnson Controls.



Grundfos RC pump

"Now they have become commonplace, and we are producing them in large-scale industrial systems."

Demand for refrigeration systems using natural refrigerants is rising as legislation and consumers have pressured companies to use natural refrigerants instead of synthetic ones, he says. Natural refrigerants such as CO₂ and ammonia (NH₃) can significantly reduce the overall environmental impact of refrigeration systems.

How it works

Pachai shows off the CO₂/propane cascade system in the engine room at Pastella, a Danish pasta maker owned by Beauvais.

"In this case we are refrigerating both the cold stores and the production areas. It's built on a system where we are pumping CO₂ using the Grundfos pumps," Pachai says. "You pump it out as a liquid, and then you evaporate parts of this CO₂ to generate the refrigerating effect."

The mixture of gas and liquid returns to the vessel, where a pipe takes the gaseous CO₂ to two, compact propane units on the roof of the building. The propane chills the gas through plate heat exchangers, causing it to condense and drip back to the vessel, where the whole trip begins again, says Pachai.

"I can talk about this system for days, because it is my baby," he says with a laugh.



No cavitation

In addition to the RC’s energy-saving abilities, Pachai says that it handles the special requirements of CO₂ much better than standard centrifugal pumps. Those cannot handle the vapour bubbles that occur when the CO₂ liquid accelerates through the rotating impeller. The associated drop in static pressure can cause the CO₂ to boil, forming vapour bubbles. These bubbles can cause an immediate reduction in the performance of the pump.

“You lose your cooling capacity when this happens,” Pachai says. “It’s why we always used an additional impeller with the old type, just to overcome this problem. But with this new [RC] pump, there are so many impellers, they are more robust to handling this situation without loss of capacity.”

Rasmussen explains that Grundfos

has designed the RC with more impellers than the competitor pumps.

“The RC pumps treat the liquid more gently,” Rasmussen says. “We don’t have to accelerate the liquid as much in the first stage, as is the case for our competitors with fewer stages. This causes less boiling – and therefore fewer problems with loss of performance due to vapour bubbles.”

With its low-required NPSH, the RC does not need the traditional loss-generating protective devices. Designers can thus reduce the dimensions and cost of a system, he adds.

“We anticipate that this pump – designed and optimised for CO₂ – will help to increase the efficiency of refrigeration systems and speed up and help the use of CO₂ in general,” says Rasmussen.

Facts

- Pump: Grundfos RC8-7
- Refrigeration: Cascade system with R290 (Propane) and CO₂ carbon dioxide (CO₂)
- OEM contractor: Johnson Controls Inc.
- Installation: Pasta factory
- Capacity: 272 kW at -10°C, 12 kW at -25°C
- Location: Pastella (Beauvais A/S), Skovlund, Denmark.



Pastella’s technical manager, Thomas Tyndkjær (above left), Johnson Controls’ Alexander Cohr Pachai (right), and Grundfos’s Bjarne Dindler Rasmussen (below left) discuss the RC pump in Pastella’s CO₂ refrigeration system.



Advantages: Grundfos RC pumps

Optimised for CO₂

A barrel type pump design is used due to the high system pressure in CO₂ refrigeration systems. The mechanical system and hydraulics are designed and optimised for the properties of CO₂ (density, viscosity and low temperature).

Easy integration into a refrigeration system

A reduced demand for NPSH and high hydraulic robustness makes integration into refrigeration systems easier. It also means overall height of system may be reduced. Control and protection of pump can be achieved with electronic components with built-in intelligence, avoiding losses associated with mechanical protective devices.

Designed for variable speed

Pump capacity can be controlled by variable motor speed, allowing operation with constant pressure difference and stabilising operation of the entire refrigeration system.

Low energy consumption

The high energy-efficiency of the pump, the use of variable speed capacity control and the use of intelligent pump protection reduces the energy consumption of the pump considerably, compared to traditional installations.

Compact and light

The complete use of stainless steel and the compact design have reduced the size and weight of the RC pump considerably when compared to competitors' pumps. Handling during installation and service is also much easier.



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