

Chapter 20

Current and Future Trends of Refrigerants Development

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ABSTRACT

In this chapter is addressed the thematic of refrigerants: its historical evolution; properties; legislation applied in the area and future trends. The first refrigerant being marketed on a large scale was ethyl ether (R610), in 1834. Since then, the evolution of the utilized refrigerants was stimulated, initially due to constructive issues in the refrigeration system and later to environmental issues. This evolution may be divided into four generations: 1st use of any fluid that worked; 2nd safety and durability of the equipment; 3rd ozone layer protection and 4th increase of global warming concerns. During the process of evolution many refrigerants were tested to understanding of their properties. Currently, environmental concerns are taken as guide in the search for new refrigerants. The most promising refrigerants to be used in future are the HFEs, HFOs and HFCs with low-GWP, natural refrigerants and blends between (HCs/HFCs and HFCs/HFOs) refrigerants.

INTRODUCTION

Refrigerants are all the fluids that have a high capacity to “absorb” large amounts of thermal energy during the evaporation process at low temperature. This characteristic makes it ideal for use in refrigeration systems that operate a refrigeration vapour compression cycle, the cycle applied in air conditioners, heat pumps and cooling systems. Refrigerants can be classified as primary or secondary. Primary refrigerants are those that circulate inside the cooling system, being compressed in the compressor and expanded in the expansion device, i.e. those whose width of biphasic zone measured in (p, h) diagram is important. Some examples of primary refrigerants are the halogenated compounds, hydrocarbons, inorganic compounds, azeotropic and zeotropic mixtures. Secondary refrigerants are usually liquids used as heat carriers at low temperature from primary refrigerant to other fluid. This type of refrigerants is

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only used in refrigeration vapour compression systems that operate by indirect expansion. Are examples of secondary refrigerants, the brines and antifreezes.

Exceptionally, absorption refrigeration systems use two substances (refrigerant and absorbent). In these systems it is intended to take advantage of the chemical affinity existing between these two fluids, in order to its combination and dissociation allows the desired cooling effect.

The ethyl ether (R610) was the first fluid known with excellent thermodynamic properties that makes it a good refrigerant (i.e. the evaporative effect at low temperature). This characteristic was perceptible when a small amount is spilled on the hand. The almost instantaneous evaporative effect causes a cooling sensation in the skin, while a portion of substance is evaporated “stealing” thermal energy at hand.

For this reason, the ethyl ether (R610) was used in the first refrigerating machine patented to operate a refrigeration vapour compression cycle, machine built in 1834 by Jacob Perkins. This was the first refrigerant marketed in a large scale (Dincer & Kanoglu, 2010).

Since then, there has been an impressive evolution of the used refrigerants, stimulated initially due to constructive issues related with the refrigeration system and later as environmental issues.

This evolution may be divided into four generations (Calm, 2008):

- 1\(^{st}\) marked by the use of any fluid that worked – the natural refrigerants were the firsts to be used because they abound in nature. But the use of some natural refrigerants was very dangerous as they are highly toxic and flammable, having occurred several accidents, including people’s death;
- 2\(^{nd}\) marked by the safety and durability of the equipment – in attempting to find more stable refrigerants whose use was safer for equipment and users, were discovered the CFCs compounds in 1928. These compounds revolutionized the chemical industry, having been used in several applications beyond refrigeration;
- 3\(^{rd}\) marked by the ozone layer protection – for being too stable the CFCs compounds are very harmful to environment, with great participation in the destruction process of ozone layer and increase of global warming;
- 4\(^{th}\) marked by the increase of global warming – currently, the trend is towards the disuse of CFCs and HCFCs compounds and bet on HFCs with a low-GWP, HFOs, HFEs and the return to natural refrigerants.

In this chapter are discussed the thematic related with the refrigerants and its historical evolution, taking into account the main events that marked this evolution. The main characteristics and properties that characterize the refrigerants in order to allow its classification according to the respective family also are presented. Finally are discussed the different replacement possibilities for the currently most used refrigerants and those that are indicated as long-term future possibilities, the different substitution methods and collection and recycling of refrigerants.

**FRAMEWORK**

Refrigerants are currently used in air conditioning systems, commercial refrigeration systems, domestic refrigerators and freezers, mobile refrigeration systems, cryogenic and low temperature freezers and industrial refrigeration systems.
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