Background

Natural refrigerants: great potential in small capacity ranges

Natural refrigerants now have a firm place in the market as an environmentally friendly solution for industrial refrigeration. In view of legal directives and increasing ecological awareness on the part of operators and customers, the market is becoming more dynamic – new components are being developed and new applications installed. This does not only apply to refrigeration plants with a large capacity, but more and more to smaller capacity ranges too, such as those found in deep-freeze rooms. Even though many end users still rely on synthetic refrigerants, there are already signs today that these preferences will be redefined in future. In fact, this will be in favour of natural refrigerants, as their potential, especially for refrigeration systems with smaller capacity ranges, is enormous. It is not without reason, for example, that carbon dioxide has already been successfully used as a refrigerant in the deep-freeze area of many supermarkets for over ten years. Ammonia too, which until now has predominantly been used in systems over 100 kW, appears increasingly attractive for smaller systems. This is shown by the following case studies and experiences of the eurammon company members Frigopol, Star Refrigeration and HKT Huber-Kälte-Technik.

Frigopol cools biogas plant in Germany with ammonia

Frigopol Kälteanlagen GmbH, based in the Austrian town of Frauental is an expert for small production runs and has been making special refrigeration and air-conditioning solutions for over 60 years. For this purpose, the traditional company relies on natural refrigerants – for the sake of the environment. This was also clear to the operators of a biogas plant right from the start: the intention was to design their refrigeration to be environmentally friendly, in accordance with sustainability principles. Frigopol installed two dual-circuit refrigeration systems with ammonia and a capacity of 2 * 20 and 2 * 100 kilowatts respectively. The system is used to cool the biogas plant's gas motors and keep the process water at a temperature between plus two degrees Celsius and plus six degrees Celsius at all times.

Frigopol's many years of experience and its expertise in the construction of small production runs using NH3 made it perfectly feasible to implement the project with low capacities. With a total of eight separating hood compressors from Frigopol as well as suitable plate heat exchangers from AlfaLaval, dry coolers from Güntner, condensers from Thermofin, valves from Danfoss and oil separators from Klimal, Frigopol was able to successfully implement

the refrigeration system. ‘We believe that the demand for applications in the low-capacity range will continue to grow. After all, such an eco-efficient solution is ideal for many areas in the food and non-food sector. That applies both to industrial and commercial use,’ says Johann Herunter, managing director of Frigopol. If a position outdoors could be ensured, using an indirect refrigeration system with ammonia would also be practicable in sectors like the hotel and gastronomy trade.

Famous UK department store opts for carbon dioxide in small refrigeration rooms

An internationally renowned department store from London, was also looking for an environmentally friendly and efficient refrigeration plant for the newly developed Thames Valley distribution centre, Thatcham. The aim was to cool two small refrigeration rooms used for drinks and perishable foods. The department store contracted Star Refrigeration to plan this system. As a special solution for the small refrigeration rooms, the refrigeration specialist developed a customised carbon dioxide refrigeration plant. The single-stage trans-critical plant has a capacity of 20 kilowatts and is equipped with an Envichill DX system. With the aid of the carbon dioxide gas cooler plus several compressors and an efficient evaporator control system using electronic expansion valves, the plant keeps both refrigeration rooms at a constant plus four degrees Celsius even in the middle of summer. ‘The customer was looking for a future-proof solution with natural refrigerants. With the energy-efficient carbon dioxide refrigeration system, we have enabled the customer to reduce its carbon footprint and prevent any negative effects in terms of global warming and ozone depletion,’ says Andy Butler, retail manager at Star Refrigeration. ‘The result is quite astounding: our system helped the famous department store to achieve a high BREEAM assessment, an ecological evaluation for sustainable buildings, with its new distribution centre.’

High energy-efficiency in small capacity ranges

The two practical examples make it quite clear: systems with small capacities can be successfully implemented using natural coolants such as ammonia or carbon dioxide. Not only is this good for the environment, but it also allows energy-efficient refrigeration solutions. ‘Above all, applications like cascade systems with carbon dioxide in the subcritical range for deep-freezing and with ammonia for normal refrigeration are very efficient,’ Johann Herunter explains. Karl Huber, managing director of HKT Huber-Kälte-Technik, also sees the benefits of CO2 in the low temperature level of cascades and subcritical applications: ‘CO2 will establish itself especially for supermarket refrigeration. Installing an additional refrigeration unit or a pressure compensation container allows excess pressure build-up to be prevented on these systems, even in the event of a stoppage or fault.’

Set for the future with green refrigeration plants

Natural refrigerants such as ammonia and carbon dioxide are becoming increasingly important especially in small application areas. For suppliers of innovative refrigeration systems, above all this means a rapid growth in market potential. Current research, such as that carried out by Behzad Abholhassani Monfared, is also being focused on their use in residential buildings. Monfared, who took second place in the eurammon Natural Refrigeration Awards 2011, is developing an ammonia heat pump with seven kilowatt hours for a single-family house as part of his research project. 'The demand for refrigeration using natural refrigerants is noticeably increasing. After all, these systems are not only impressive in ecological, but also in economic terms. Higher acquisition costs than those for applications using synthetic refrigerants will be quickly recouped by considerably lower operating costs resulting from optimal technical design and dimensions,' explains Johann Herunter. Karl Huber also sees further market opportunities in future: 'With the development of innovative components, natural refrigerants can also be used where they are not yet so common. For the pilot project conducted by the student Behzad Abolhassani Monfared, we supplied a component that was fitted into the ammonia heat pump for a single-family house. We are convinced that many new applications with natural refrigerants will be prospectively put into place for private use too.'

The development of refrigeration systems using natural refrigerants will, however, also largely depend on future ecological and political developments. Also the Montreal Protocol from 1987 and its ratifications promote the use of natural refrigerants. 'Against this background, an environmentally friendly natural refrigerant should already take preference in any case – even if it is "only" as energy-efficient as a synthetic one,' Karl Huber adds. To achieve this, however, the task remains to break down existing reservations towards natural refrigerants. 'More clarification work is needed, especially when it comes to the end customers. Around 70 per cent of companies still do not know that there is an environmentally friendly alternative for their refrigeration plant, with which they can save hard cash in the long run,' says Johann Herunter, pointing out future potential for natural refrigerants in the end-customer business.

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Captions:

Kälteanlage_Frigopol.jpg
The two-circuit NH3 chillers cool a biogas plant in Germany.

Photo: Frigopol
(Printout free of charge)

star_refrigeration_enchivill_DX_packaged_unit.jpg
Naturally a better way to cool: A famous UK department store opts for the complete CO2 system from Star Refrigeration.

Photo: Star Refrigeration

(Printout free of charge)

Annex

Ammonia (NH_3)

Ammonia has been successfully used as a refrigerant in industrial refrigeration plants for over 100 years. It is a colourless gas, liquefies under pressure, and has a pungent odour. In coolant technology, ammonia is known as R 717 (R = Refrigerant) and is synthetically produced for use in refrigeration. Ammonia has no ozone depletion potential (ODP = 0) and no direct global warming potential (GWP = 0). Thanks to its high energy efficiency, its contribution to the indirect global warming potential is also low. Ammonia is flammable. However, its ignition energy is 50 times higher than that of natural gas and ammonia will not burn without a supporting flame. Due to the high affinity of ammonia for atmospheric humidity it is rated as “hardly flammable”. Ammonia is toxic, but has a characteristic, sharp smell which gives a warning below concentrations of 3 mg/m³ ammonia in air possible. This means that ammonia is evident at levels far below those which endanger health (>1,750 mg/m³). Furthermore ammonia is lighter than air and therefore rises quickly.

Carbon dioxide (CO_2)

Carbon dioxide is known in refrigeration technology as R 744 and has a long history extending back to the mid 19th century. It is a colourless gas that liquefies under pressure, with a slightly acidic odour and taste. Carbon dioxide has no ozone depletion potential (ODP = 0) and negligible direct global warming potential (GWP = 1) when used as a refrigerant in closed cycles. It is non-flammable, chemically inert and heavier than air. Carbon dioxide has a narcotic and asphyxiating effect only in high concentrations. Carbon dioxide occurs naturally in abundance.

Ozone Depletion and Global Warming Potential of Refrigerants

	Ozone Depletion Potential (ODP)	Global Warming Potential (GWP)
Ammonia (NH_3)	0	0
Carbon dioxide (CO_2)	0	1
Hydrocarbons (propane C_3H_8, propene C_3H_6, isobutane C_4H_{10})	0	<3
Water (H_2O)	0	0
Chlorofluoro-hydrocarbons (CFCs)	1	4680–10720
Partially halogenated chlorofluoro-hydrocarbons (HCFCs)	0.02–0.06	76–12100

Per-fluorocarbons (PFCs)	0	5820–12010
Partially halogenated fluorinated hydrocarbons (HFCs)	0	122–14310

Ozone Depletion Potential (ODP)

The ozone layer is damaged by the catalytic action of chlorine, fluorine and bromine in compounds, which reduce ozone to oxygen and thus destroy the ozone layer. The Ozone Depletion Potential (ODP) of a compound is shown as chlorine equivalent (ODP of a chlorine molecule = 1).

Global Warming Potential (GWP)

The greenhouse effect arises from the capacity of materials in the atmosphere to reflect the heat emitted by the Earth back onto the Earth. The direct Global Warming Potential (GWP) of a compound is shown as a CO_2 equivalent (GWP of a CO_2 molecule = 1).

About eurammon

eurammon is a joint European initiative of companies, institutions and individuals who advocate an increased use of natural refrigerants. As a knowledge pool for the use of natural refrigerants in refrigeration engineering, the initiative sees as its mandate the creation of a platform for information sharing and the promotion of public awareness and acceptance of natural refrigerants. The objective is to promote the use of natural refrigerants in the interest of a healthy environment, and thereby encourage a sustainable approach in refrigeration engineering. eurammon provides comprehensive information about all aspects of natural refrigerants to experts, politicians and the public at large. It serves as a qualified contact for anyone interested in the subject. Users and designers of refrigeration projects can turn to eurammon for specific project experience and extensive information, as well as for advice on all matters of planning, licensing and operating refrigeration plants. The initiative was set up in 1996 and is open to European companies and institutions with a vested interest in natural refrigerants, as well as to individuals e.g. scientists and researchers.
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