Expert interview

Energy efficiency in defrosting systems

Characteristics and special aspects in systems with natural refrigerants

Frankfurt (Main), 01 November 2017. One of the most frequent causes of operational problems with both freezer and normal chilling temperature refrigeration systems is ice build up on air coolers and evaporators. Ice formation on the evaporator's fins for example is detrimental to the heat transfer and results in a temperature increase in the cold room. To minimise the energy consumption as far as possible, an effective and efficient defrosting system is required. This will help to keep the whole refrigerating system running efficiently in the long term.

eurammon member Michael Freiherr, Chief Technical Officer at Güntner GmbH & Co. KG, talks about various influencing factors on the energy efficiency of defrosting systems and looks at the special requirements when using natural refrigerants.

1. How can the energy efficiency of a defrosting system be calculated?

Michael Freiherr: The energy efficiency of a defrosting system is the sum of the latent and sensible heat necessary to convert the ice build up on the evaporators to water just above 0°C, divided by the energy actually consumed by the system during defrosting. Well rated systems reach a defrosting efficiency of approx. 0.5 in real operation, however the efficiency of many systems is far lower.

2. What aspects influence the energy efficiency of a defrosting system in practice?

Michael Freiherr: The energy demand of the defrosting system depends primarily on the defrosting method, for example, air defrost, water, electric or hot gas. The efficiency also depends on equipment layout and fine tuning during commissioning by the engineer on site. Important aspects here include good positioning of the defrost sensor as well as a correct calculation of defrosting times and intervals. Defrost-on-demand is particularly efficient, as this is only activated when a sensor fitted on the evaporator or cooler detects the corresponding demand.

Another possibility of minimising defrost energy consumption is to use the waste heat already present in the system rather than consuming additional defrosting energy.

Possibilities include hot glycol/brine/Thermobank, hot gas defrosting and Bäckström defrosting method in particular.
Energy can also be saved by keeping as much of the heat inside the evaporator/cooler during the defrost process. If less heat escapes into the cold room, this reduces the refrigerating capacity necessary to maintain the room set-point temperature after a defrost. Smart solutions include the use of a hood on the backside of the cooler and socks or dampers on the air outlet side impeding hot air heat circulation, or an insulated cooler preventing it entirely.

3. Which special aspects apply to defrosting methods in NH_3 systems?

Michael Freiherr: Basically, every established defrosting method can be used in systems with natural refrigerants, taking account of all safety aspects that apply to normal chilling operation. Hot-gas defrosting is widely used for NH_3 pump systems on a very broad global scale. One of the reasons is that in NH_3 systems, it is particularly easy for the refrigerant condensate generated in the evaporator during defrosting to flow back into the wet return pipe or to the separator. Ammonia also has a relatively high evaporation enthalpy compared to other refrigerants which makes it possible to achieve shorter defrost times than with other refrigerants.

One characteristic of NH_3 systems are the relatively high discharge temperatures. If this is not taken into consideration during the system design, defrosting could cause unwanted vapour formation and result in ice formation in the cold room. Another advantage of hot gas defrosting , regardless of the specific refrigerant used is the very uniform heat supply from the inside. This removes frost and ice very quickly with shorter defrosting cycles and as such enhanced efficiency.

4. Which special aspects apply to defrosting methods in CO_2 refrigerating systems?

Michael Freiherr: If CO_2 is used for hot gas defrosting, it would require the air cooler and the hot gas piping to be rated to the same pressures as the CO_2 gas cooler / condenser. However, CO_2 air coolers are usually designed for far lower pressure levels. In terms of efficiency, hot brine defrosting would therefore appear to be a better alternative when compared to electric defrosting in CO_2 cascade systems.

5. **How can energy efficiency be evaluated in general for defrosting systems with natural refrigerants?**

Michael Freiherr: It is not possible to generalise here. The efficiency of the defrosting system depends on many different individual parameters so that it is relatively difficult to make comparisons. However, when deciding which refrigerant to use, it is far more important to note that systems with natural refrigerants fundamentally offer operators a high degree of future viability. Ammonia and CO_2 are not affected by current and future restrictions imposed by the F-Gases Regulation or other environmental requirements and are therefore suitable for long-term planning.

Picture:

Caption: eurammon member Michael Freiherr, Technical Director at Güntner GmbH & Co. KG.

((Systems))

Ammonia (NH_3)

Ammonia has been successfully used as a refrigerant in industrial refrigeration systems for over 130 years. It is a colourless, liquefied compressed gas with a pungent odour. The refrigerant ammonia is known under the refrigeration designation R717 (R = Refrigerant) and is produced synthetically for use in refrigeration. Ammonia has no ozone depletion potential (ODP = 0) and no direct global warming potential (GWP = 0). Due to the high energy efficiency, contribution to the indirect greenhouse effect is comparatively low. Ammonia is combustible. However, the required ignition energy is 50 times higher than that of natural gas, and without a supporting flame ammonia will not continue to burn. In conjunction with the high chemical affinity of ammonia for atmospheric humidity it is rated as difficult to ignite. Ammonia is toxic, but has a characteristic acrid odour with a high warning effect and is noticeable in the air from a concentration of 3 mg/m³, which means that the warning effect occurs long before a harmful concentration builds up (> 1,750 mg/m³). Furthermore, ammonia is lighter than air and therefore rises quickly.

Carbon dioxide (CO_2)

Carbon dioxide is known in the refrigeration industry under the refrigeration designation R 744 and has a long tradition dating back into the early 19th century. It is a colourless, liquefied compressed gas with slightly acidic smell and taste. Carbon dioxide has a ozone depletion potential (ODP = 0) and, when used as a refrigerant in closed circuits, a negligible direct greenhouse effect (GWP = 1). It is non-flammable, chemically inert and heavier than air. Carbon dioxide has an anaesthetising and suffocating affect on humans only in high concentrations. Since the energy efficiency of carbon dioxide is low compared to other refrigerants, there has been a particular effort recently to optimize plant technology for specific applications and more efficient refrigeration systems are continuously under development to close this gap. Carbon dioxide is naturally present in very large amounts.

Hydrocarbons

Refrigeration systems with hydrocarbons such as propane (C_3H_8), in refrigeration technology also known as R 290, or butane (C_4H_{10}), known as R 600a, have been used worldwide for many years in. Hydrocarbons are liquefied under pressure, colourless and nearly odourless gases that have neither an ozone depletion potential (ODP = 0) nor a significant direct global warming potential (GWP = 3). Thanks to their outstanding thermodynamic properties, hydrocarbons are particularly energy efficient refrigerants. They are heavier than air and have an anaesthetising and suffocating affect in high concentrations. Hydrocarbons are flammable and may form explosive mixtures with air. Due to the existing security devices, however, refrigerant losses are near zero. Hydrocarbons are worldwide inexpensively available and are used particularly thanks to their ideal refrigeration properties in systems with low refrigerant charges.

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, butane C_4H_{10})	0	3
Water (H_2O)	0	0
Chlorofluorocarbons (CFCs)	1	4,680–10,720
Partially halogenated hydrochlorofluorocarbons (HCFCs)	0.02–0.06	76–2,270
Perfluorocarbons (PFCs)	0	5,820–12,010
Partially halogenated fluorocarbons (HFCs)	0	122–14,310

Ozone Depletion Potential (ODP)

Ozone depletion is mainly caused by chlorine, fluorine or bromine in compounds, which are able to split ozone (O_3) molecules and thus destroy the ozone layer. Ozone depletion potential (ODP) of a compound will be indicated as chlorine equivalent (ODP of a chlorine molecule = 1).

Global Warming Potential (GWP)

The greenhouse effect is caused by the ability of substances in the atmosphere to reflect the heat emitted by the earth back to the earth. The direct global warming potential (GWP) of a compound is measured as CO_2 equivalent (GWP of a CO_2 molecule = 1).

About eurammon

eurammon is a joint 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 companies and institutions with a vested interest in natural refrigerants, as well as to individuals e.g. scientists and researchers.

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