R744 innovations from Japan Part 2: integrated systems and improving CO_2 system efficiency in warm climates

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In part 2 of our reporting on the CO_2 technology innovations discussed at ATMOsphere Asia 2015 we focus on the presentations from Carel, Bitzer, and Danfoss on integrated CO_2 systems and technologies to increase the energy efficiency of CO_2 in warm climates. These include more traditional systems such as mechanical subcooling and newer ones such as parallel compression and ejectors.

Parallel Compression increases COP significantly

Oliver Javerschek, Bitzer, presented an empirical study of a CO_2 booster system of the 3rd generation with parallel compression (PC) and flash gas bypass (FGB), and no heat reclaim. Bitzer's study used the smallest available compressor for the parallel compressor, the 2MTE-7K.

An analysis of a parallel compression system in three different climates, Tokyo, Beijing and New Delhi presented by Javerschek showed that thanks to parallel compression an increase in COP of up to 14% is possible in higher ambient temperatures, and a maximum COP of up to 6 can be achieved. At the lower ambient temperatures the COP gradually decreases because of the reduced amount of flash gas bypass. At ambient temperatures of below 12.5°C the system has to be switched from parallel compression to flash gas bypass.

Overall, Javerschek concluded that parallel compression shifts the "CO_2 equator" into warm regions. He explained that parallel compression is more efficient than a flash gas bypass system because the temperature lift of the flash gas is not further increased before it can be compressed. Instead it is taken in with a high density and high pressure level which means a smaller displacement is required to compress the flash gas.

According to Anders Juul, Segment Strategy Manager, Danfoss, parallel compression, can achieve 5-10% energy improvement in warm climates, and approximately 25% energy savings on installed capacity.

Echoing what was said by Javerschek, Katsunori Shibata, president of Shibata Welding Constructions Co., (SWC), and CEO of CAREL Japan Co., Ltd, confirmed that parallel compression offers higher CO_2 system efficiencies at higher outside temperatures. When Carel compared the two different types of CO_2 system, a booster with flash valve and a booster with parallel compression, in three different climates, Munich, Venice and Palermo, the CO_2 booster systems with parallel compression was shown to reduce power consumption in each city by 4%, 7% and 10% respectively. What is more, compared to a hybrid CO_2/R134a system, the CO_2 system with parallel compression had almost the same power consumption, unlike the CO_2 booster with flash valve.

Shibata also said that a parallel compressor with flash gas valve synchronisation significantly increases efficiency of CO_2 transcritical refrigeration.

How will mechanical subcooling perform?

Another technology used to improve the efficiency of CO_2 transcritical systems is mechanical subcooling. According to Ian Crookston Sobeys Manager, Energy Management, the retailer has two stores being used for a CO_2 transcritical system benchmarking exercise, one of which uses mechanical subcooling. The power profile of the two stores, described below, will be used to verify energy savings:

- Milton, Ontario: 5,800m^2, with two racks and with reverse cycle defrost. Rack A has a cooling capacity of 42kW for low temperature and 111.5kW for medium temperature. Rack B has a cooling capacity of 52kW for low temperature and 127.5kW for medium temperature.
- Stratford, Ontario: 5,000m^2, with two racks and reverse cycle defrost. Rack A has a cooling capacity of 51kW for low temperature and 99kW for medium temperature. Rack B has a cooling capacity of 46kW for low temperature and 98kW for medium temperature. In addition the store has three separate low temperature suction groups per rack and mechanical subcooling, upstream of the gas/liquid receiver and upstream of the

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low temperature evaporators.

Data collection is currently underway, and first results will be presented at ATMOsphere America 2015, in Atlanta in June.

New to the game: ejectors

A third technology being investigated for its potential to increase efficiencies of CO_2 transcritical systems in warm climates are ejectors. An ejector works as a pre-compressor for the parallel compressor. Initial lab applications and field tests by Danfoss to investigate the benefits of ejectors have revealed conservative energy performance improvements over traditional R4041 plants of around 20%. There are two different types of ejectors: variable ejectors, controlled electronically, and fixed ejectors, which is the technology that Danfoss is focused on testing.

Improving efficiencies in colder climates: CO_2 systems with heat reclaim

In more northerly climates integrated CO_2 systems with heat reclaim were highlighted in several of the ATMOsphere Asia 2015 presentations as another key energy saving technology. In Norway Danfoss has provided different components for a KIWI CO_2 transcritical store featuring state of the art heat reclaim. The 1300m^2 pilot store, which has a transcritical CO_2 booster system, has achieved 40% energy savings, and is expected to perform even better after system setting optimising. The energy savings can be attributed largely to both the refrigeration system with heat reclaim and the fact that the KIWI store is based on a total store approach.

Carel's Katsunori Shibata also touched on integrated CO_2 systems with heat reclaim, highlighting the benefits of controls able to regulate many different CO_2 rack components with one unit. Controllers such as Carel's, are able to regulate MT and LT compressors, heat recovery, flash gas valves and more, helping to reduce installation costs, improve efficiency, and increase usability. They also allow for faster commissioning.

According to Crookston, in Canada, Sobeys, who first trialled CO_2 transcritical refrigeration technology in 2009, uses booster system with heat reclaim as its standard refrigeration technology. In the UK, Tesco is also finding that CO_2 systems with heat reclaim are cost effective and therefore sustainable over the long term, said Robert Hurley, Group Head of Refrigeration & HVAC Standards, Tesco.

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PRODUCTS OF INTEREST

Rack controller
Compressor
from CAREL INDUSTRIES S.p.A.

Controller to regulate CO_2 gas cooling, type EKC 326
Gas Cooler
from Danfoss

Extended range: transcritical CO_2 compressor models
Compressor
from BITZER

MORE INFORMATION

- ATMOsphere Asia 2015 events page
- Anders Juul: Retailers ensure sustainable technology uptake
- Ian Crookston: CO2 transcritical system benchmarking
- Oliver Javerschek: Empirical evaluation of CO2 booster system with parallel compression
- Katsunori Shibata: Small footprint CO2 applications

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