A Brief Discussion on Refrigeration Technology and Its Applications in Multiple Fields

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Abstract: With the development of China's economy, people's living standards have significantly improved, and higher requirements have been put forward for the quality and comfort of life. Refrigeration technology covers multiple fields of human life. This article briefly introduces the concept and classification of refrigeration technology, including traditional refrigeration technology and new refrigeration technology. It also describes the current application status of refrigeration technology in multiple fields, ranging from household appliances such as air conditioners and refrigerators to space exploration and aerospace. Refrigeration technology, like flowing water, permeates our lives and has a very promising application prospect. It is worth researching and innovating.

Keywords: Refrigeration technology; Multi field; Applications

1. Introduction

Refrigeration technology is widely used in human production and life, covering multiple fields such as industry, agriculture, and healthcare. Environmental temperature regulation, food storage, and transportation are all major issues related to people's livelihoods. So in today's constantly developing society, it requires us to constantly improve and enhance refrigeration technology to meet the growing needs of humanity. At the same time, it is necessary to take into account the requirements of national policies and the overall environment, requiring low-carbon, environmentally friendly, and energy-saving refrigeration technology. The following is the author's understanding of current refrigeration technology and its application

2. Concept and Classification of Refrigeration Technology

Refrigeration technology is a technical system that achieves cooling through energy conversion. Its core principle is to use mechanisms such as thermodynamic total cycle or thermoacoustic effect to reduce and maintain the temperature of objects or spaces below the ambient temperature.

2.1 Classified by Method

2.1.1 Compression Refrigeration

Compression refrigeration is widely used, and its principle is that the compressor drives the refrigerant cycle to absorb and dissipate heat through compression, condensation, throttling, evaporation, and phase change. Applied to household air conditioners, refrigerators, large cold storage facilities, transportation vehicles, etc.

2.1.2 Absorption Refrigeration

The principle of absorption refrigeration is to drive the refrigeration cycle through thermal energy (gas, waste heat). The application areas include industrial waste heat recovery, solar refrigeration, geothermal refrigeration, such as ships, metallurgy, etc. Cooling environment above 0℃, such as central air conditioning. Cooling below 0℃ can be used for low-temperature absorption refrigeration of water ammonia working fluid, mainly used in food processing, pharmaceutical production, etc.

2.2 New Refrigeration Technology

2.2.1 Semiconductor Refrigeration

Semiconductor refrigeration is based on the Peltier Effect, which utilizes the thermoelectric effect of semiconductor materials to transfer heat from one end to the other, achieving refrigeration effect. Application field: Firstly, cooling of electronic devices, such as computers, communication equipment, and other components. Secondly, medical devices such as human temperature control systems. Thirdly, food preservation, such as making small refrigerators or insulated boxes. Fourth, air purification, such as air purifiers, air conditioners, and other equipment.

2.2.2 Thermoacoustic Refrigeration

Thermoacoustic refrigeration is based on the thermoacoustic effect, where the pressure changes generated by sound waves in a resonant cavity form a temperature difference, achieving refrigeration without mechanical moving parts. Application areas, such as aerospace.

2.2.3 Magnetic Refrigeration

Magnetic refrigeration, based on the magnetocaloric effect of materials absorbing and releasing heat in magnetic field changes, can cover the entire temperature range, especially in the field of extremely low temperatures, such as space exploration and other cutting-edge scientific research.

1) According to the method of obtaining the cold source, it can be divided into natural cooling and artificial cooling
2) According to whether it relies on external energy drive, it can be divided into active cooling and passive cooling. Thermal radiation and conduction belong to passive refrigeration. The forced circulation of communication equipment to achieve heat transfer belongs to active cooling.
3) Classify according to the required temperature.

Ordinary refrigeration (above 120k), deep refrigeration (120k-20k), low-temperature refrigeration (20k-0.3k), and extremely low-temperature refrigeration (below 0.3k).

3. The Application and Development of Refrigeration Technology in Multiple Fields

3.1 Application and Development of Refrigeration Technology in Logistics Field

At present, with the rapid development of the application of the Internet in the global logistics industry, refrigeration technology plays a guarantee role in the transportation of drugs, fresh food and other goods with temperature requirements. Logistics can not only transport goods, but also energy and chemical reagents, and requires corresponding refrigeration technology to match the corresponding temperature requirements. If natural gas transportation requires deep cooling technology to liquefy natural gas, it greatly increases the energy carried per unit volume.[1] All of the above belong to cold chain logistics, usually stored in cold storage and transported by refrigerated

transportation vehicles. Cold storage facilities often use carbon dioxide refrigeration technology, while transportation vehicles mostly use compression refrigeration technology. With the development of AI and low altitude economy, some drones are used for short distance delivery, while others are autonomous vehicles for delivering food. In addition, hotels and catering industries use delivery robots for food delivery.

Green, energy-saving, and environmentally friendly are universal requirements, so further improvement of refrigeration technology is essential. Combined with AI and intelligent equipment technology,[2] new energy refrigerated transportation vehicles will make cold chain logistics more precise, stable, safe, efficient, and more in line with people's current living needs.

3.2 The Application of Refrigeration Technology in the Medical Field

Refrigeration technology can effectively provide suitable low-temperature storage temperatures for biomedical products, including biological samples, drugs, blood products, vaccines, etc. In clinical practice, the strong storage capacity of biological samples is necessary to ensure the advantage of strong emergency response and play an important role in disease diagnosis and efficacy evaluation [3].

Short term storage at 2-8℃, utilizing semiconductor refrigeration technology and vapor compression refrigeration technology. Semiconductor refrigeration technology is suitable for small-scale storage in refrigerated temperature zones [4].

-60℃—-20℃. Plasma and vaccines have a longer storage period and stable activity indicators. Mainly based on bipolar compression refrigeration technology and cascade refrigeration technology. Tianjin University of Commerce uses R404 • AIR 50813 as the refrigerant. Research has shown that when Rh negative blood reaches -80℃, the cooling capacity decreases by 21% [5]. So, storing biomedical samples above -80℃ is more stable.

Low temperature therapy rapidly cools down through high-pressure gas throttling effect, destroys lesion tissue, and achieves precise tumor treatment through argon helium knife and ultra-low temperature freezing (-150℃).

Equipment cooling, The laser therapy device maintains a stable temperature through thermoelectric cooling technology, reducing damage to the patient's skin and tissues.

3.3 Application of Refrigeration Technology in Mining Operations

The mine is deep, with high temperature, humidity, and dust, and may even contain toxic gases. Refrigeration technology is needed to improve work efficiency, safety, and comfort [6].

The continuous operation of mining equipment releases a lot of heat, and compressed air is used to expand and cool down, achieving temperature control underground. The large amount of waste heat generated can be recovered through absorption refrigeration technology.

Improving the energy efficiency of the refrigeration system can be achieved by using variable frequency compressors for cooling and reducing the load. The intelligent refrigeration system adopts an explosion-proof structure, utilizes intelligent optimization of refrigeration programs, and establishes an early warning mechanism to reduce downtime [7] and lower the incidence of underground accidents.

3.4 The Application of Refrigeration Technology in the Petrochemical Industry

The purification of petroleum is crucial in the petroleum industry. Usually, low-temperature

separation technology is used, but traditional low-temperature separation has high consumption and is not economical.

Cut off refrigeration technology. The raw gas must undergo cooling treatment before entering the separation process. After being cooled, the feed gas undergoes isentropic expansion through a flow interception device, utilizing the Joule Thomson effect to further reduce the temperature, especially with a significant increase in cooling amplitude near the critical point, until reaching the deep cryogenic temperature range below -100℃. Then, low-temperature separation is carried out to achieve the separation and purification of petroleum through various methods such as distillation, absorption, and adsorption. Choosing the appropriate working fluid is also a key factor affecting the performance of flow cutoff refrigeration [8]. The gaseous and liquid products separated at low temperatures need to be heated to ambient temperature through a heat exchanger before qualified petroleum can be transported to storage tanks using a centrifugal pump. The cold energy released during the low-temperature separation process is recovered and utilized in a gradient manner. There are results indicating that the interception refrigeration technology can effectively improve the efficiency of low-temperature separation processes in petrochemical industry [9].

3.5 Application of Low Temperature Technology in Aerospace Field

Low temperature technology belongs to the category of refrigeration technology. Low temperature propellant in orbit transfer is a key technology for future in orbit activities and large-scale deep space exploration missions [10]. The typical combination of low-temperature propellants is liquid oxygen and liquid hydrogen [11], which must be stored in a low-temperature environment. Therefore, other launch vehicles such as rockets need to be equipped with vacuum insulated low-temperature storage tanks. When conducting deep space exploration missions, detectors must operate at low temperatures, so low-temperature technology is the basic condition for obtaining high-sensitivity observation data [12]. Like the Planck Space Telescope, cooled by radiation. The combination of Joule Thomson refrigeration unit and 3He/4He dilution refrigeration unit cools the high-frequency detector to 0.1k. Additionally, the only way to supply hydrogen to rocket engines is through low-temperature liquefaction, thereby increasing the fuel tank's storage to weight ratio.

4. Low Temperature Technology, Application in new Energy Vehicles

New energy vehicles mainly use the following three types of energy as their power sources. Firstly, electrical energy. Pure electric vehicles, which rely entirely on battery pack storage to drive electric motors, have the largest market share. Secondly, hybrid vehicles can be charged externally and equipped with an internal combustion engine, which can be driven by either battery or fuel. It is a transitional model and still has applications. Thirdly, hydrogen fuel cell vehicles generate electrical energy through a chemical reaction between hydrogen and oxygen to drive an electric motor. Due to technological and cost limitations, its application is limited. Due to only emitting water vapor, it has almost zero emissions and the highest environmental performance. Hydrogen has a high energy conversion efficiency and is considered one of the future clean and efficient fuels, so clean fuels have been found as alternatives [13].

Therefore, hydrogen fuel cell vehicles will play an important role in the future of new energy vehicles. This raises higher requirements for the storage of hydrogen energy, which can be achieved through low-temperature liquefaction and high-pressure storage. [14] In the 1970s, Germany and France researched vehicle mounted liquid hydrogen cylinders. The car stores cold energy during

operation, and after parking, liquefied air absorbs external heat leakage, recovers cold energy, and achieves non-destructive storage of liquid hydrogen. Until 2015, BMW Germany launched the BMW 5 Series hydrogen fuel cell model. There is still a certain gap between China and developed countries in this field, which has provided us with research directions.

In summary, refrigeration technology is constantly improving and its application areas are becoming more and more extensive. In the future, the development of refrigeration technology will focus on greening, AI intelligence, and multifunctional collaboration. Realize dual reduction of energy consumption and carbon emissions, while balancing personalization and precision. Refrigeration technology plays a very important role in meeting the diverse needs of humanity. How to promote the updating and development of refrigeration technology in China is still an important issue that needs to be studied. Only under policy guidance and international joint innovation can refrigeration technology continue to develop and create a more efficient and low-carbon future for humanity.

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