Development of refrigerant and innovation of refrigeration technology

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Abstract

Under the theme of low-carbon and environmental protection in China,Low energy consumption and environmental friendliness became the main requirements.And China's energy consumption for cooling and heating has increased by 40%[1].Facing such huge energy consumption of refrigeration industry, How to adopt reasonable energy-saving measures is particularly important.In addition to the development of new refrigerants and optimization of components, the optimization of refrigeration cycle system is also very important. In the condenser outlet coolant for supercooled to improve the cooling efficiency of cooling system is of great importance, the main ways of supercooling are regenerative , using the cooling capacity of the system and mechanical undercooling..The regenerator and its supercooling degree of supercooling of cooling capacity is small, usually 3-10 °C, the mechanical super-cooling can realize larger supercooling degree[2]. In the replacement of new refrigerants,It is mainly about the elimination of HCFCs refrigerant and the development and utilization of natural refrigerant and synthetic refrigerant. This paper mainly discusses the research and development of refrigerant replacement and the improvement and innovation of refrigeration technology, summarizes the advanced technologies and practical cases with development prospects in recent years, and briefly analyzes their advantages and disadvantages.

Keywords

Energy-saving,supercooled,refrigerant.

1. Refrigerant replacement and development

With the “greenhouse effect” on human living environment increasingly prominent.Many countries attach great importance to the research of refrigerant.Since the beginning of the 21st century,all countries have been trying to find energy saving, environmental protection and more efficient alternative working medium.The United States has proposed to accelerate the replacement of HFCs, will use low GWP refrigeration medium, especially to develop research, promote the application of natural working medium[3].

For China, the elimination process of HCFCs refrigerant has been started during the 12th five-year plan period. The commonly used HCFCs mainly include R22, R142b,R141b and R123, among which R22 is the main one, accounting for 70% of all HCFCs[4].

1.1 Research progress at home and abroad

J. Steven Browner [5] conducted a comparative study on the performance of two refrigerants applied in automobile refrigeration system in 2002. The results showed that COP of CO_2 system was 21% lower than that of R134a system at 32.2℃, and 34% lower at 48.9 ℃.

Ren Nuoying[6] aiming at the existing problem of R22 alternative working medium presented with good environmental performance, saturated vapour pressure close to R22 alternative natural working substance propylene, through to the R1270, R22 and thermal physical properties of R290 and thermodynamic cycle performance analysis and comparison, found that propylene instead of R22 in a certain extent, can improve the running characteristic of system and have more advantages than the existing alternative working medium.

Wang Hongli[7] established an analysis equation of energy and exergy for R1234yf heat pump system, and analyzed the influence of evaporation temperature on COP of system,compressor pressure ratio and exergy loss.The results showed that the cooling COP of R134a system was higher than that of R1234yf system from 1.07% to 2.06%, and the heating COP was higher than that of R1234yf system from 1.05% to 1.74%.The existing R134a system does not need major adjustment, and can be replaced by R1234yf.

He Yongning[8] compared the thermophysiological properties of working fluids such as R1234ze, R134a, R124 and R142b, and analyzed the performance parameters of several working fluids such as pressure ratio, COP, compressor exhaust volume and exhaust temperature under the same working conditions in the application of high temperature heat pump.The comparison results show that R1234ze has the characteristics of high COP, moderate pressure ratio and low exhaust temperature of compressor in the working range of high temperature heat pump 75 ~ 95℃.At the same time, its good thermal properties and low GWP value determine that it can be used in high temperature heat pumps.

2. Analysis of several methods to improve refrigeration efficiency

At present, the ways of undercooling in refrigeration system include: regenerative , using the cooling capacity of the system and mechanical undercooling.

2.1 Supercooling system with regenerator

The regenerator mainly has the following functions :(1)Reducing harmful overheat, increase COP;(2) the regenerator makes the liquid entering the evaporator undercooled, reducing throttling loss;(3) Vaporize the liquid droplets contained in the return gas and prevent the compressor from producing liquid impact[9].

Boewe[10] conducted experiments on a trans-critical CO_2 automotive air conditioning system with regenerator of different lengths, and found that by reducing the expansion loss in the cycle, the heat transfer effect in the heat exchanger was improved, and the cooling capacity and COP of the system were increased by 25%.

Domanski[11] conducted an experimental study on the advantages of regenerator for system performance and thermal power.

2.2 Using the system's cooling capacity

The use of the system's own cooling capacity for supercooling is, in essence,to change the flow path of refrigerant pipeline in the refrigeration system, to divert some refrigerant from the compressor to the throttling device to reduce the dryness and temperature of the refrigerant, and to absorb the heat of the other part of the refrigerant in the supercooling device to achieve the purpose of supercooling the refrigerant[12].

Wang junyong[13] has developed a device to improve the undercooling degree of air conditioner. An auxiliary branch is added at the cooling outlet, and the refrigerant in the auxiliary branch throttles and depressurizes and cools, and then conducts heat exchange with the main flow path to improve the undercooling degree of the system.

Meng Qinghai[14] will rely on its own, such as the amount of cold too cold cycle is divided into a traditional too cold circulation and a no overheating too cold refrigeration cycle, and to the thermal analysis, the analysis results show that the condensation temperature of 40℃,the evaporating temperature of 0 ℃, its circulation cooling capacity with the increase of heat heat cycle refrigeration coefficient first decreases after the rise, the degree of superheat below 50 degrees, on its own too cold cycle refrigerating capacity than too cold circulation.

2.3 Mechanical subcooling

The most common method of mechanical supercooling is to attach a steam compression cooling system to the condenser outlet.

Gu kaichun[15] studied the feasibility of applying mechanical supercooling in automobile air conditioning.By experimental comparison, for not using mechanical automobile air conditioning is too cold, in the same working medium, the same condensation temperature, evaporation temperature, degree of supercooling and superheating temperature, adopt mechanical supercooling of automotive air conditioning refrigerating efficiency increased by 12.6%, discharge temperature of compressor fell by 0.94 ℃, thus the mechanical supercooled effectively improve the refrigeration efficiency.

Ren yunfeng[16] proposed a new mechanical supercooled jet cooling system NERS,which introduced an auxiliary liquid-gas jet pump and supercooled the liquid out of the condenser through a small amount of pump work. In this system, COP of the new cycle was 12% and 11% higher than that of the conventional system for refrigerant R600a and R152a respectively.

Baomin Dai[17] proposed a residential heating system combining direct special mechanical supercooling and CO2 heat pump.The results show that the equipment cost and electricity cost of CO2 heat pump system with direct mechanical supercooling are reduced.

3. Conclusion

Since the birth of refrigeration technology, about two hundred years of development, China's refrigeration industry requirements for low energy consumption and environmentally friendly. Among them, the energy consumption of air conditioning is an important part of the energy consumption of commercial buildings. Faced with this problem, heat pump technology is widely used in the field of hvac due to its high energy efficiency ratio and advantages of clean and environmental protection. In view of the existing problems in the refrigeration industry, this paper mainly makes a discussion and summary through the replacement of traditional refrigerant and innovation of refrigeration technology:

(1)At present, the elimination process of HCFCs has been started, the main replacement working medium for CO_2, NH_3 and other natural working medium; On the other hand is R1234yf and R1234ze and other synthetic working medium. Combined with the results of some domestic and foreign researchers, it can be known that these new refrigerants have obvious advantages and significant effects in replacing traditional refrigerants.

(2)Supercooling can improve the efficiency of the refrigeration system. At present, the ways of undercooling in refrigeration system include: regenerator undercooling, self-cooling and mechanical undercooling. Under the same experimental conditions, through comparison with the traditional refrigeration system, it can be seen that the cooling capacity and COP of the system can be significantly improved by undercooling, but the energy saving effect may not be brought by undercooling.

References

[1] Huang Min.The influence of supercooling degree on energy saving in two-stage compression refrigeration system[J].Journal of jiangsu vocational and technical college of economics and trade,2015(06):70-73.

[2] Zhang Hua,Tang Junyu,Zhang Long,ChenJie.Performance Analysis of Sub-cooled Refrigeration Cycle of Some Refrigerants[J].Home appliance of science and technology,2006(03):42-43.

[3] Zhang Xialing,Zhang Meiqiong,Wang Yan,Wang Kaiming.The trend of refrigerant substitution guided by laws and regulations[J].lubricating oil ,2019,34(03):1-6.

[4] Wang Xin,Li Zongshuai,Xu Qiang,Sun Sen.Development situation of alternative refrigerant and production status of refrigerant in China[J].Refrigeration & Air-Conditioning,2011,11(01):110-115.

[5] J.Steven Brown; Samuel F.Yana－Motta; Piotr A.Domanski.Comparitive analysis of an automotive air conditioning systems operating with CO2 and R134a［J］.International Journal of Refrigeration，2002，25(1) : 19－32．

[6] Ren Nuoying,YanGang,Song Fei. Performance Analysis of Natural Refrigerant Propylene as Substitute for R22[J].Home appliance of science and technology,2006(03):44-46.
[7] Wang Hongli,Li Huasong,Han Jianming,Zhang Guoqing.Energy and exergy analysis of R 1234yf heat pump system[J].Cryogenics & Superconductivity,2019,47(01):62-65.
[8] He Yongning,Xia Yuan,Jin Lei,Yang Dongfang,Cao Feng.Investigation on Application of R efrigerant R1234ze in High-temperature Heat Pump[J].fluid machinery ,2014,42(03):62-66.
[9] Guo Yaqi,Ye Zuliang,Wang Yikai,Yin Xiang,Cao Feng.Overview of Progress in Research of Internal Heat Exchanger in Transcritical CO_2 System[J].fluid machinery,2019,47(01):84-88.
[10] Boewe D E， Bullard C W， Yin J M， et al. Contribution of internal heat exchanger to transcritical r-744 cycle performance ［J］.Hvac & R Research，2001，7（2）：155-168.
[11] Domanski P A,Didion D A,Doyle J P.Evaluation of suction line-liquid line heat exchange in the refrigeration cycle ［J］.International Journal of Refrigeration,1992，17（7）：487-493.
[12] Jin Tingxiang,Lv Zijian. Research development of the application of subcooling technologies in the vapor compression refrigeration system[J].Cryogenics & Superconductivity,2016,44(02):67-72.
[13] Wang Junyong.A research on the supercooling device of air conditioner[J].Industrial technology，2011(5) : 91-92.
[14] Meng Qinghai,Qin Haijie,Shan Yongming,Xu Jing.Application and analysis of subcooling technology in refrigeration system[J].Refrigeration and Air-Conditioning,2009,9(04):87-90.
[15] Gu Kaichun,Zhang Hua,Wu Zhaolin.Application of mechanical super-cooling refrigeration system in a auto air conditioning[J].Refrigeration and Air-Conditioning,2003(04):54-56.
[16] Ren Yunfeng,Yu Jianlin,Li Yanzhong.Theoretical study on a new mechanical subcooling ejector refrigeration system[J].Journal of Harbin Institute of Technology,2008(01):164-168.
[17] Baomin Dai,Haifeng Qi,Shengchun Liu,Muyu Ma,Zhifeng Zhong,Hailong Li,Mengjie Song,Zhili Sun. Evaluation of transcritical CO2 heat pump system integrated with mechanical subcooling by utilizing energy, exergy and economic methodologies for residential heating[J]. Energy Conversion and Management,2019,192.