REFRIGERANTS: ALTERNATIVES TO HCFCs AND HIGH GWP HFCs IN INDUSTRIAL FOOD PROCESSING

Many **refrigeration systems in industrial food processing** worldwide still use refrigerants that are harmful to the environment (depleting the ozone layer and increasing global warming). Examples are R22, R134a, R404A, and R410A. Another generation of alternative synthetical, low GWP refrigerants have been proposed by the chemical companies. However, their **decomposition products are highly toxic** and the extent of their total environmental impact is yet **unknown**. Most of them are flammable.

There are many benefits in increasing the use of **natural refrigerants,** like carbon dioxide (CO_2) and ammonia (NH_3), providing excellent thermophysical properties, enabling high efficient and compact system designs, and having no negative environmental impact.

Introduction

Refrigeration is necessary in industrial food processing, for chilling and freezing and thereby preserving food quality and reducing food waste. Refrigeration systems are different in sizes and designs, but they all contain at least one kind of refrigerant.

In the early days of mechanical refrigeration (~140 years ago), only natural refrigerants were available, for example air, ethyl ether, ammonia and carbon dioxide. After the second world war, synthetic working fluids (CFCs) were widely introduced and many different fluids and blends were developed in the following decades, along with a large spreading and increased usage of refrigeration systems. However, it was found that these refrigerants were harmful to the ozone layer. When the Montreal Protocol (1987) was in place, the next generation of synthetic refrigerants, the hydrofluorocarbons (HFCs) were promoted and widely introduced. The drawback of the applied HFCs is their high global warming potential, which was first addressed in the Kyoto Protocol (1997). Twenty years later, the Kigali Amendment addresses the global need for a dramatically phase down the usage of HFCs on a global scale.

Refrigerants

Today's refrigerants in the market can be divided into three groups; saturated, unsaturated and natural working fluids. The saturated CFCs, HCFCs and HFCs affect the climate and the environment. Therefore, they are part of phase-out programs. The unsaturated HFCs are flammable and have toxic decomposition products (even without a fire) when leaking. Consequently, the only sustainable alternative refrigerant are the natural working fluids. When adopting the system architecture to the fluid properties, energy- and total cost efficient systems can be supplied to satisfy end-users and customers.

	Formula (name)	Type	ODP	GWP_{100}
saturated	R12 (freon)	CFC	1 (high)	10 900
	R22	HCFC	0.055 (medium)	1 810
	R404a	HFC	0	3 922
	R410a	HFC	0	2 088
	R134a	HFC	0	1 430
	R32	HFC	0	675
unsat-urated	R1234yf (HFO)	HFC	0	4
	R1234ze (HFO)	HFC	0	6
natural	R717 (ammonia)	Natural	0	0
	R744 (CO_2)	Natural	0	0*
	R290 (propane)	Natural	0	3

***ODP**: Ozone depleting potential*

***GWP_{100}**: Global warming potential – calculated over 100 years*

Summary

In Norway, a successful transition from ozone depleting refrigerants (with high global warming potential) to climate friendly natural refrigerants has been made during the last decades. For example, in 1993, 91 % of all fishing vessels had R22 refrigeration systems, but today, most of them use ammonia units onboard, while some also use carbon dioxide systems. Several refrigeration vendors have performed intensive research and development within this area and gained important know-how.

The risks related to widespread introduction and usage of the new short life, unsaturated hydrofluorocarbons ("HFOs") when it comes to human health and safety are not fully understood. In the past, numerous cases are on record where new chemicals, believed to be a harmless, have turned out to be environmentally unacceptable, sometimes even in quite small quantities.

It is recommended to continue and strengthen the good research and development activities for natural refrigerant systems in food processing industries. It is necessary to intensify the knowledge transfer and information distribution globally to all stakeholders in this sector. There are no technical barriers in applying and operating natural working fluid refrigeration systems globally both energy- and cost efficient.

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Literature

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