White paper from Eckelmann AG, Wiesbaden
CO_2 refrigeration systems in modern bakery technology. First published similar in KKA 2/2019 (DE).

CO_2 refrigeration systems in modern bakery technology

Photo: KOLB KÄLTE

The Mangold bakery is an Austrian family business and is managed in the fourth generation by Monika Haag (née Mangold) and Egon Haag. During the last 15 years, the company has experienced strong growth and plans to open its 32nd branch in Vorarlberg in Austria by the end of 2018. In 2002 it had just 5. The establishment of its own network of stores also means greater independence for the company; 15 years ago, the Mangold bakery achieved around 90 percent of its turnover from retailers, but today this ratio has completely reversed in favor of its own branches. Sales in 2016 amounted to 17 million euros.

Mangold currently employs about 400 people. In order to create the conditions for further solid growth, Mangold built a new main facility in nearby Dornbirn in 2017/18. The company is investing around 9 million euros in this new site. The previous company headquarters in Wolfurt near Bregenz is closed down.

Production is located on the ground floor of the two-story building, which has a floor area of almost 3,000 m^2 and a store integrated into it. The upper floor offers space for the administration of the company and lounges for the staff. The production facility has been planned to meet the requirements of a modern craft bakery. This allows for more efficient work processes and higher quality. Production capacity has been expanded by up to 40 percent compared to the previous main production facility in Wolfurt.

“Cold” baking costs energy

Refrigeration technology plays a key role here because in a modern bakery partially cooked dough, in particular, need to be cooled using gentle processes and stored in refrigerated rooms before being delivered to the stores and then being baked there. The new facility has around 420 m^2 refrigerated space (a cooling capacity of 2580 m^3) with a large number of refrigeration and freezing rooms as well as temperature-controlled rooms for fermentation.
The refrigeration system was created by Kolb Kälte from Rüthi in Switzerland, a company belonging to Pitec AG, the largest full-range supplier of bakery and catering technology in Switzerland. Kolb Kälte specializes in bakery refrigeration and has been offering refrigeration and energy-saving solutions for commercial and industrial bakeries for over 35 years. The company worked closely together with Eckelmann AG in making the MSR solution a reality. Decisive for the choice of the E*LDS control system were, among other things, the many years of competence in the control of sophisticated CO_2 booster systems and the high degree of flexibility in the integration of special functions for heat recovery and temperature-controlled processes.

Fig. 1: The new facility has around 420 m^2 refrigerated space (a cooling capacity of 2580 m^3) with a large number of refrigeration and freezing rooms as well as temperature-controlled rooms for fermentation. (Photo: KOLB KÄLTE)

Statistics from Switzerland show that the refrigeration system accounts for around 30 percent of the electricity consumption in bakeries on average.1 If one considers the total energy demand (Ø 60% gas/heating oil, Ø 40% electricity), the refrigeration system requires almost 15 percent of the total energy. It is precisely through the processing and storage of intermediate products that the electricity requirement for the fermentation interruption and for the freezing and storing of frozen dough pieces in bakeries can be even higher today. Any measure to increase the energy efficiency of the refrigeration system therefore makes a significant contribution toward economic efficiency.

"Larger bakeries with many branches and employees tend to have lower proportion of energy costs. Energy costs per sale average 3.3 %."2 Where a bakery has fewer than 20 employees, energy costs can constitute as much as 5 percent.3

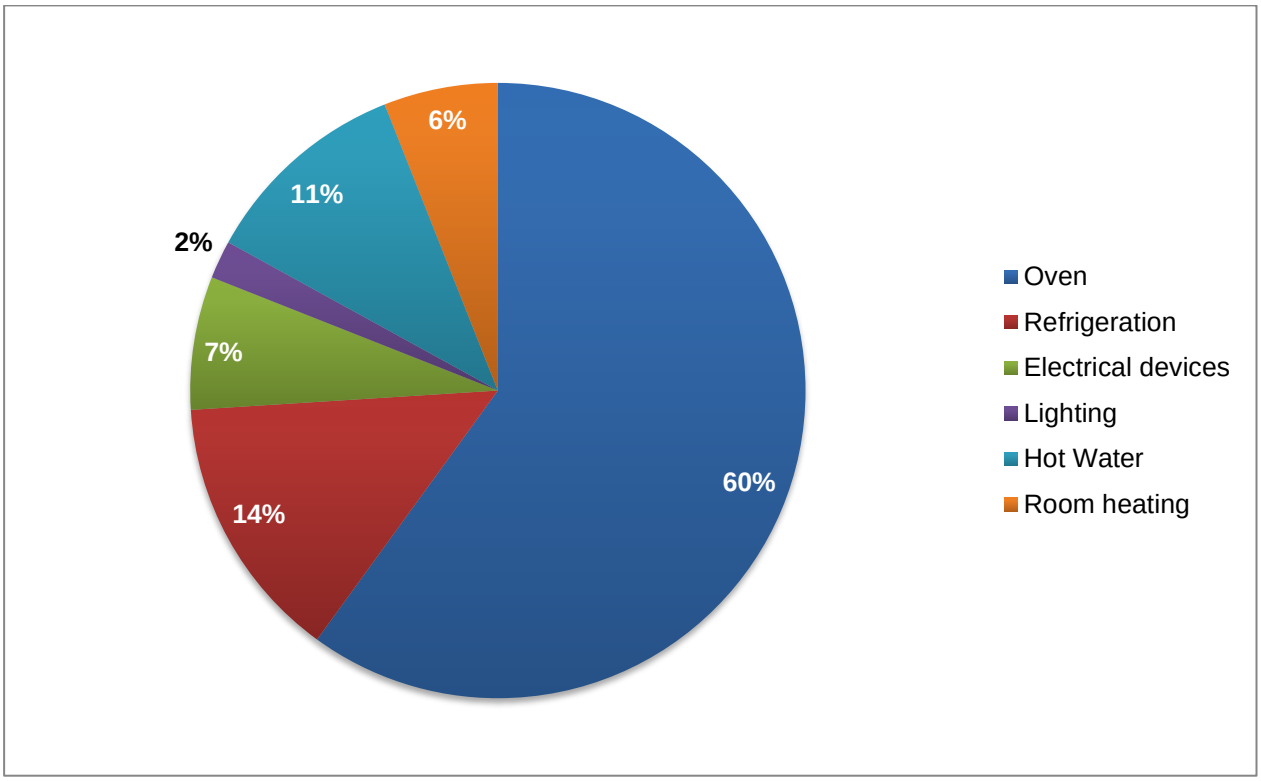

Fig. 2: Distribution of the total operational energy consumption of bakeries4

1 *„Energieeffizienz in Bäckereien*". Online: www.energie.ch/baeckerei, retrieved on 25.09.2018.

2 Handwerkskammer zu Leipzig / Mittelstandsinitiative Energiewende und Klimaschutz: *„Die energieeffiziente Bäckerei*". January 2017. Online: www.mittelstand-energiewende.de/fileadmin/user_upload_mittelstand/MIE_vor_Ort/2017_02_10_Vorlage-B%C3%A4cker-Finale.pdf , retrieved on 20.09.2018.

3 EnergieAgentur.NRW: "*Energiesparen in der Bäckerei*". Online: www.energieagentur.nrw/energieeffizienz/energieeffizienz-nach-branchen/energiesparen_in_der_baeckerei , retrieved on 25 September 2019.

4 Source: Müller, Karla Rika: "*Nutzung von Abwärme im Gewerbe"*. Bakeries case study. bachelor thesis, HafenCity University Hamburg 2013, p. 14. online: http://edoc.sub.uni-hamburg.de/hcu/volltexte/2013/99/pdf/Bac_Mueller.pdf, retrieved on 14 September 2018.

A complete CO_2 booster system

Eckelmann has automated the refrigeration pack with three pressure levels as well as the heat recovery. The refrigeration system consists of a transcritical CO_2 booster system containing a total of 11 compressors. In order to increase the efficiency of the chiller, the GU / GV network (GU = fermentation interruption, deep-freezing / GV = fermentation retardation, normal cooling), a total of eight compressors for the high- and low-pressure stage, is driven by a parallel compressor, which at the same time takes over the air conditioning. The additional medium-pressure compressor ensures that plant operation is safe and extremely stable. The GU/GV compound delivers a total cooling capacity of 180 kW / 180 kW / 320 kW with evaporation temperatures of -35 °C /. -10 °C or +3.5 °C. The air-pressurized gas coolers have a total capacity of 1078 kW.
In cooling/freezing/shock freezing, a distinction is made between the individual pressure stages depending on the process and product requirements in order to always achieve the best possible COP. Meeting the requirements of the individual products with high repeat accuracy is particularly challenging in terms of the control technology. Eckelmann supplied the six control cabinets for the refrigeration system and an additional cold-water chiller as a complete solution and assisted the customer on site during the system launch and fine-tuning.

Fig. 3: The transcritical CO_2 booster system containing a total of 11 compressors (Photo: KOLB KÄLTE)

The VS 3010 CT is used as the compound controller. It regulates the suction pressure, the medium pressure (MP via the pressure in the refrigerant receiver), the high pressure (HP) and the gas cooler. No separate components are therefore required. In transcritical mode, the optimum high pressure for achieving a high COP is continuously calculated and used as the control variable.

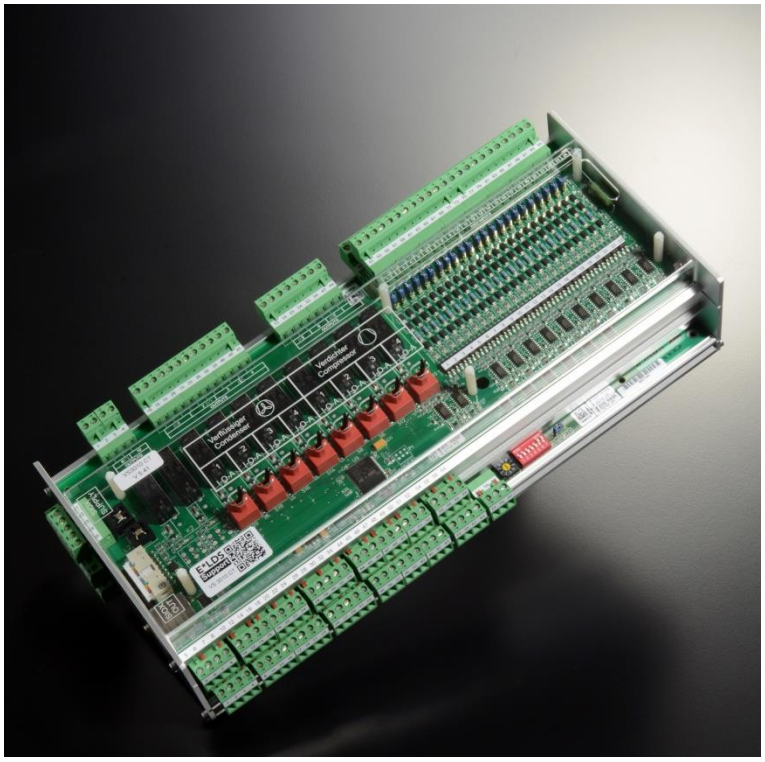

Fig. 4: VS 3010 CT, the compound controller for transcritical CO_2 booster systems. (Eckelmann AG)

Cool down

The booster system supplies the PATT fermentation interrupters developed and patented by Kolb Kälte. The original acronym PATT translates as the "programmed cooling of partially cooked dough pieces". If pre-cooked dough pieces are cooled down too quickly, a difference in temperature exists between the inside and the outer surface of the dough piece, which would result in crystallization that would reduce quality. As a result, dough pieces must be cooled particularly gently and slowly so that the temperature difference is almost $\Delta t \approx 0$ K. The new Mangold production facility alone contains eight PATT rooms into which the dough pieces are brought on special trolleys.
Thanks to its many years of experience in bakery refrigeration and extensive process know-how, Kolb Kältetechnik has perfected this gentle freezing process. Compared to conventional shock freezing, in which dough pieces are cooled to a core temperature of -7 °C in around an hour, the PATT process saves approx. 30 percent energy because it does not require such a high cooling performance in a short time. Due to this, compound systems can also be made correspondingly smaller, thereby saving investment costs.

Fig. 5: Evaporators inside the fermentation interrupters (Photo: KOLB KÄLTE)

For Kolb, it was particularly important that the E*LDS control system provided suitable interfaces for the seamless integration of the PATT controls since this was the only way to ensure that the required cooling performance could be controlled efficiently and optimized according to demand. In addition to the fermentation interrupters, the refrigeration system also supplies the normal refrigeration/deep-freeze rooms.

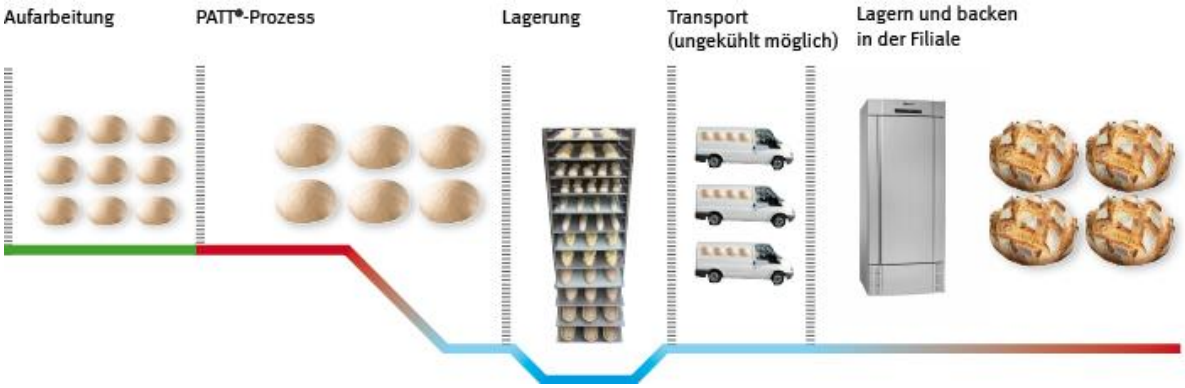

Fig. 6: Cooling chain of a bakery using the PATT process for the gentle freezing of dough pieces (Photo: KOLB KÄLTE)

The PATT control for fermentation interruption is integrated via a 0-10 V control signal, which is processed by the refrigeration controller and provides the requested evaporation capacity. The UA 410 E controller for electronic expansion valves dynamically adjusts the setpoint.

Industry heat recovery solution for bakery refrigeration

The waste heat from the refrigeration system is separated off through heat exchangers and utilized for heating and hot water preparation. The crate dishwasher (heating), for example, can be run from the high temperature component of +75°C.
Control of the heat recovery system is easy with E*LDS as the control system has a heat recovery system control that is optimally matched to Advansor compound systems. As WRG 3010 E, however, it is also available as a standard solution for compound systems from other manufacturers. The controller regulates up to two independent heat recovery circuits (high and low temperature) including the pump rotation speed. The controller receives signals from the superordinate building automation system and automatically determines the optimum heat recovery capacity, which is regulated virtually continuously over several stages. To ensure that the compressors are always at the optimum operating point even in heat recovery mode, the heat recovery control system communicates cyclically with the compound control system.

Fig. 7: Heat recovery (Photo: KOLB KÄLTE)

The outlook

In supermarket refrigeration, CO_2 booster systems with heat recovery are now state-of-the-art. Bakery refrigeration can sustainably profit from the experience gained in this area. This is demonstrated by the cooperation between Kolb Kälte and Eckelmann. “Our solution uses proven E*LDS features from supermarket refrigeration,” explains Martin Stocker, Technical Manager at Pitec AG / Kältetechnik. “However, E*LDS also gives us the freedom to easily implement industry-specific special functions by means of suitable interfaces, such as the PATT process for gentle cooling of dough pieces in this case".

The future of refrigeration technology remains exciting! Having been successfully put into operation, new concepts are already being worked on together upon how the other energy-intensive aspects of a bakery can be better digitally interlinked. With its new IoT-compatible Virtus 5 system hub and a cloud platform, Eckelmann is creating the ideal conditions for this. Standardized web interfaces are to be used in future to connect any devices and systems to form a "digital ecosystem" that can be modularly adapted to industry-specific requirements – from the plug-in for energy management to AI-supported online simulation and process optimization.

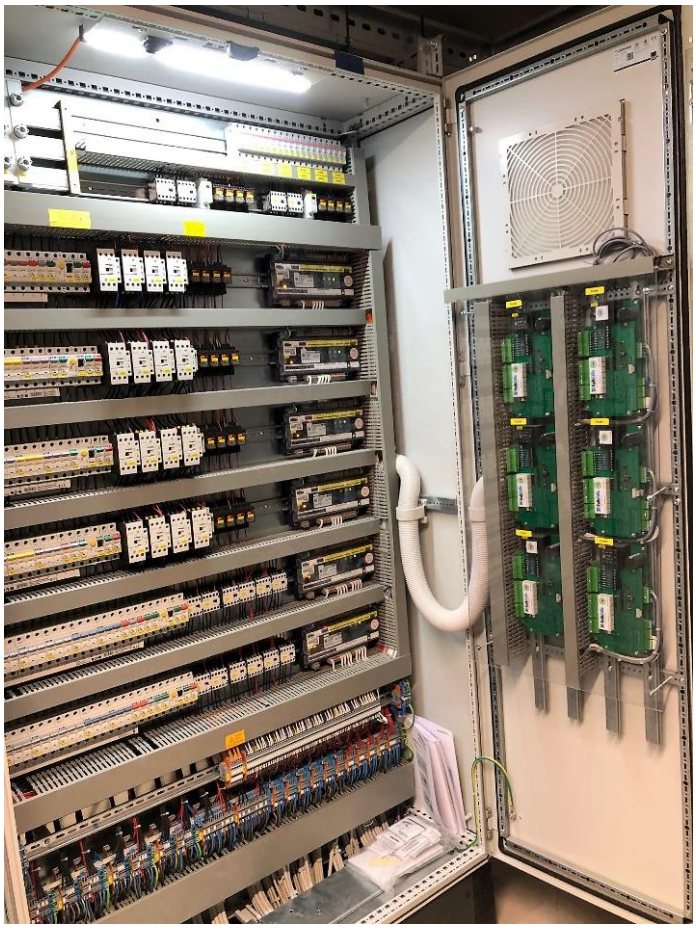

Fig. 8: One of a total of six control cabinets for the refrigeration system (Photo: KOLB KÄLTE)

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