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“A REVIEW OF NANO REFRIGERANT AS ALTERNATIVE REFRIGERANT REPLACEMENT IN DOMESTIC REFRIGERATION SYSTEM”

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ABSTRACT

Many refrigerants, which are used to transfer heat from low temperature reservoir to high temperature reservoir by using, vapour compression refrigeration system. The working of different refrigerants due to their environmental impact, toxicity, flammability and high pressure which makes them more hazardous than other working fluids according to safety and environmental issues. Keeping in mind the present scenario of climatic change and demand comfort of modern human age the researcher and inventors must have to take a steps on all possible ways to protect/prevent or save the earth and its environment in terms of global warming effect. Refrigerants are one of the reasons which contribute the change in temperature by exchanging heat to the environment so our efforts should also be focused on the use of possible natural refrigerants replacements at lesser cost and a Low potential effect on environment. As there is large no. of natural refrigerants are available with varying nature of their thermodynamic properties, chemical properties and its stability.

Key Words: Refrigerants, COP, Nano Refrigerants, Thermal Performance.

I. INTRODUCTION

Refrigeration systems are required for food and vaccines transportation, comfort cooling, cold storage applications, supermarket display and retails. Industry market research for business leaders, January 2011, statistically stated that the global demand for commercial refrigeration equipment is projected to rise 5.2% per year through 2014 to \$29.7 billion [1]. The global industry analysts announced that the global market of air conditioning is expected to reach 78.8 million units in volume sales by 2015 and this global demand is significant in areas of warm climate and high capita income. Currently, most of the above demand is met by mechanical vapour compression systems driven by high grade electrical power input and utilises environmentally harmful refrigerants [2-4]. Refrigeration and air conditioning systems consume around 30% of total worldwide energy consumption [5]. Based on the new environmental regulations (Kyoto protocol, Vienna Convention and Montreal Protocol) CFCs and HCFCs phase-out have been agreed. Moreover, HFCs were one of the six addressed greenhouse gases by Kyoto protocol and countries may seek to limit its use to meet its legally binding greenhouse gas emissions targets.

II. ENVIRONMENTAL REGULATIONS

The environmental regulations were adopted to solve the problems of ozone depletion and global warming, which are the major problems nowadays. The thinning of ozone layer that absorbs 98% of the sun's high frequency ultraviolet

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lights has been confirmed in 1980s .

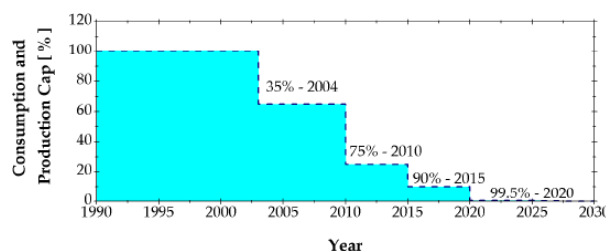


Figure No. 1 Montreal protocol of HCFCs

Hydrocarbons (HCs) are the class of natural occurring substances that include propane, pentane and butane. HCs are excellent refrigerants in many ways energy efficiency, critical point, solubility, transport, heat transfer properties and environmentally sound but their major concern is their flammability.

Hydrocarbons (HCs) are very good refrigerants for many reasons:

- They are compatible with copper and the standard mineral oils.
- They have a very low environmental impact in comparison with CFCs, HCFCs and HFCs.
- They perform very well, with good capacity and efficiency.
- Due to lower liquid densities, low refrigerant charge than that of HFCs then the high heat transfer coefficients hence high latent heat of vaporization.
- Coefficient performance (COP) of the system increases and Power consumption reduced with HCs.
- It improves Compressor life due to low discharge temperature compare to HFCs, HCFCs and CFCs.

III. REFRIGERANT

1. **Freon R12:** - This refrigerant is CFC based and is also known as R12. The refrigerants chlorofluorocarbon (CFCs) and Hydro chlorofluorocarbon (HCFCs) both have high ozone depleting potential (ODP) and global warming potential (GWP) and con-tributes to ozone layer depletion and global warming.
2. **Tetrafluoroethane:** - Refrigerant is also known as R134a which is most commonly used replacement refrigerant for R12 because of having favourable characteristics such as zero ODP, non-flammability, stability and similar vapour pressure as that of R12. The ODP of R134a is zero, but it has a relatively high global warming potential.
3. **Isobutane:** - This refrigerant is also known as R600a which has zero ozone depletion and negligible global warning potential. it is a high purity isobutane which is derived from natural ingredients.

Refrigerant	R 600a	R 134a	R 12
Name	Isobutane	TetraFluro – Ethane	Chlorofluoroca rbon
Formula	C ₄ H ₁₀	CH ₃ CH ₂ F	CCL ₂ F ₂
Critical Temp °C	135	101	112
Molecular W in kg/k mole	58.1	102	120.9
Normal Boil point	-11.6	-26.5	-29.8
Pressure at -25 °C in bar (absolute)	0.58	1.07	1.24
Liquid density kg/lit	0.60	1.37	1.47
Vapour density kg/m ³	1.3	4.4	6.0
Volumetric capacity k J/m ³	373	658	727

Table No. 1 : Properties of Refrigerants

IV. MIXTURE OF REFRIGERANTS

A refrigerant mixture consists of two or more components. The extent to which these dissolve in the compressor oil varies for the different components. In systems where the refrigerant charge is small in comparison to the oil volume, this difference in solubility may lead to problems. For example, if a mixture has a small percentage of one component that dissolves more readily in the oil than the other components, this will influence the physical properties and thereby the system performance. **Azeotropic Mixture:** Although it contains two or more refrigerants, at a certain pressure an azeotropic mixture evaporates and condenses at a constant temperature. Because of this, azeotropic mixtures behave like pure refrigerants in all practical aspects.

Zeotropic mixtures:

Zeotropic mixtures have a gliding evaporation and condensing temperature. When evaporating, the most volatile component will boil off first and the least volatile component will boil off last. The opposite happens when gas condenses into liquid these results in a gliding evaporation and condensing temperature along the heat transfer surface.

Nanofluids:

Nanofluids were found to exhibit thermo physical properties such as higher thermal conductivity, thermal diffusivity and viscosity than those of base fluids. Heat transfer enhancement in a solid fluid two phase flow has been investigated for many years ago. Research on gas particle flow seen that by adding particles, particularly small particles in gas, the convection heat transfer coefficient can be significantly increased. The enhancement of heat transfer, in case addition to the possible increase in the efficient thermal conductivity was mainly due to the reduced thickness of the thermal boundary layer.

V. PREPARATION AND DESCRIPTION

Preparation of nanofluids is the first step in experimental studies with nanofluids. Nanofluids are not simply liquid-solid mixtures only. Some important special requirements are essential e.g. even and fixed suspension, durable suspension, negligible agglomeration of particles, no any chemical change of the fluid, etc. Nanofluids are produced by dispersing nanometer scale solid particles into base liquids such as water, ethylene glycol, oils, refrigerant, etc. [6] As per the recommendation from Montreal Protocol to out of CFCs and HCFCs and Kyoto Protocol even new developed HFCs refrigerants. Due to their high global warming potentials. Most commonly used condensing and evaporating temperatures 550C and -250C respectively. [7] Global warming which affect the environment by the use of refrigerant and aim is to reduce the effect of global warming as well as optimize the performance of domestic refrigerators by using the latest refrigerants. Performance of refrigerator is increased by using different refrigerants. Which has zero ozone depletion potential and almost good thermodynamic properties, The higher GWP due to emissions from domestic refrigerators leads to identifying a long term alternative to meet the requirements of system performance. Therefore it is going to be banned very soon for environmental safety. [8] Hydrocarbon mixture is an alternative refrigerant for Hydro Fluorocarbon and Chlorofluorocarbon compounds due to their lower GWP and zero Ozone Depletion Potential. The impact on the environment is also reduced due to usage of hydrocarbon mixture in different mass ratio. [9]The manufacturers of refrigerants and refrigeration, air conditioning equipment, governmental agencies, and environmental groups continue working together toward the goal of reduced environmental impact via reduced emissions and improved energy efficiency. Examples of progress are presented for several sectors of refrigeration and air conditioning, followed by projections for further significant reductions. Looking forward refrigeration has adverse effect on environment.

[10] Performance of refrigerator is increased by using different refrigerants. Domestic refrigeration and other vapor compression system having zero ozone depletion potential and almost good thermodynamic properties, but it has a high Global Warming Potential . Some new refrigerants is been found by researchers which are environmental friendly refrigerants having low GWP and low ODP. Hydrocarbon refrigerants particularly propane, butane and isobutene are proposed as an environment friendly refrigerants. [11] Indian traditional cooler and much more quantity of water has been used every year. Also to make this efficient woods product known as “wood wool / khas” have been used which became a major reason of deforestation. The refrigerant R134a absorbs the heat from air and makes the cool air by

getting vaporised in evaporator and then the cooled air is sent outward from the opening in the research model with help of fan running on motor and gives the cooling effect. This use of VCRS system with eco -friendly refrigerant reduces the consumption of the water, electricity consumption and tree which is used for making wood wool in conventional cooler. This ultimately reduces the global warming. Air Conditioners. In 21st century the world facing problem of electricity and water to overcome this problem worldwide many researches going on. Further cooler uses water so as cooling air, for this application [12] This consumes large amount of water and electricity so for reducing the use of these main sources research involves the use of VCRS system which include eco- friendly refrigerant R134a in cooler system. This system is mounted in the research model in a proper manner so that it is compact in size. The refrigerant R134a absorbs the heat from air and makes the air cooled, itself getting vaporized in evaporator and then the cooled air is sent outward from the opening. In the research model with help of fan running on motor and gives the cooling effect. This use of VCRS system with eco -friendly refrigerant reduces the consumption of the water, electricity consumption and tree which is used for making wood wool in conventional cooler.

[13] There are many kind refrigerants, which are used to transfer heat from low temperature reservoir to high temperature reservoir by using vapour compression refrigeration system. There are various obstacles faced in working of different refrigerants due to their environmental impact, toxicity, flammability and high pressure which makes them more hazardous than other working fluids according to safety and environmental issues. Keeping in mind the present scenario of climatic change and demand comfort of modern human age the researcher and inventors must have to be taking steps on all possible ways to protect/prevent or save the earth and its environment in terms of global warming effect. Refrigerants are one of the reasons which contribute the change in temperature by exchanging heat to the environment so our efforts should also be focused on the use of possible natural refrigerants replacements at lesser cost and at low potential effect on environment. As there is large no. of natural refrigerants are available with varying nature of their thermodynamic properties, chemical properties and its stability so it is possible to find better mixture of natural refrigerants by using these refrigerants at different proportion of composition to get the better heat absorbing substance at lesser cost.

VI. NANO REFRIGERANT

Nanorefrigerant is one type of nanofluids. This is mixed of nanoparticles with refrigerants. It has higher heat transfer performance than traditional pure refrigerants. Also, some researchers have been done about nanorefrigerants. Most of them were related to thermal conductivity of these fluids. Viscosity also deserves as increase consideration as thermal conductivity. Pumping power consumption and pressure drop depends on viscosity. Convective heat transfer is important in the HVAC, refrigeration and microelectronics cooling applications. R134a is most extensively adopted alternate refrigerant in refrigeration systems, such as domestic refrigerators and air conditioners. While the global warming up potential of R134a is relatively high, it is acknowledged that it is a long term alternate refrigerants in lots of countries. The adding of nanoparticles to the refrigerant results in improvements in the thermo-physical properties and heat transfer characteristics of the refrigerant, thereby improving the performance of the refrigeration system. [14] Refrigeration systems has find wide applications, and so therefore, it becomes necessary to focus on the performance of these systems. Performance of refrigeration systems depend upon heat rejected at high temperatures, which is accomplished by condensers. In condensers, latent heat of the refrigerant is removed. In present research work, performance of condenser for a domestic refrigerator is targeted by using different condenser materials, and also by using different refrigerants, and heat flux and thermal gradient values are proposed for different combinations using ANSYS. [15] The environmental problems of ozone depletion and global warming are of major concern in the world. Refrigeration and air-conditioning have been identified as major causes for ozone layer depletion and global warming. Thus, there is a great need to search for alternative refrigerants which can be used to replace the conventional CFC and HFC refrigerants used in the refrigeration and air-conditioning systems .This paper presents a detailed study on identifying various alternative refrigerants based on exergetic analysis of vapour compression refrigeration system. The alternative ecofriendly refrigerants for different systems like domestic refrigeration, air-conditioning and automobile air-conditioning have been proposed in this study. [16] Refrigerant is being widely used in current refrigeration and air-conditioning systems. But they consume more power and have high global warming potential. By addition of the nanoparticles to the refrigerant results in improvements in the thermo physical properties the performance of the refrigeration system. An experimental apparatus was build according to the national standards of India. Aluminium

oxide and copper oxide nano fluids are used with R134a refrigerant in vapour compression refrigeration system and the heat transfer coefficient and performance of the system were evaluated by using TK Solver, using nano concentration 0 to 1%. The experimental results shows that the heat transfer coefficient of refrigerant based nanofluid is higher than that of pure refrigerant and also coefficient of performance is higher than the existing.[17] As and when an existing refrigerator of R134a has to be recharged it is suggested to retrofit the system with new/natural and alternative refrigerants. Presently, hydrocarbon mixtures and pure hydrocarbons are available in market to replace R134a, but the optimum ratio and mass fraction to be used for better and safe performance of the system is given by only few researchers. [18] According to American Society of Heating, Refrigerating and Air conditioning Engineers in short ASHRAE.

Human comfort is defined as the condition of mind which expresses satisfaction with surrounding air. In this project, we developed the water cooling refrigerator and air cooling system by combining both the systems through which water is chilled by an eco-friendly refrigerant R-134a and then the air is cooled by this chilled water. Performance analysis of the water cooling refrigeration system was done and analyzed with varying condenser length. By combining these both systems we can reduce the compressor work, cost, save the electrical energy and environment too. [19] The performance of a vapor compression refrigeration system is affected by changing the working fluid. A household refrigerator has been selected for the experimental investigation of performance under various refrigerants like Freon 12, Isobutene and Tetrafluoroethane. The results indicated that Tetrafluoroethane results in best performance over other two refrigerants by considerably reducing the compressor work. Refrigerant R134a base systems has higher GWP value that's why the conversion of same into eco-friendly system is the major concern for refrigeration industry. [20] This investigation focuses on mixture ratio of pure hydrocarbon R290 and R600a used in 200 liter domestic refrigeration system by certain changes in mass ratio of refrigerants. In the present work, first of all the effect of mass ratio of HCM refrigerants on the performance of the system.[16] As now there is nothing hidden about the use of refrigerants, its contribution to increase the entropy of universe and its harmful effects producing capacity to the nature and on there living things in terms of global warming and ozone layer depleting potential.. The regulation implies or applied an HFC phase-down from 2015 to 2030 by means of bans on high GWP refrigerants. R134a is especially under pressure and more likely to be phased out of all commercial systems. [21] VCR system with refrigerant mixture and pure isobutene as drop in replacement of R134a was conducted. Continuation running tests were performed under different length of capillary for R600a/R290 & R600a. length were tested and the results are best for L=10 feet length. The overall performance has proved that the 100g with 10feet length capillary could be the best long term alternative refrigerant to phase out R134a. [22] Effects of sub-cooling on the performance of four ozone-friendly alternative refrigerants in a domestic refrigeration system. The study was performed using a system designed for R12 with the aim of finding a drop-in replacement for the refrigerant. The results obtained showed that the sub-cooler in the refrigeration system positively affected the system performance and all the investigated refrigerants benefited from the performance improvement.[23] An increase in sub- cooling effectiveness reduces the compressors work input and increases the system refrigeration capacity. Also, an increase in the degree of sub- cooling, reduces the pressure ratio, and increases both the refrigerant mass flow rate and coefficient of performance (COP) of the system. The comparison of the performance of R12 and the investigated alternative refrigerants showed that R152a and R134a have the most similar performance characteristics to R12, with R152a having a slightly better performance. These two refrigerants are the best replacements for R12 in a domestic refrigeration system.

The performances of R32 and R143a were significantly lower than that of R12.[24] Retrofitting activity replaces or adds equipment to existing system to improve their energy efficiency, increase their output and extend their lifespan, while decreasing emissions. Initially the refrigeration system works on Vapor Compression cycle was loaded with the R12 refrigerant, which was causing the adverse environmental effects like global warming and Ozone depletion, So it was decided choose the alternative refrigerant for the R12 which is more eco-friendly and also more economical. The refrigerant selected for the system was R134a which has zero ODP and lesser GWP. The major advantage of choosing R134a over R12 is both are having almost the same properties so the system can run on R134a without any major changes in the system. The performance of the system almost remains the same with retrofitting of R12 system by R134a with slightly increased COP (coefficient of performance). And also it reduced cost as well as quantity of the refrigerant gets reduced. Which means R134a is more effective, eco- friendly and economical.

VII. CONCLUSION

Climatic change and awareness of use of refrigerants on VCRS it is found that chemical refrigerants are creating a serious impact on environment by using the existing CFC, HCFC and R290 refrigerants in terms of global warming. The above mentioned harmful existing refrigerants must be replaced with the possible natural alternative refrigerants. The summarized paper can be as follows.

- Out of the given natural refrigerants it is possible to obtained the new mixture alternate refrigerants by blending these refrigerants.
- By mixing these refrigerants it is possible to obtained better refrigerants properties.
- The performance of VCRS may be enhanced by using these alternate refrigerants.

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