



Güntner gas coolers for the first transcritical CO₂ plant in China significantly improve the COP

A wealth of Güntner's expertise has gone into China's first transcritical CO₂ plant, which provides reliable refrigeration for Metro's new Cash & Carry market in Beijing Li Shui Qiao. Peak summertime temperatures that almost reach the 40 °C/104 °F mark are the reason for using this efficient technology. An effective gas cooler solution by Güntner has been installed: A flatbed gas cooler in dry cooling mode combined with a V-SHAPE gas cooler in optional adiabatic cooling mode for summer.

Thanks to the adiabatic system, the temperature of the air entering the coil is significantly lower. Hence, the CO₂ outlet temperature can be much lower, improving the system's COP by an average of 25 % during the summer months and by even up to 50 % at extreme ambient conditions with a dry bulb temperature of 40 °C/104 °F and a relative humidity of 35 %.



Overview

Business line:	Supermarket refrigeration
Application:	Air conditioning and logistics
Country/Region:	China/Beijing
Fluid:	CO ₂
Product:	FLAT Vario flatbed cooler of type GGHV V-SHAPE Compact condenser GGDC CUBIC Vario direct evaporator of type CXGHN SLIM Compact direct evaporator of type GASC CX

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▲ A Gntner V-SHAPE compact gas cooler of type GGDC is sprayed when the outside temperature rises above 20 °C/68 °F, thus reliably cooling the hot CO₂ gas from 41 °C/105.8 °F to 34 °C/93.2 °F with this design.



▲ At the top and bottom of the image: Gntner Flat VARIO flatbed gas coolers of type GGHV, which perform the initial stage of CO₂ cooling and heat recovery by cooling the hot gas from between 121 °C and 103 °C/ 249.8 to 217.4 °F down to 41 °C/ 105.8 °F with this design.

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China and the German wholesale chain Metro both have the same ambitious environmental objective, namely to cease using HCFC refrigerants in favour of natural ones. By 2030, Metro plans to use natural refrigerants in its department stores all over the world wherever this is economically feasible. Metro, which operates in China under the name “Mai De Long”, has declared CO₂ to be the refrigerant of choice for this. By the end of 2017, Metro had already installed 28 subcritical CO₂ systems in China.

Just as in Germany, customers of Metro’s Cash & Carry stores in China include hotels and restaurants, caterers, small and medium-sized retailers and institutions. As of June 2018, “Mai de Long” operated 93 wholesale stores in China.

Metro is the only wholesaler in the Chinese market to have introduced the international HACCP concept. Metro trains around 400 Chinese companies and the 20,000 farmers who supply them to ensure high-quality products and good production standards. Accordingly, the full-range vendor Metro also attaches great importance to using state-of-the-art refrigeration technology.

Phasing down of F-gases

Olaf Schulze, Metro’s Director of Energy Management, describes the installation of the first transcritical CO₂ system at the end of 2017 as “a milestone on the road to phasing down fluorinated gases”, both for the company and for China. And ultimately, from 2025, Metro plans to equip all new Cash & Carry wholesale stores in China with transcritical CO₂ systems.

The continental climate of large parts of China poses a special challenge to implementing climate-friendly cooling systems. Over 80 % of Chinese cities experience temperatures in excess of 35 °C/95 °F during the summer months, and such climatic conditions were previously thought to preclude the economic use of the refrigerant CO₂.

A further challenge to introducing transcritical CO₂ technology into the Chinese market was that the mature technique was developed in Europe, and at the time of its market launch, there were very few skilled locals in China who could install and maintain this environmentally-friendly technology. It was therefore necessary to either supply this expertise alongside the technology or to train people locally.

Local Chinese partners

Looking for a locally active, technically experienced and CO₂-aware company to install and maintain CO₂ cooling technology, Metro found a suitable partner in the plant contractor and system integrator Shanghai Fute Refrigeration & Electrical Engineering. This company already had considerable experience in carrying out design tasks, installing and maintaining subcritical CO₂ systems, and they also have enough knowledge regarding the design, equipment supply, installation and system maintenance of transcritical refrigeration systems.

The collaboration between the European component manufacturers and the local refrigeration engineer was characterised by such constructive, close cooperation that all the refrigeration equipment could be installed within two months and taken into operation in January 2018.

The refrigeration system supplies an area for chilled goods on the sales floor, a small low-temperature storage room, a normal-temperature cold room and a cooled workspace.

Metro relies on Gntner technology, and this also applies for air coolers: Gntner CUBIC Vario CXGHN CO₂ evaporators cool the cold storage facilities and Gntner SLIM Compact GASC CX CO₂ evaporators are used to air-condition the sales floor and lobbies.

CO₂ booster systems

Two transcritical CO₂ systems were installed in the machine room of the new market: one for applications at high temperatures (16 to 20 °C/60.8 to 68 °F), and one for medium (0 to 8 °C/32 bis 46.4 °F) and low temperatures (-18 to -20 °C/-0.4 bis -4 °F). They run in transcritical mode only in the hot summer months but are mainly operated subcritically. The total cooling capacity is about 360 kW/1,228,371 Btu/h: half of it is used for the high-temperature applications, and the other half for the medium- and low-temperature applications. Some of the total refrigerating capacity was installed redundantly for safety reasons.

Both the high-temperature system and the medium- and low-temperature system is equipped with the parallel compression feature. This can avoid the unnecessary CO₂ pressure drop across the bypass valve comparing to the conventional system with flash gas bypass, thus improving the system's COP.

The refrigeration system is also notable for its efficient heat recovery. When required, a heat exchanger upstream of the gas coolers extracts heat from the hot CO₂ gas and removes it from the CO₂ cycle.

A further special feature of this installation is Güntner's two-stage gas cooler, which ensures that the system operates so far as possible in subcritical mode. With conventional dry gas cooling, the system would switch to transcritical mode at outside temperatures above 20 °C/68 °F. With the solution installed here, the system will not switch to transcritical (and less efficient) operation until the outside temperature reaches a value between 26 °C and 28 °C/78.8 to 82.4 °F.

Güntner's two-stage CO₂ gas cooling with Güntner FLAT Vario and Güntner V-SHAPE Compact

In view of the limited footprint available on the roof and after intensive consultation with the plant contractor, Güntner reduced the size of the gas cooler equipment as far as technically feasible. Because water is scarce in northern China, it was also necessary to limit its use to the absolute minimum.

Most of the heat from the hot gas is removed from the process using a "dry" Güntner FLAT Vario flatbed cooler of type GGHV. The incoming hot gas has a temperature between 121 and 103 °C/249.8 and 217.4 °F and is cooled to 41 °C/105.8 °F.

During the second gas cooling stage, gas is cooled down to 34 °C/93.2°F inside a Güntner V-SHAPE Compact gas cooler of type GGDC with HydroPad. In adiabatic

Beijing

The Chinese capital Beijing is an economically flourishing metropolis. In 2017, the population of the municipalities that make up Beijing reached 21.71 million. On weekdays, Beijing also has a large influx of tourists and visitors from other parts of China.

The citizens of Beijing include a comparatively large number of wealthy and affluent consumers who are increasingly adopting western consumption habits. The per capita income is well above average.

Beijing is also one of the few cities that has opened up its retail sector to foreign investors and joint venture companies. Unsurprisingly, since the late 1990s, the number of supermarkets and chain stores in Beijing has been rapidly increasing.

operation, temperatures drop below the outside air temperature in the gap between the pads and the fins. This means that, when operating in transcritical mode, the two-stage gas cooler cools the hot gas to an average of 3 K/37.4 °F below the dry bulb temperature of the ambient air.

This represents a 25 % increase in the system's COP compared to mere dry cooling operation. A gas cooler in dry cooling mode would typically achieve values of only 2 K/35.6 °F above the ambient temperature. If, for example, the ambient temperature at midday is 40.4 °C/104.72 °F, then the second (adiabatic) stage cools down the hot CO₂ to 31.6 °C/88.88 °F. The resulting final temperature is thus 10.8 K/51.44 °F lower than with just dry cooling. Judging by this example, the COP of the entire refrigeration system would be improved by as much as 50 %.

Shifting the “conventional” CO₂ equator

The controller of the rack system has a higher priority than the Güntner controllers of both gas coolers used to control the fan speed. The Güntner Motor Management (GMM) operates in slave mode and serves only as receiver of signals from the master system. The Güntner Hydro Management (GHM) regulates the use of water for the HydroPad of the Güntner V-SHAPE Compact.

Adiabatic pre-cooling is a very effective solution that allows using transcritical processes for refrigeration also in subtropical and tropical regions. This solution has the further advantage of a low risk of corrosion because there is no need to apply any (untreated) water directly to the coil compared to conventional water spray solutions where some water will evaporate on the coil. Yet another benefit is that, in particular in view of the extremely hard water in Beijing, there is no danger of the heat exchanger coil furring up, which would lead to a steadily increasing loss of capacity.

The use of parallel compression also helps to move the CO₂ equator into warmer climatic zones prevailing, for example, in Beijing. Both the contractor, Shanghai Fute Refrigeration & Electrical Engineering, and Metro are extremely satisfied with the operation of the installed solution in Beijing Li Shui Qiao.