Four-stage heat recovery at wholesale store

A transcritical CO_2 booster system with four-stage heat recovery at a wholesale store allows savings of €200,000/$235,756 per year. A net investment of €1.4m/$1,650,880 was made to remodel the refrigeration equipment. Due to the annual savings in operating costs, however, the return on investment is expected to be reached already in about five years.

The lion's share of the energy costs in the food retailing industry – 45 per cent in average – is used by the cooling equipment. At the same time, the waste heat of an average supermarket refrigerating system is several times higher than the annual heat requirement. Reason enough to unlock cost savings here based on an economic efficiency calculation. This is why the entire technology of a wholesale store was remodelled from 2014 to 2015 in line with this approach.

Previously, a central R-22 refrigerating plant as well as two decentralised refrigerating plants were installed at the site of the wholesaler. The room volume to be cooled was 3,600 m^3/127,134 ft^3 while the annual energy consumption was about 2.4m kWh / 8,188.8 MBTU. In the framework of remodelling, the normal- and low-temperature

Overview

Business line:	Commercial Refrigeration
Application:	Supermarket Refrigeration
Country/Region:	Germany
Fluid:	CO_2
Product:	Gas cooler V-SHAPE Vario GVD (new series: GCDV AS)
	Heat pump evaporator CXGHN (new series: GACV CX)
	Evaporator CUBIC Vario CXGHF (new series: GACV CX)
	Evaporator SLIM Compact CXGDF (new series: GASC CX)
	Evaporator FLAT Compact DHF (new series: GADC CX)

Güntner GmbH & Co. KG
Hans-Güntner-Straße 2 – 6
82256 FÜRSTENFELDBRUCK
GERMANY
www.guentner.eu

▲ Ten high efficiency compressors that can be used for a wide range of applications are installed in the machinery room and can provide cold for four temperature levels via the evaporating temperature.

▲ In the processing and order-picking rooms, the Güntner CO_2 evaporators DHF and GHF in stainless steel design with epoxy-coated fins were integrated to prevent corrosion.

cooling capacities were expanded by about 80 per cent to a room volume of 6,500 m^3/229,548 ft^3. In addition to the cooled room volume, refrigerated cabinets of 150 metres/492 ft in length were installed.

Despite this cooling capacity expansion by approx. 80 per cent, the energy consumption of the wholesale store is only about 1.6m kWh / 5,459 MBTU per year now. As about 400,000 kWh/1,365 MBTU of heat are recovered, two thirds of the heating demand are covered using regenerative sources.

In addition to these energy savings of about 33 per cent, the goods turnover rate increased by 3.5 per cent thanks to the new equipment, thus further improving the wholesaler's operating result.

Transcritical CO_2 booster system

The new transcritical CO_2 booster system follows the basic principles established by system provider Meilbeck Kälte- und Klimatechnik commissioned with the planning and execution: On one hand, cooling is in line with demand and, on the other hand, the waste heat is used for internal needs (raw water, heating, ventilation) via interfaces and dissipated to the surroundings only in case it cannot reasonably be used for the building (e.g. at high external temperatures).

Ten high efficiency compressors that can be used for a wide range of applications are installed in the machinery room and can provide cold for four temperature levels via the evaporating temperature. The individual temperature zones are each partly redundant, and the compressor groups are connected with one another via a controlled valve. Hence, other compressors can easily compensate for failures. The refrigerant CO_2 is artificially cooled after leaving the Güntner gas cooler V-SHAPE Vario GVD to reduce thermodynamic losses caused by flash gas in the refrigerant lines and to achieve in this way smooth operation of the plant and higher efficiency levels respectively. The ErP-compliant CO_2 gas cooler is designed for transcritical operation (capacity of 518 kW/ 1.768 MBTU/h) as well as subcritical operation (capacity of 444 kW/ 1.515 MBTU/h) – this means a maximum of 120 bar/1,741 psi and 150 °C/ 302 °F.

Depending on the capacity requirement and room space, the normal- and low-temperature storage rooms and sales areas respectively for meat, dairy products, fruits and vegetables, and for the air locks installed between the individual temperature zones, are equipped with the Güntner CO_2 direct evaporators CUBIC Vario CXGHF (new series: GACV CX) and the evaporators SLIM Compact CXGDF (new series: GASC CX) and FLAT Compact DHF (new series: GADC CX).

In the processing and order-picking rooms, the Güntner CO_2 evaporators DHF and GHF in stainless steel design with epoxy-coated fins were integrated to prevent corrosion.

Auto-adaptive system control

The extreme cold for the low-temperature storage rooms is generated at an evaporating temperature of -34 °C/-29 °F whereas the freezer cabinets require -29 °C/-20.2 °F, the normal cold rooms -7 °C/19.4 °F and the air conditioning plant -1 °C/30.2 °F. For optimal control, the refrigerated cabinets and cold rooms are equipped with electronic expansion valves. Thanks to the system networking, the control automatically sets the ideal operating point. Also defrosting of cold rooms and refrigerated equipment is achieved via auto-adaptive defrost methods.

The combined low-temperature unit installation was designed in such a way it can supply the LT equipment as well as the LT rooms. Compressor units consisting of either two or three compressors are deployed for this purpose. This „division" is also applied in normal temperature applications for supplying the air conditioning plant and the NT storage rooms. With this need-based design for the actually required tem-

Güntner GmbH & Co. KG
Hans-Güntner-Straße 2 – 6
82256 FÜRSTENFELDBRUCK
GERMANY
www.guentner.eu

perature levels (and not only for the lower one of the two), the energy consumption for temperature control decreases, and cooling is based on the temperature requirements of the respective foodstuffs to be cooled.

Meilbeck Kälte- und Klimatechnik states that the savings achieved through this zone control amount to about 10 per cent of the operating costs. For this, the scalable heat recovery is a prerequisite for increasing the efficiency as a whole.

Güntner V-SHAPE Vario GVD as gas cooler in four-stage heat recovery

The heat recovery from CO_2 hot gas takes place in four stages and is controlled via electronic valves. During the first stage, the hot gas flows through plate heat exchangers in the opposite direction to the hot water flow, thereby desuperheating the hot gas and heating up the raw water. The heat is first stored in a hot water buffer tank with a filling volume of 6,500 l/229.5 ft³ so that the plant can respond flexibly to heat requirements, allowing to compensate for capacity fluctuations regarding heat recovery.

About 25 per cent of the heat of the hot gas are already dissipated at this step. Heat can be transferred to a heating circuit via two other plate heat exchangers connected in parallel, resulting in another 35 per cent of heat dissipated from the already desuperheated hot gas. In stage three, a Güntner V-SHAPE Vario GVD exclusively dissipates non-usable heat to the environment. Using a bypass, it is also possible to circumvent the gas cooler completely when heat requirements are high; the heat of the hot gas is then recovered by 100 per cent and supplied for operational use. The Güntner CO_2 gas cooler V-SHAPE Vario GVD provides a total condenser capacity of 520 kWh/1.774,240 MBTU.

CO_2 heat pump evaporators for the purpose of heating

If more heat is needed than provided by the refrigerating plant or the cooling points, two CO_2 heat pump evaporators can be operated to cover the heat demand peaks. The evaporators have a COP of up to 4.2. Adding the waste heat of the refrigerating plants, the compound system can provide an average thermal output of 300 kW/1.024 MBTU for the raw water and the heating. This is about two thirds of the heat required in average so that the condensing boiler on site is used only for the purpose of covering wintry peak loads, or when external temperatures drop below -5 °C/-23 °F.

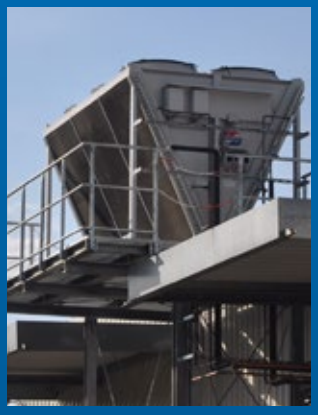
Complex control

The challenge for the control of such a complex transcritical CO_2 refrigerating plant with several temperature zones is that all the refrigeration circuits are interconnected and that any intervention in one circuit has an impact on all the other circuits. The combined control developed specifically for the operation of transcritical CO_2 systems controls the suction pressure (low pressure), the intermediate pressure (via the pressure in the refrigerant receiver), the high pressure and the gas cooler. The low pressure range of the booster system is controlled separately through the combined control.

The heat recovery functions are implemented in the combined control, allowing to coordinate at any time the current operating state of the refrigerating plant with the heat recovery. The precise heat demand is transferred in each case to the four-step heat recovery via an analogue heating control signal. Thanks to the system networking, the control automatically sets the ideal and hence most economic operating point.

Energy management

In order to energetically and hence economically further optimize the plant, energy consumption data are recorded and analysed in detail to unlock further cost savings.



▲ The refrigerant CO_2 is artificially cooled after leaving the Güntner gas cooler V-SHAPE Vario GVD to reduce thermodynamic losses caused by flash gas in the refrigerant lines and to achieve in this way smooth operation of the plant and higher efficiency levels respectively.

▲ The heat is first stored in a hot water buffer tank with a filling volume of 6,500 l/229.5 ft³ so that the plant can respond flexibly to heat requirements, allowing to compensate for capacity fluctuations regarding heat recovery.

Güntner GmbH & Co. KG
Hans-Güntner-Straße 2 – 6
82256 FÜRSTENFELDBRUCK
GERMANY
www.guentner.eu

After all, energy management is, according to system provider Meilbeck, a process of improvement during the operation of the plant. This process continuously ensures that plants are becoming increasingly efficient.

The transcritical booster system has an advantage that should not be underestimated: The system is scalable for the capacity range between 100 and 1,000 kWh (341,200 and 3,412,000 BTU) and can thus be adapted for the most diverse applications.

Güntner GmbH & Co. KG
Hans-Güntner-Straße 2 – 6
82256 FÜRSTENFELDBRUCK
GERMANY
www.guentner.eu

G_REF_108_V1_EN