Upcoming Developments In Modern Refrigeration Technology

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Abstract

Refrigeration has come a long way from the icebox to the modern electric fridge. Despite that, this technology still has much more room to grow. Engineers and scientists alike are evaluating how to further improve performance and efficiency, as well as lessen the impact refrigeration has on the environment. These new developments include but are not limited to Magnetic Refrigeration, Solid-State Refrigeration and the implementation of natural refrigerants.

Introduction

There are two important aspects of refrigeration that the new advancements aim to improve.

One of them is Coefficient of Performance (COP), the main metric that determines how effective a refrigerator is at using energy to remove heat from a given system.

COP = Cooling Capacity / Energy Input

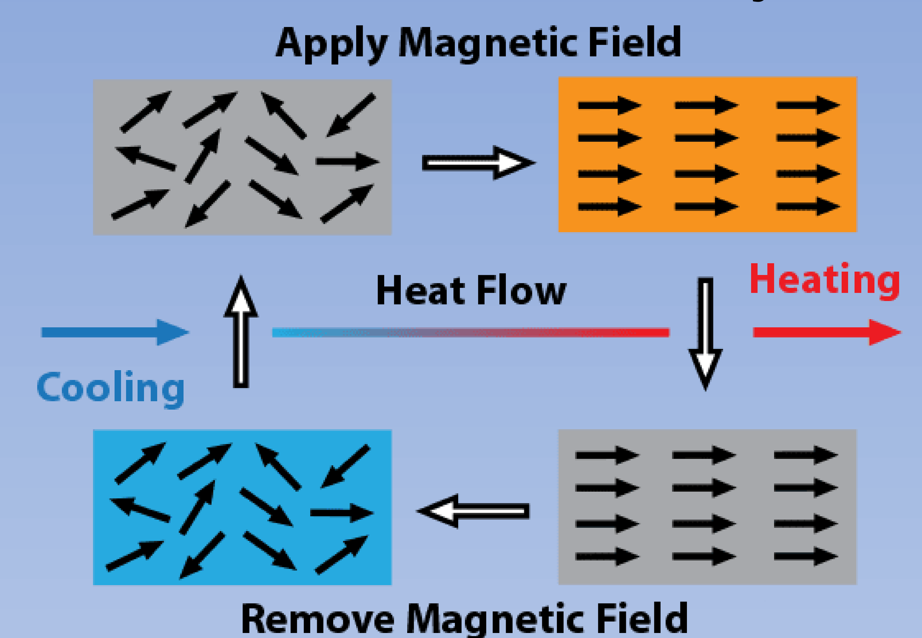
The other one is Global Warming Potential, which quantifies the energy emissions from one ton of a gas will soak up over a 100-year timeframe in proportion to a single ton of Carbon dioxide.

Greenhouse Gas (GHG)	Atmospheric Lifetime (yrs)	Global Warming Potential (GWP)
Carbon dioxide (CO_2)	50-200	1
Hydrofluorocarbons (HFCs)	1.5 to 209	150 to 11,700
Perfluorocarbons (PFCs)	2,600 to 50,000	6,500 to 9,200
Sulfur Hexafluoride (SF_6)	3,200	23,900

Table 1: Showcases the different GWP ranges of refrigerant types.

Magnetic Refrigeration

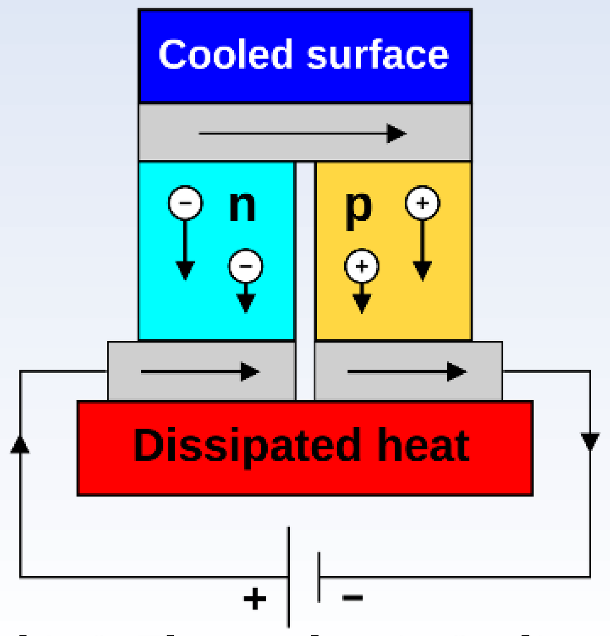
A magnetic material is situated within a magnetic field. This causes it to undergo the magnetocaloric effect and heat up. When the material is no longer exposed to the magnetic field, it cools down. This process can be used to transfer heat out of a condition space similarly to modern refrigerants. Especially now that the magnetic material options are cost effective and environmentally friendly.



Graphic 1: Magnetic cooling cycle

Thermoelectric Cooling

Instead of relying on refrigerants, this method utilizes two different conductors. DC Voltage is applied which then leads to direct current flowing from one conductor to the other. Then heat transfer occurs from the shared surface between the two conducting materials to the heat sink in contact with the separate plates. This technology is silent, which translates to no vibrations. The solid-state variant has no moving parts as well which drastically reduces its chances of breaking.



Graphic 2: Thermoelectric Cooling Cycle

Natural Refrigerants

These have several advantages over their counterparts. Normally they have notably less GWP than synthetics, some of them even have no impact on the atmosphere. Regarding industrial applications, natural refrigerants, especially ammonia and carbon dioxide, their material cost is often less than that of synthetics. They have showcased the potential to be more efficient than their synthetic counterparts.

Synthetic Refrigerants	Designation	GWP
Freon-12	R12	10,900
HCFC-22	R22	1,810
1,1,1,2-Tetrafluoroethane	R134a	1,430
Freon 404A	R404a	3,922
Freon 507	R507	3,985

Natural Refrigerants	Designation	GWP
Ammonia	R717	0
Carbon Dioxide	R744	1
Propane	R290	3.3
Isobutane	R600	3
Air	R729	0
Water	R718	0

Table 2: Displays GWP values for synthetic and natural refrigerants

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