Research Progress of Nano-refrigerant and Its Application in Refrigeration

Jie Li, Fanshuo Meng, Biao Yanga and Peiyao Xiao

ABSTRACT

As a new type of refrigerant, nano-refrigerant has attracted more and more attention. The nano-refrigerant proposed in the concept of nano-fluid is to add nanoparticles into the refrigerant according to a certain mass fraction to form a refrigerant with stable and high-efficiency heat exchange capability. This paper mainly describes the application of nano-refrigerant in refrigeration, the preparation method of nano-refrigerant, the characteristics of nano-refrigerant and the factors affecting the properties of nano-fluid refrigerant.

KEYWORDS

Nano-Refrigerant; Coefficient of Thermal Conductivity; Stability; Refrigeration

PROPOSAL OF NANO REFRIGERANT

Chio[1] first proposed the concept of "nanofluid" in 1995. Researchers from various countries have studied the preparation, physical properties and application of nanofluids in different base fluids and achieved certain results. Nanofluid refrigerants have been proposed. With the development of social economy and the improvement of people's living standards, people's demand for air conditioners is increasing, and air-conditioning equipment has been widely used. With the popularization of air conditioners, the operation of refrigeration equipment has generated a lot of energy consumption. In the concept of sustainable development of refrigeration and air-conditioning industry, air-conditioning technology is also

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constantly Progress, improving energy efficiency, reducing pollution has become a top priority.

PREPARATION OF NANO REFRIGERANT

The preparation of nanofluidic refrigerant is divided into physical dispersion method and chemical dispersion method by using a dispersion method[2-4]. The nanoparticles are added to the refrigerant, and after being added with a surface dispersant, the nanometer refrigerant is oscillated in an ultrasonic oscillator. The prepared nanomaterials and refrigerant paired with TiO$_2$/R141b[5], Cu/R113[6-7], Al$_2$O$_3$/R141b[8], etc. Ultrasonic vibration is an indispensable step in the preparation of nanorefrigerants, and the time is generally 1-2 hours.

THERMAL CONDUCTIVITY OF NANO REFRIGERANTS

Masuda et al. [9] measured the thermal conductivity of Al$_2$O$_3$/water and TiO$_2$/water. And experiments show that a certain volume fraction of $\gamma$-Al$_2$O$_3$ and TiO$_2$ nanoparticles are mixed in deionized water, and the thermal conductivity of the mixed solution is increased by 32% and 11% compared with pure water.

Bi Shengshan[10] measured the thermal conductivity of TiO$_2$-R134a nano-refrigerant and found that when the volume fraction is 0.2g/L, the thermal conductivity of nano-refrigerant is 7.9% higher than that of pure R134a.Jiang Weiting[11] prepared nearly 20 kinds of nano-refrigerants with refrigerant R113 as the base liquid. The thermal conductivity and stability of these nano-refrigerants were measured experimentally, and the corresponding mathematical models were established. The experimental results show that the thermal conductivity of the nano-refrigerant increases significantly after the addition of nanoparticles to R113, and increases with the concentration of the mixed solution. According to the experimental results of the above researchers, adding a certain amount of nanoparticles in a pure fluid can significantly increase the thermal conductivity of the fluid, and the thermal conductivity is closely related to the volume fraction of the nanoparticles, the concentration of the mixed solution, and the temperature of the fluid.

NANO-REFRIGERANT STABILITY

The methods for measuring the stability of nano-refrigerants are mainly Zeta potential method, transmittance method, sedimentation method and particle size observation method.

Bi Shengshan et al.[12] measured the transmittance of nano-refrigerant and evaluated the stability of nano-refrigerant by comparing the transmittance.
Experimental results show that the stability of nano-refrigerant is mainly affected by the physical properties of nanoparticles and refrigerant itself, among them, the polarity and dielectric constant of the refrigerant have the greatest influence on the stability.

Bi Shengshan et al.[13] also made a detailed study on the dispersion of TiO2 in R113, R123 and R141b. The results show that the nanoparticle TiO2 is more stable in the refrigerant, and the dielectric constant and polarity of the refrigerant are the main influencing factors; Span-80 can be used as a dispersant for nano TiO2 particles in a refrigerant; temperature has a significant influence on the dispersion stability of nano TiO2 particles in a refrigerant.

Zhu Dongsheng[14] et al. studied the effect of pH and sodium dodecylbenzene sulfonate surfactant on the stability of Al2O3-water suspension. The zeta potential and absorbance of nanofluids were measured. The results showed that zeta potential and absorbance were nanometer. The stability of the fluid has an effect; the optimal ratio of surfactant is obtained through experiments.

At present, the stability of the nano refrigerant prepared by the conventional method still has many problems, and it is not suitable for the nanofluid for long-term use. To achieve the universal application of nano-refrigerants in various fields, it is difficult to prepare long-term stable nano-refrigerants, which needs further research.

APPLICATION OF NANO REFRIGERANT IN REFRIGERATION

Research results show that nanofluidic refrigerants can be used in air conditioning and refrigeration equipment. The addition of nanoparticles to the refrigerant enhances heat transfer performance, increases the COP of the refrigeration system, and reduces energy consumption[15].

Nano-refrigerants can improve the performance of the compressor. Lee et al.[16-17], Xing et al.[18] used fullerene C60 nanomaterials when exploring the effects of nano-refrigerant oil on compressor performance. Lee et al.[16] explored the wear resistance of a refrigerant incorporating fullerene nano-oil in a rolling compressor of a sliding thrust bearing. In the sliding thrust bearing, when the track plate speed is between 300 r/min and 3000 r/min, the coefficient of friction of the nano oil is smaller than that of the pure oil. It is speculated that it may be because the fullerene nanoparticles are embedded between the friction surfaces to improve the lubricating properties, and also to prevent the wear caused by the direct contact between the metal surfaces of the rotors. Lee et al.[17] found that mixing fullerene nanoparticles with mineral oil can work stably in a refrigerator compressor, and when the concentration of nanoparticles is 0.1% (volume fraction), the lubrication effect is best and the friction coefficient is reduced by 90%. Xing et al.[18] added fullerene nanoparticles to mineral oil SUNISO 3GS and mixed with refrigerant R600a to study the effect on the performance of refrigerator compressors. It was found that the friction coefficient of nano-oil decreased with the decrease of nano-particle concentration. The drop is more obvious at low load, the surface temperature of the
Compressor casing is also reduced, the lubrication effect is good, and the performance of the refrigerator compressor is improved.

Fu et al. [19] added Fe3O4 nanoparticles to mineral oil and HFC134a/HC600a as refrigerant to test the performance of the refrigerator. The experimental data showed that the temperature of the compressor casing increased slightly by 2.2°C, and the suction temperature slightly changed. The temperature dropped by 3.5°C, the average evaporator temperature dropped by 0.3°C, and the cooling time was reduced by 148s.

Bi et al. [20] found that HFC134a/mineral oil/TiO2 nanofluids can run smoothly and efficiently in the work of household refrigerators. When the TiO2 mass fraction is 0.1%, the energy consumption is 26.1% lower than that of HFC134a/POE. Nanoparticles increase the solubility of mineral oil in HFC134a and increase the oil return rate of the compressor.

In the experiment of exploring the effect of nano-graphite refrigeration oil on the performance of refrigerator, Lou Jiangfeng et al. [21] found that the average power consumption decreased by 4.55% when using 0.1% nano-graphite refrigeration oil, and the exhaust and suction pressure of the compressor were all related to the concentration of nano-refrigerated oil. Increase and decrease, and the reduction of exhaust pressure is greater.

According to the above research results, the addition of nanoparticles can reduce friction and reduce the intake and exhaust pressure of the compressor. The nano-refrigerant significantly improves the performance of the compressor, reduces energy consumption, and enhances the refrigeration capacity of the compressor.

CONCLUSIONS

Nano-refrigerants have attracted more and more scholars in the field of refrigeration. Researchers have made some achievements in the field of refrigeration through a large number of experimental studies, but the research of nano-refrigerants is still in its infancy. There are still many problems that need to be solved. These include the choice of nanoparticles and refrigerants. Since the nano-refrigerant belongs to the nano-fluid, the choice of the refrigerant is limited, and it is necessary to select a refrigerant that is liquid under normal temperature and normal pressure, so only high-temperature refrigerant can be selected. Also consider the problem of refrigerant volatilization when preparing nano-refrigerant, and the volatilization of the refrigerant will affect the concentration of the nano-refrigerant. Ensuring the long-term stability of nano-refrigerants is the focus and difficulty in the research of nano-refrigerants.
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