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International Journal for Modern Trends in Science and Technology
Volume 9, Issue 11, pages 09-14.
ISSN: 2455-3778 online
Available online at: http://www.ijmtst.com/vol9issue10.html
DOI: https://doi.org/10.46501/IJMTST0911003

Review on different types of refrigerants and their performance characteristics

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To Cite this Article
Dr. M. Paul Daniel, Dr. P. Sreenivasulu, Shaik Abdulla and Daggubati Sunil. Review on different types of refrigerants and their performance characteristics, International Journal for Modern Trends in Science and Technology, 2023, 9(11), pages. 09-14.https://doi.org/10.46501/IJMTST0911003

Article Info
Received: 16 October 2023; Accepted: 07 November 2023; Published: 10 November 2023.

ABSTRACT

In this review we have done studies on different types of refrigerants usage and with the inclusion of nano particles in the refrigerant their performance characteristics. The cooling time of R1234yf decreases up to 7% because R1234yf has about 25% more mass than R134a.The GWP of R1234yf is 4 whereas the GWP of R134a is 1430.The combination of HCFC-134a with ester lubricants is suggested as a better option than other lubricants for refrigeration applications.The use of carbon dioxide gas is a good option for electrical cars. The use of nano particles with refrigerant improves the performance of air conditioning systems.

KEYWORDS: Automobile air conditioning system, nano particles, R134a refrigerant, COP, energy consumption, cooling capacity

1. INTRODUCTION

The present literature review focuses on performance of Automobile air conditioning system and nano fluids. Khalid et al. (2003) simulated the automobile air conditioning system with five refrigerants. In this, he has found R290/R600a to be the best alternative to replace R12.The superheat temperature of R290/R600a is 1–3°C less than that of R-12, depending on the outdoor temperature and load. The results shows that R12 has a better COP and energy consumption. But the alternate mixture had better subcooling, evaporator discharge temperature, cooldown time, and less time consumption to reach passenger comfort conditions when compared with R12.

2. AUTOMOBILE AIR CONDITIONING SYSTEM

Gaurav et al. (2015) has experimented with car air conditioning systems using R134a refrigerant and R1234yf refrigerant, which has a lower global warming potential of 4. Flammability, cooling time, blower speed, and humidity of automobile air conditioning systems were investigated. The cooling time of R1234yf decreases up to 7% because R1234yf has about 25% more mass than R134a. It is concluded that using R1234yf, there will be no leakage due to the low compression ratio in the system, and thus flammability is reduced. With the decrease in cooling time, there will be an increase in blower speed.

Zhang et al. (2016) proposed a model-based design approach to the automobile air conditioning system. Fuel consumption and cooling performance are addressed by studying energy optimisation. The test results showed that a model-based approach reduces fuel consumption, increases the performance of the air conditioning system, and achieves desired passenger comfort conditions in less time.

Verde et al. (2016) conducted theoretical and experimental investigations on adsorption systems as an alternative to conventional automobile air conditioning systems. A prototype of an adsorption system is made that takes into account all the mass transfer and pressure drop for each component of the system. The tested chiller was able to produce an average cooling capacity of about 2.1 kW with a COP of 0.35 at the rated operating conditions. Heat recovery system results in increasing the COP by 43% and the cooling power by 4%.The test results showed that the proposed prototype predicted the performance of the system under different operating conditions. The cooling capacity is increased, the COP is improved, and power consumption is reduced.

Jignesh et al. (2017) have studied theoretically different refrigerants to find a drop-in substitute for R134a in automobile air conditioning systems. For this analysis, refprop software and the energy equation solver were used. The GWP of R1234yf is 4 whereas the GWP of R134a is 1430.From the analysis, it is concluded that the COP of R1234yf is less than that of R134a, but R1234yf is the best alternative to R134a in terms of low global warming potential and requires fewer system modifications.

Huang et al. (2017) proposed a controller for AAC that saves energy compared to the traditional controller. The proposed controller has two options: a slow time scale and a fast time scale. The slow time scale uses the steady state model to find energy efficiency at set points. The fast time scale uses extracted set points. The proposed controller can improve performance while reducing the energy consumption by 9% comparing with the on/off controller. Experiments were conducted with both the proposed and traditional controllers, and it was observed that, compared to the traditional controller, the proposed controller reduced energy consumption more than the traditional controller.

Cen et al. (2018) stated that a lithium-ion battery thermal management (BTM) system that directly cools the battery pack with the refrigerant used in electric vehicles (EV) is being researched. The system's battery pack thermal management module is made with cylindrical-shaped lithium-ion batteries using a simple finned-tube heat exchanger structure and a unique aluminium frame. Using two electronic expansion valves and self-programmed control software, the module is then incorporated into the electric vehicle air conditioning system. This allows for autonomous temperature regulation of the pack. According to experimental findings, the BTM system can readily maintain the temperature of the battery pack at a suitable preset setting even in conditions of extremely high ambient temperatures, up to 40°C. Additionally, by optimising the refrigerant circuit, the temperature irregularities inside the battery pack were reduced.

Jadhav et al. (2019) stated that the compressor used in car air conditioning systems reduces the performance of the engine. In the proposed vapour absorption refrigeration system, the exhaust heat from the car is employed in VARC systems for cooling. Electric heaters are installed, which are used as a source for exhaust gas heat that can be utilised when the engine is not running. This system works better when electric power is used. They also concluded that when the vehicle maintains high speeds, the system performs well.

Hamisa et al. (2019) experimented with automobile air conditioning systems that use nanoparticles mixed with lubricants. The experimental results were compared with the previously published results and concluded that there was an increase in COP and reduction in power consumption by utilising the nanoparticles in the lubricating oil of automobile air conditioning systems.

Mohanraj et al. (2020) discussed environmentally friendly refrigerant usage in automobile air conditioning systems. They reviewed the thermodynamic, thermophysical, and chemical characteristics of various refrigerants mixed with nanoparticles. They concluded that the usage of hydrocarbon refrigerants gives better performance compared with other refrigerants; only the flammable characteristics of hydrocarbon refrigerants have been reduced. The use of carbon dioxide gas is a good option for electrical cars.Although hydrofluoroolefins have a short atmospheric life, they form trifluoroacetic acid when they get decomposed, which is dangerous to aquatic life.

In the above twelve papers, the environmentally friendly refrigerant selections suited to automobile air conditioners are reviewed. The thermophysical, physics, and chemical properties of the environmentally friendly refrigerants were taken into consideration. Due to their favourable physics, thermophysical, and environmental characteristics, organic compound refrigerants can predominate within the automotive air conditioning market.

3. PERFORMANCE AND BEHAVIORAL ASPECTS OF ALTERNATE REFRIGERANTS

Jung et al. (1991) discussed finding a suitable replacement for R12 refrigerant by comparing it with pure and mixed refrigerants. A computer simulation programme is utilised in which both successive substitution and the.

Preisegger et al. (1992) summarised the importance of R134a refrigerant selections in terms of their properties, material compatibility, chemical properties, compressor lubricants, and thermodynamic properties. With the absence of chlorine atoms in the R134a refrigerant, it acts better for chemical and thermal stability. The usage of R134a refrigerants in metals such as copper and brass was found to be non-corrosive compared with that of CFC refrigerants. therefore well-matched with all the metal alloys used in the machinery. They also discussed the cleanliness of the system before filling the R134a refrigerant into it because the impurities, oil, and foreign matter present in the condenser and compressor will be mixed easily with the R134a refrigerant, thus creating problems of blockage at the capillary tube. So proper cleanliness of the system is more important than CFC refrigerant.

Lorentzen et al. (1993) summarised that there is a general belief that only new refrigerants will have less ozone depletion potential, which results in the development and releases of several refrigerants into the atmosphere, which affect the environment in many ways. With already available natural refrigerants, there are a number of ways to utilise them in a proper manner and benefit the environment. CO2 is used in car air-conditioning systems and is compared with that of CFC refrigerant. The design changes in the heat changes while using CO2, like the number of tubes of heat exchanges, are more than those of CFC refrigerants, which results in a large air side surface and light weight construction, thereby reducing refrigerant surfaces, which are compensated for by the higher inside heat transfer coefficients of CO2.

Devotta et al. (1995) discussed alternatives to CFC-11, CFC-12, CFC-114, and HCFC-22 and compared them with other HFC refrigerants. HCFC-134a has emerged as an alternative to CFC-11, except for its flammability problem. The combination of HCFC-134a with ester lubricants is suggested as a better option than other lubricants for refrigeration applications. The prospective short- and long-term replacements for CFC-114 in high-temperature heat pumps are HFC-143 and HFC-134a refrigerants.

Tamura et al. (2005) summarised solutions to global warming and energy conservation issues and suggested natural refrigerants as alternatives. CO2 is considered as a better replacement for HFC refrigerants in automobile air conditioning systems. The research was done on a CO2-based heat pump; instead of drawing heat from electric heaters, the waste heat from the heat pump is used as an auxiliary heat source. From the test results, it was observed that system performance was improved compared with the R134a system.

Mohanraj et al. (2009) experimentally invested in a domestic refrigerator test rig to find an alternative to R134a refrigerant with hydrocarbon refrigerant. Because of its high global warming potential, R134a has to be phased out soon. The test results showed that mixtures of R290 and R600a in different ratios had lower energy consumption and a higher COP compared with R134a. The discharge temperature of R134a is higher than that of hydrocarbon refrigerant, and the system performance enhancement was compared with that of R134a.

Ravikumar et al. (2009) experimentally investigated an automobile air-conditioning test rig. R134a is mixed with a hydrocarbon blend; it is compared with CFC-12 and R134a refrigerants. However, the use of PAG oil as the lubricant presents a concern. The proposed refrigerant blend, along with mineral oil, proved to be a better replacement for PAG oil as a lubricant, and it is a better alternative to R12. It is observed that system performance is improved compared with that of R12.

Kasni et al. (2016) numerically investigated the performance of automotive air conditioning systems with R134a and R152a refrigerants. The engine was made to run at three speeds: 1000, 2000, and 3000 rpm, which indicate ideal city and high-speed conditions. The cooling capacity improved at condensing temperatures above 50°C. There was a reduction in power consumption, which indicates the consumption of fuel is reduced. The COP of R152a is slightly higher than that of refrigerant R134a.

Leiwang et al. (2016) made a system that is a combination of both an ejector refrigeration system and a vapour compression system. The ejector refrigeration system received its drive source from the waste heat energy given by automobiles. Ejector performance is investigated by examining the effect of ejector geometry parameters. The proposed model is compared with a conventional system. It was observed that in the hybrid system, COP improved much better than in the conventional system.

Yue et al. (2016) proposed a new air conditioning system for automobiles that is a combination organic Rankine cycle and automobile air conditioning system. It is compared with conventional automobile air conditioning systems from a thermal and economic point of view. The results obtained showed that the proposed system improves performance; thus, COP increases and fuel consumption decreases compared to the conventional air conditioning system.

Harby et al. (2017) discussed that energy consumption is higher in refrigerants, which are not environmentally friendly. It is suggested that the use of hydrocarbon refrigerants is a good option for replacing refrigerants that have a higher global warming potential and ozone depletion potential. A review of previous papers published on hydrocarbon as an alternative to halogenated refrigerants is studied, and an attempt has been made to cover all the options related to hydrocarbon refrigerant usage in the present and future. Although hydrocarbon refrigerants have flammable features, they are better in terms of energy efficiency, discharge temperature, and COP compared with other refrigerants with higher ODP and GWP.

Kasaeian et al. (2018) suggested that the refrigeration and air conditioning sectors are significantly impacted by the development of environmental refrigerants. The refrigeration and air conditioning sectors can benefit from scientific research on environmentally friendly refrigerants to make a seamless shift to sustainability. The present paper is a review paper on refrigerants that have low GWP and low ODP. The research is focused on HFO and HC refrigerants, and it was concluded that the usage of R1234yf is a good replacement for R134a refrigerant. Despite the remarkable advantages of nanorefrigerants, it appears that HFC and HCFC were most frequently used in research on these substances.

WeiPang et al. (2019) designed a solar PV-powered air conditioning system for automobile systems. The automobile air conditioning, which uses battery power for running, increases the power consumption. In this case, DC (direct current) from solar PV is utilised for the air conditioning system. The main aim is to replace the battery power with solar PV power. The test results showed that human comfort conditions inside the automobile cabin were not compromised by using solar PV modules. The air conditioning system's performance was similar to that of already existing battery-powered systems.

Yang et al. (2019) proposed regression methods with multiple variables for the genetic algorithm. In order to accelerate the iteration speed, a fixed-point iteration algorithm is used. A genetic algorithm is combined with distributed parameters to guess the accuracy of a microchannel gas cooler. It is also used to represent the actual effectiveness of different heat exchangers. For the first time, the fixed-point iteration technique was put forth as an alternative to the established bisection and Newton-Raphson iteration algorithms for use with MCGC models. The heat transfer efficiency of gas coolers can be accurately predicted by the proposed numerical model.

Pabon et al. (2020) discussed refrigerants with high GWP values, which is one of the current issues that refrigeration systems encounter. R134a sticks out among them and is still utilised in a number of applications. The most pertinent uses of R1234yf as a replacement for

R134a have been reviewed in this article. Due to its low GWP, R1234yf is considered the best compared to R134a. In refrigeration devices that employ an ejector, such as a compression/pumping device or an expansion device, R1234yf exhibits compatible behaviour compared with R134a. New PAG oils must be used for R1234yf because R1234yf has some implementation issues with lubricants made specifically for R134a.

Yang et al. (2020) proposed a hybrid air conditioning system that incorporates conventional air conditioning systems combined with a new air conditioner composed of a network of heat exchangers, a packed bed, and a set of air-to-water cooling coils. The operating energy consumption of a hybrid air conditioning (HAC) system can be decreased by a packed cooling tower with a reasonable air-to-water heat capacity ratio. The HAC-P parallel mode technology, however, is more adaptable. The HAC-P system's ideal fresh air flowrate, in terms of energy savings, ranges from 0.2-0.25 kg/s. The parallel mode of the hybrid air conditioning (HAC-P) system has an energy-saving rate between 42.5 and 64.0% when compared to the mechanical vapour compression (MVC-E) system, and its typical energy savings per hour are between 0.36-0.82 kW.

Zhang et al. (2020) considered the natural refrigerant R290 as a potential replacement for R134a in automobile air-conditioning systems. The use of R290, an A3-class refrigerant, presents the greatest problem due to its explosive and flammable properties. The major factors affecting R290 distribution in the engine compartment leakage case were identified as being leak pressure, leak hole size, and wind speed. In order to reduce the R290 leakage by decreasing the wind speed and increasing the hole size.

4. CONCLUSION

From the above literature survey, it was noticed that despite the remarkable advantages of nanorefrigerants, it appears that HFC and HCFC were most frequently used in research on these substances.The experimental results were comparedthere was an increase in COP and reduction in power consumption by utilising the nanoparticles in the lubricating oil of automobile air conditioning systems.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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