A Review on Enhancement in Performance of Refrigeration System using Nanofluid with Refrigerant and Lubricating Oil

N. P. Satange[1] N. M. Bagde[2] S. S. Sevatkar[3] A. M. Nimje[4] S. I. Harinkhede[5]
[1,2,3,4,5]UG Scholar
[1,2,3,4,5]Department of Mechanical Engineering
[1,2,3,4,5]J D College of Engineering & Management, Nagpur-441501, Maharashtra, India

Abstract— In this paper, we are presenting a review on improving the performance of the vapor compression refrigeration system using nanofluids and nanoparticles with refrigerant in refrigeration system. Number of researchers has come forward after knowing the newly evolved technology called as Nanotechnology which introduced nanoparticles to this word. Many researchers were attracted by this new technology and had done experiments with different nanoparticles and refrigerant in the refrigeration system and other heat exchanging devices. This paper mainly focusses on enhancement in performance of refrigeration system. Various reviews and research papers were studied and after that we conclude that we can use nanoparticles and nanofluids with refrigerants and lubricating oil in the refrigeration system without or with any small critical issues (which can be easily solved) and with the help of nanoparticles can improve the performance of refrigerator system.

Keywords: Nano-particles, Nano-technology, Refrigerant, %vf, VCRS, lubricating oil, Coefficient of performance

I. INTRODUCTION

Nanotechnology deals primarily with nanostructured material synthesis, characteristics, exploration and exploitation. In recent decades, after the discovery of fullerenes and nanotubes, nanophysics and nano chemistry became a new area of science and research. Nanoparticles are distinguished by a nano range of at least one dimension and a nanometer (nm) of 10^{-9}m approximately equal to 10 hydrogen or 5 silicon atoms arranged in a line. Some of the physical and chemical material properties on this nanoscale may differ from those of the same consumption bulky or mass structured materials. As a result, many material properties now need to re-examine in view of the fact that there is a significant increase in the surface to volume ratio associated with decrease in material size. Nanofluid is a liquid that keeps nanoparticles immersed in a base fluid like water and lubricating oil to enhance the properties of that base fluid. Mainly minerals, metal oxides and non-metal oxides are these molecules. Such nanofluids have multiple advantages compared to traditional solid and liquid heat transfer intensification suspension, such as lower specific surface area and more heat transfer interface between particles and liquids, better dispersion strength, high thermal conductivity and surface wettability.

The method of extracting heat from a product under controlled environment can be known as refrigeration. It also involves the method of increasing and holding the body temperature below its ambient general temperature. Today it is used for ice and similar product processing. It is also used for chamber refrigeration and transport. Throughout naval boats, planes and missiles, refrigeration is also commonly used.

The refrigerant is a fluid material which absorbs heat from a low temperature system and discard the heat consumed as a heat carrying medium in the refrigeration system into a higher temperature system. Because of protection or lack of chemical or thermal resilience, most of the early refrigerants such as ethanol, ammonia, sulfur dioxide, methyl chloride has been discarded.

There is no such refrigerant that can be used for all product forms, which ensures that if that refrigerant has some positive benefits, it will also have some drawbacks. It should be remembered that one chlorine atom will kill 150 molecules of ozone and those CFC refrigerants such as R11 andR12 have the maximum ODP (potential for ozone depletion) = 1 (worst one). HCFC refrigerants like R22, have relatively ODP = 0.05 and R123 has ODP = 0.02. HFC has null ODP like R134a [32]. Today, on the one hand, this ODP and GWP (Global Warming Potential) and, on the other, spiraling oil prices have become the biggest challenge to the heat exchangers, cooling systems, such as refrigeration systems and air conditioning systems. To the large extent, effective and efficient functioning for living and nonliving things depends on the physical environment and as the need for ventilation and air conditioning rises day by day.

A. Nanotechnology and nanoparticles:

In this new era technology, nanotechnology is growing rapidly [31]. Nanostructure's physics and chemistry or nano-physics and nano- chemistry are new areas of science that is attracting lots of researchers in the last decades and many researchers has done various projects related to nanotechnology. Nanomaterials are currently used for insulation reinforcement of composites etc. A lot of scientists have been drawn by the exciting uses of nanotechnology in chemistry, medicine and biology. Nanoparticles in nano array are distinguished by at least one dimension. Nano-meter (nm) is 10^{-9}m, around 10 hydrogen or 5 silicon atoms arranged in a line. Some of the physical and chemical material properties on this nanoscale can vary from those of the same consumption bulky or mass formed materials.

B. Nanoparticles preparation process:

There are essentially two general approaches to nanomaterials synthesis and nanostructure production.

1) Bottom-up approach
2) Top-down approach

Nanoparticles are synthesized in a variety of ways, both through physical processes and chemical reactions. However, it is possible to divide the most common approach to commercial and industrial nanoparticles into four main groups.

1) Vapour Phase Process

The vapor phase cycle which involves vapor deposition, flame pyrolysis, evaporation at high temperatures and synthesis of plasma. It is also used to make thin films, multilayers, nanotubes, nanomaterials, and molecules that are nanosized. This method is further known as either mechanical vapor deposition or chemical vapor deposition involving the transition of solid material into gaseous form by physical process and then cooled and returned to a deduct with some alternation such as gas reaction. The following method is further graded as,

- Gas vapor deposition
- Plasma based deposition
- Molecular beam epitaxy
- Inert gas condensation
- Flame pyrolysis

2) Liquid phase method

This process involves chemical solvent reactions that leads to colloids, aerosols, being formed. These precipitating nanoparticles can be divided into five groups from a chemical compound solution.

1) Colloidal methods- The process of wet chemistry precipitation is simplest and well known in which solution of various ions is mixed to form insoluble precipitation under regulated temperature and pressure. The nanoparticles produced by wet chemical process can stay in liquid suspension for further use or can be extracted by filtering to produce dry powder.
2) Solution precipitation- This approach relies on nano-size particles accumulation within a continuous fluid solvent. In an inorganic metal salt like chlorides, nitrides, etc., water is soluble. Metal hydrate species arise because of these metal cations, these species of hydrate are added in low solution such as NaOH or Na_4OH. This hydrolysed species is compressed to create the final product and then washed, fermented, dried and calcinated.
3) Electrodeposition-

3) Sol-gel technique

It also includes chemical reaction and calcination followed. It's a technology of colloidal chemistry. It offers the possibility of producing different materials with new, predefined properties in a very simple and relatively low-cost process. The name sol is a colloidal solution that consists of l=100nm in a liquid phase suspended particle in diameter. The chemical conversion of water (the sol) into the gel state (a rigid macromolecules dissolved in a solvent) and the resulting transition into solid oxide product. This system is further known as

1) Sol gel process
2) Sol gel coating process

4) Solid phase mechanical process

This requires moulding and alloying. There are two forms of it,

1) Mechanical milling, attriction and alloying
2) Severe plastic deformation.

C. Vapor Compression Refrigeration System (VCRS):

Refrigeration: It is a method of heat removal regulated by a material. It is a constant heat recovery cycle from a hot body whose temperature is below the temperature the temperature around it. Heat is pumped from lower temperatures to higher temperatures in the cooling system. In this process, refrigerant is used as a solvent that collects heat from the cold body and transfers it to the hot body. Humans has understood the cooling system since 19^{th} century. The modern refrigeration system has a wide range of applications for cooling storage rooms where perishable foods, drinks and medicines are stored. Refrigeration system is also used for the production of ice and the like [32]. A revised type of refrigeration system. There are five essential components consist of a basic VCRS: compressor, condenser, receiver, expansion valve and evaporator.

1) Compressor

It is a process in which low pressure high temperature evaporated refrigerant is injected through the inlet or suction valve into the compressor where it is compressed through high pressure and temperature refrigerant, which is then discharged through the injection or discharge valve into the condenser. In general, the reciprocating compressor in VCRS is hermetically sealed.

2) Condenser:

It is a cooling system composed of coils of piping that cool and condense the high pressure and temperature vapor refrigerant. As the refrigerant moves through the condenser, it gives up the latent heat to the ambient medium, normally air or water. There are 3 condenser types namely 1. Condenser cooled by air, 2. Condenser cooled with water and Evaporative capacitor. Generally,naturally air-cooled convective condenser is used or seen in VCRS.

3) Receiver-

The compressed and condensed fluid refrigerant is contained in a small receiver called the receiver.

4) Expansion valve:

It is also called as throttling tool or metering device which distinguishes the high-pressure side of the refrigeration system from the low-pressure arm. It is then passed through the expansion valve or throttling valve whose main function is to reduce pressure from high-pressure refrigerant to the low-pressure refrigerant which is then fed to the evaporator. It can also preserve the optimal difference in temperature between the high- and low-pressure sides of the device so that liquid refrigerant vaporizes at the desired pressure in the evaporator. The extension unit's capillary tube shape is usually used in the home refrigerator.

5) Evaporator

It is a heat exchanger used to draw heat from a liquid or fluid or medium to be cooled. The low pressure and low temperature refrigerant from the expansion valve enters the evaporator via its inlet valve where it boils and changes to the vapor refrigerant due to the heat absorption from the contained medium. Bare tube coil evaporator is the fastest and easiest way to clean and defrost.

II. LITERATURE REVIEW:

Other scientist has carried out studies on the vapor compression refrigeration system as well as testing the impact of nanoparticles in the refrigerant and lubricant in the refrigeration system on their efficiency. Some of the comments focused on the nanoparticle's refrigerants were presented as follows.

1) Kaufui V. Wong et al. [1] has presented A review article in the year 2009 on Application of Nanofluids: Current and Future. In this paper, they concluded that nanofluids are significant and it can be used in many applications

involving heat transfer and other applications. Researchers found that nanofluids can be used in industrial cooling systems, resulting in high cooling effects and high energy efficiency resulting in reducing emissions. It could benefit from engine oils, automotive transmission fluids, refrigerants, lubricants and other heat transfer devices. They also concluded that nanofluids can be used to boost brake fluid properties in automobiles. Nanofluids can also be used in electronic applications such as microchip cooling in computers and other heat-emitting electronic components. In biomedical applications and nanomedical applications for nanogels or gold-coated nanoparticles, nanofluids and nanoparticles can also be used.

2) Diana C. Hernandez et al. [2] presented a research paper Analysis of working of Nanofluids for a Refrigeration system in 2015. They published a paper showing the applications of nano-refrigerant fluid to boost the refrigerants thermal conductivity and also improves the refrigeration system's thermal efficiency. They conducted stimulation with a mixture of refrigerant R113, R123 and R134a with Al_2O_3 nanoparticles at 1%vf and 5%vf (%vf- volumetric fraction density concentration) flowing through a steady wall temperature horizontal pipe. Through adding 1%vf and 5vf% of Al_2O_3, the result shows an increase in thermal characteristics. Finally, they picked 1%vf of 30nm medium diameter Al_2O_3 because it has higher thermal efficiency and its beneficial properties as a refrigerant. They also found that the size of nanoparticles does not affect nanofluid's thermal properties.
3) Satnam Singh et al. [3] has presented a paper on The Behaviour of nano refrigerant in vapor compression cycle. They found that the thermal nanofluid properties did not affect the size of nanoparticles. Similar experiments were also carried out with the refrigerant mass the size of 150gm, 180gm and 200gm. The outcome was that the length of the capillary tube was 10.5m, the maximum COP of 3.5 was reached and then declines with the expansion of the capillary tube path. They found that the use of low concentration nano-refrigerant is not always accurate. Consequently, they suggested measuring the nano-refrigerant in different concentration. they also proposed that an investigation into the impact of different types of nanofluid with different base refrigerant under different compressor pressure ratio, evaporator and condenser parameters such as temperature and pressure decrease should be carried out.
4) K. T. Pawale et al. [4] has presented a paper named as Performance analysis of VCRS with nano refrigerant. In their experiment they used Al_2O_3 nanoparticles of 40-50nm diameter which were dispersed in R134a refrigerant to enhance its heat transfer performance to have their improved thermal and physical properties over the conventional refrigerant. The concentration of nanoparticles was chosen as 0.5 to 1% by mass. They performed experiment on the project setup made by themselves. Theoretical COP evaluated was 4.17 for pure R134a and for0.5% and 1% Al_2O_3 was found to be 3.75 and 3.54. 0.5% Al_2O_3 shows reduction in COP by 10.07% and 1% Al_2O_3 shows reduction by 15.1%. While actual COP of pure r134 was 2.69. after adding 0.5% and 1% Al_2O_3 cop was found to be 3.52 and 2.92. 0.5% Al_2O_3 shows increment by 30.85% and 1% of Al_2O_3 shows decrement by8.55%. Discharge temperature of compressor of pure R134a was 84^0C. at 0.5% discharge temperature was reduced by 2.8% and increased by 3.55% at 1% Al_2O_3. Suction temperature for pure R134a was 52^0C and it was decreased by 23.07% and 28.84% in 0.5% and 1% of Al_2O_3. Suction pressure was reduced by 28.9% at 0.5% Al_2O_3 and for 1% Al_2O_3 reduced by 18.42%. Discharge pressure was increased by0.005% and 8% for 0.5% and 1% Al_2O_3. Superheat was improved by 200% and 114% for 0.5% and 1% Al_2O_3. Subcooling was improved by 118% and 181% for 0.5% and 1% Al_2O_3. Compression ratio for pure R134a was 4.68 and was increased by 37.82 and 31.83 % for 0.5 and 1 % Al_2O_3. They concluded that addition of 0.5% Al_2O_3 with R134a refrigerant gives best result which leads us to improvement in overall performance of VCRS than pure refrigerant. they also concluded that increment in % of nanoparticles in refrigerant will result in decrement in performance of a system.
5) T. Coumaressin et al. [5] has done performance Analysis of Refrigeration system using Nanofluid. In this project, CuO nanoparticles with R134a refrigerant were used in the refrigeration system for Vapour compression. This research was first analysed using the FLUENT technology for CFD heat transfer analysis. After that they made a project setup and tested nanoparticles with refrigerant. The size of nanoparticles was from 10 to 70 nm. The consequences is that the heat transfer coefficient of the evaporator decreases with the use of nano CuO. Result from fluent shows that heat transfer coefficient of CuO from 0 to 0.55% but after that it decreases. At heat flux q=10kWatt, h=3.04Kwatt/m^2K. At q=20kWatt, h=18.09kWatt/m^2K. At q=30kWatt, h=48.45kWatt/m^2K. And at q=40kWatt, h=93.02kWatt/m^2K.
6) K. Dilip Kumar et al. [6] has presented a paper on An Experimental Investigation on Application of Al_2O_3 Nanoparticles as Lubricant Additive in VCRS inthe year. In their project, they used Al_2O_3nano oil which was proposed as a good lubricant in vapor compression refrigerator compressor. They experimentally studied the mobility of Al_2O_3nanoparticles in oil. The size of nanoparticles was 40 to 50 nm and base fluid used to make nanofluid was PAG oil (poly alkylene glycol) and then this mixture was added with compressor oil. They performed experiment by adding nano oil with concentration 1.5%, 1.7% and 1.9% by mass fraction were mixed with compressor oil. And the outcome that has been obtained has been good. This raised the COP of the refrigeration system by 19.14%, 21.6% and 11.22% respectively.
7) D. Sendil Kumar et al. [7] presented a paper on Experimental Study on $Al_2O_3$with R134a Nano Refrigerant in Refrigeration System. In this paper, they used nano $Al_2O_3$with PAG oil with R134a refrigerant in a vapor compression refrigeration system in an experimental setup which was fabricated in lab by themselves. Using energy Sumption and freezing

capability test, this device output was investigated. And the result so obtained indicated that Al_2O_3nano refrigerant works safely and normally in the VCRS. The refrigeration system performance was enhanced by 10.32% than pure R134a refrigerant. They used 0.2% concentration of Al_2O_3nanoparticles in R134a refrigerant of 150gm. The similar test was performed repeatedly for 3 to 4 times with mass of order of 150gm, 180gm and 200gm. COP of refrigeration system was enhanced 2.4 to 3.5 with length of capillary tube from 8m to 10.5m but after that it decreased. The discharge pressure shows increment with time and attains maximum value but then it decreases while suction pressure decreases at starting and then increases with time. For a load weight of 150gm, less suction force was observed.

8) R. Reji Kumar et al. [8] published a paper named as Heat transfer enhancement in Domestic Refrigerator System using R600a/ mineral oil/ nano Al_2O_3as a working fluid. They used Al_2O_3nanoparticles with R600a refrigerant in a domestic refrigerator in their experiment. They presented 3 cases, 1) the hermetic compressor filled with pure POE oil, 2) mineral oil and 3) mineral oil+ Al_2O_3nanoparticles lubricant with concentration of 0.06%. Their experiment concluded that R600a refrigerant and mineral oil+ Al_2O_3nanoparticles oil mixture has highest COPas compared to other cases. The cooling capacity of the refrigeration system with mineral oil+ Al_2O_3oil mixture was higher compared to the POE oil system. They found at the time that the compressor's power consumption was decreased by 11.5% when that nano lubricant was used instead of standard POE oil and the system's COP was raised by 19.6%.
9) F. T. Ndoye et al. [9] has done Numerical study of Energy Performance of Nanofluids for Refrigeration system in the year. In this paper, they developed a mathematical model to predict the energy performance of the refrigeration system using nanofluid for use in cold chain cooling plants. This model was based on combining the efficiency number of the method of the transfer unit with the classical heat transfer unit. They had tested tubular heat exchangers in turbulent and laminar regimes. System has been tested using published data. The simulation shows that with increased concentration of nanoparticles for laminar and turbulent regimes, heat transfer coefficient has been significantly increased.
10) D. Sendil Kumar et al. [10] presented their project of ZnO nano refrigerant in R152a in refrigeration system for energy conversion and green environment. In this paper, they explored the reliability and performance of a vapor compression refrigeration system in a working fluid with ZnO nanoparticles. They used VCRS refrigerant R152a. The concentration of ZnO that they used 150gm of R152a in their experimental study varies of 0.1%, 0.3% and 0.5%vf. ZnO nanoparticles were 50nm in diameter. Their experimental results revealed that ZnO nano refrigerant operates in refrigeration system normally and safely. The efficiency of the system increased by 21% less energy consumption when refrigerant was 0.5%vf ZnO and R152a. during this process, the use of nano refrigerant decreased both suction and discharge pressure by 6%.
11) V. K. Dongre et al. [11] has represented a paper named as Enhancement of Vapor Compression Refrigeration System Using nanofluid. In their experiment they mixed some different types of refrigerant such as R134a, M149, R600a and R290 with nanoparticles like CuO and Al_2O_3. Firstly, they had taken results of pure R134a and the COP was found to be 10.08 and with CuO nanoparticles on 300gm mixed with lubricating oil the COP was increased to 13.85. Then they used $Al_2O_3$of 300mg with R134a and COP was found to be 12.96. they had also done testing of M049 with CuO and the COP was increased to 14.09 and with Al_2O_3, it was decreased to 10.78. Finally, they had done trial with R290 and R600a with CuO nanoparticles and COP was 13.4. Trial with R290 and R600a with Al_2O_3had given the COP of 14.72. They concluded that the nanoparticles- free cooling system's COP is lower than the nanoparticles COP. By adding refrigerant nanoparticles to the refrigeration system, the COP of the system was improved by 4% to 5%. They found that the COP of Al_2O_3nanoparticles with refrigerant was smaller than that of CuO nanoparticles with refrigerant.
12) Shengshan Bi et al. [12] (2010) presented a paper on Performance of A Domestic Refrigerator using TiO_2+ R600a Nano refrigerant as a working fluid. The size of TiO_2nanoparticles was 50nm and their mass purity of 99.5%. They dispersed nanoparticles with refrigerant in concentration of 0.1 and 0.5g/L in their investigation. They concluded that $TiO_2$with R600a works normally and efficiently as compared to pure R600a. The concentration of 0.1 and 0.5g/L of TiO_2+ R600a nano-refrigerant can save 5.94 and 9.6% of energy consumption and nano-refrigerant freezing rate was faster than pure R600a.
13) Kuljeet Singh et al. [13] (2014) has done An Investigation into the Performance of a Nano refrigerant (R134a+Al_2O_3) based Refrigeration system. In this experimental study they used Al_2O_3 nanoparticles of 20nm diameter sized nanoparticles dispersed in R134a. they used 0.5 and 1% vf of nanoparticles with R134a Refrigerant in the refrigeration system. When they used 0.5%vf of Al_2O_3 the COP of the system was 8.5% and for 1%vf of Al_2O_3 the COP was decreased by 5.4% the effectiveness of condenser and evaporator increased in case of R134a+0.5% of Al_2O_3.
14) Doshi Sachindra J [14] (2017) presented A Review on Enhancement of COP of Refrigeration system by inclusion of Nanoparticles in refrigerant. In this review they concluded that the nanofluids reveals many compulsive properties and in this they discussed about the enhancement in COP of refrigeration system by mixing nanofluids with base refrigerant. Also, refrigerant thermal conductivity increases and compressor work has been reduced. They also concluded that energy was reduced by 26.1% and that the cooling system's performance was increased Using various types of nanoparticles in the cooling system by 4.4 percent.
15) I. M. Mahbubul et al. [15] (2013) has published a paper named as Therma Conductivity, Viscosity and density of

R141b refrigerant based nanofluid. In this paper, they analyzed the behavior of Al_2O_3nanoparticles based with refrigerant. Based on refrigerant analysis, with the rise in concentration and temperature, the thermal conductivity increases. They concluded that viscosity increases as the fraction of particles increases and decreases with temperature rise. Similarly, nano-refrigerant density increases with %vf enhancement and decreases with temperature increase. He also concluded that in order to achieve efficient energy efficiency, optimum volume fraction should be calculated based on thermal conductivity, viscosity and density of nano refrigerant.

16) P. K. Kushwaha et al. [16] (2016) presented a paper on Experimental study of nano refrigerant (R134a +Al_2O_3) based on vapor compression refrigeration system. They used Al_2O_3 nanoparticles of size 60 to 70 nm each and the system was charged nano refrigerant R134a + Al_2O_3 with 0.25gm and 0.50gm mass. They observed that there was more temperature drop across the condenser for the nano refrigerant from 12.37% to 10.88 percent. They also noted a reduction in power consumption of 4.35% and 14.7%.
17) N. S. Desai et al. [17] (2015) has presented a paper on Application of SiO2 nanoparticles as Lubricant additive in VCRS: An Experimental Investigation. They used SiO2 nanoparticles with the concentration of 1%, 2% and 2.5% by mass in POE oil. They observed that at concentration of 0%, 1%, 2% and 2.5 % of SiO2,the compressor work done in kWatt was 0.484, 0.45, 0.4245 and 0.4327. Likewise, for 1%, 2% and 2.5% respectively, COP was found to be 7.61, 14.05 and 11.90.
18) Veera Raghavalu K et al [18] (2018) presented A Review on Applications of Nanofluids used in Vapor compression Refrigeration system for COP enhancement. they found that nano refrigerants ' thermal conductivity was higher than the pure refrigerant. The refrigerant's thermal conductivity also increases by increasing the volume-based concentration of nanoparticles. They also concluded that the size and material of nanoparticles also effects on the performance of VCR system. The compressor work can also be reduced by adding nanoparticles up to certain limits but then it increases. They concluded that mineral oil mixed nanoparticles yield better results than POE oil.
19) Melih Aktas et al. [19] (2014) published a paper on A theoretical comparative study on nano refrigerant performance in a single stage vapor compression refrigeration cycle. They had theoretically studied $Al_2O_3$with R12, R134a, R436a and R600a. It was agreed that Al_2O_3density was equivalent to 3096kg/m^3. Their result shows that COP was increased by inserting pure nanoparticles with refrigerant and achieving the maximum value for the mixture R600a+Al_2O_3.
20) Aly M. A. Soliman et al. [20] (2015) presented a paper on Performance Enhancement of Vaporcompression cycle using nano material. In this experiment they used Al2O3 nanoparticles with POE oil with R134a refrigerant. The size of nanoparticles was less than 50nm and its density was 3600kg/m^3 and the weight concentration of nano lubricant mixture was 0.1%. They filled the reciprocating compressor with POE oil + Al2O3 and the theoretical results show that the heat transfer coefficient increased by 50% and energy losses dropped by 28%. While the experimental result shows that the system's COP with nanomaterial was higher than the system's COP without using nanoparticles theoretically and experimentally by 9.11 percent and 10.53 percent, and energy consumption was reduced by 13.3 percent. at that same time heat transfer coefficient was increases by 70.83%.
21) A. Senthil Kumar et al. [21] (2015) presented a paper on Performance analysis of a domestic refrigerator using CuO-R600a nano refrigerant as a working fluid. In this experiment they used CuO nanoparticles with R600a refrigerant in concentration of 0.1 and 0.5 g/l in the refrigeration system. They firstly investigated the performance test for pure R600a. the discharge and suction pressure of compressor were reduced for CuO-R600a nano refrigerant than pure R600a refrigerant and the largest reduction was for 0.5 g/l. they came up with result for 0.1 and 0.5% g/l concentration, energy consumption was 0.8435 and 0.7856 kWatt/hr and energy saving was 11.83% and 17.88%. they also concluded that the freezing velocity for CuO- R600a was more quickly than pure R600a refrigerant.
22) Prabhat Kumar Singh et al. [22] (2018) has published a review paper on Numerical analysis of Refrigeration system using different nanofluids by CFD. In this study they used ZnO, CuO and Al2O3 nanoparticles with size of 40 to 50 nm at 0.05, 0.1 and 0.15 %v concentration. These particles were dispersed with 150 gm of R152a refrigerant by CFD simulation. They investigated the system performance with nanoparticles according to the heat transfer characteristics.
23) T. M. Yusof et al. [23] (2015) published a paper on Experimental study of a Domestic Refrigerator with POE-Al2O3 nano lubricant. In their research they used Al2O3 nanoparticles of size 13 nm and 0.02% concentration by volume. They concluded that compressor work with POE -Al2O3 was slightly lower than that of POE oil in compressor which was a positive result due to less compressor work that leads to low energy consumption. They also concluded that refrigeration effect of POE-Al2O3 was better than POE oil only. the result shows that the highest reduction in the energy consumption of the system was 2.1% at charging pressure of 42 psi and COP was 2.67 and refrigerating effect was of 131 kJ/kg was obtained.
24) I.M. Mahbubul et al. [24] (2012) presented a paper on Investigation of viscosity of R123-TiO2 Nano refrigerant. The size of nanoparticles was 21 nm, purity was 99.5%, molecular mass was 79.87 g/mol and density was 4260 kg/m^3. They studied for 5 to 20^{0}C temperature and up to 2 vol %. They concluded that viscosity of nanofluid increases with increase of particles volume fraction. They found that volumetric fractions and temperatures have significant effects on viscosity of nanofluids.They said viscosity is directly related to the c haracteristics of pressure drop and increases with con-centrations of volume and quality of vapour.

25) Jiang-Feng Lou et al. [25] (2014) has published a paper on Experimental Investigation of Graphite nano lubricant used in a domestic refrigerator. They used graphite nano lubricant with a mass fraction of 0.05, 0.1, 0.2 and 0.5% with R600a refrigerant in their test. In the refrigeration system, they billed 44 g of R600a. They concluded that the power consumption of the system was reduced and energy consumption was saved for 0.05, 0.1, 0.2, and 0.5% mass fraction of nano lubricant was 3.54, 4.55, 3.61 and 0.64%. They concluded that nongraphite R600a could not boost the cooling system efficiency.
26) Omer A. Alawi et al. [26] (2015) presented a paper on Application of nano-refrigerant and nano-lubricants in refrigeration, air-conditioning and Heat pump system, a review. The result of their experiment indicates that with performance result, HFC134a and mineral oil with TiO_2 nanoparticles works in the refrigerator normally and safely. They also concluded that energy consumption was up to 26.1% with concentration of 0.1%mf TiO_2nanoparticles as compared to POE oil and R134a refrigerant.
27) Eed Abdel-Hafez Abdel-Hadi et al. [27] (2011) has presented a paper on Heat Transfer Analysis of Vapor Compression System Using Nano Cuo-R134aThey used CuO nanoparticles with R134a coolant with VCRs in their test. CuO nanoparticles were 15 to 70 nm in size and 0.05 to 1 percent in concentration. The perform the experiment and measured the heat flux range from 10 to 40 kW/m^2 and the concentration of CuO nanoparticle was 0.1, 0.2,0.3,0.4,0.5,0.55,0.6,0.8 and 1%. The came up with the conclusion that heat transfer coefficient increasers up to 0.55% concentration of CuO nanoparticles but then it decreases. We inferred from the experiment that the heat transfer coefficient increases within the range with an increase in heat flux.
28) R. Krishna Sabareesh et al. [28] (2012) has presented a paper on Application of TiO_2 nanoparticles as a lubricant additive for VCRs an Experimental Investigation. They used TiO_2 nanoparticles with mineral oil base lubricant using R12 as a working fluid with charge mass of 135 grams. They used 0.01% volume fraction concentration of TiO2 nanoparticles in mineral oil 700h. They concluded that the COP of the system when operated with modified mineral oil as a lubricant gives the COP valve of 1.43. They also concluded that average heat transfer rate was increase by 3.6 % as well as the compressor work was reduced by 11%. Simultaneously, COP rose by 17%.
29) Bin Sun et al.[29] (2013) published a paper on an experimental study on nano-refrigerant heat transfer features in the internal thread of the copper tube. In their experiment, we used Cu, Fe, Al2O3 and CuO nanoparticles with coolant R141b. The thermal conductivity and density coefficient showed a discrepancy between these four nanoparticles, but the heat transfer coefficient of the corresponding nano refrigerant increased by 17 to 25%. They concluded that the coefficient of heat transfer of nano-refrigerant changes and the growth relationship with the nanoparticles mass fraction were significantly linear with the increase in the nanoparticles mass fraction. We also concluded that the nano-refrigerant's mass fraction of nanoparticles was the major factor affecting the heat transfer enhancement.
30) N. Subramani et al. [30] (2011) published a paper on Experimental Study onVapour Compression System Using Nano refrigerant. They used Al2O3 nanoparticles with SUNISO 3GS oil (Lubrication oil of compressor). They performed an experiment on hermetically sealed compressor with 1. Pure POE oil, 2. SUNISO 3GS oil and 3. SUNISO 3GS oil + alumina nanoparticles as a lubricant with mass fraction of nanoparticles was 0.06%. the result shows that the time required for cooling was reduced and was the least for SUNISO3GS+Al_2O_3 nano-lubricant. The experimental conclusion is that the R134a refrigerant and mineral oil mixture with nanoparticles works normally and the refrigeration system's freezing potential was high with SUNISO3GS+Al_2O_3 nanoparticles as compared to pure base POE oi. They also concluded that compressor work was reduced by 25% when using nano-lubricant instead of POE oil while simultaneously increasing the system's COP by 33% and an evaporator energy enhancement factor was 1.53.

III. FUTURE SCOPE

From the above literature survey, we have a lot of future scope of using nanoparticles to enhance the performance of the refrigeration system.

- We can use nanoparticles with lubricant used in compressor to reduce the compressor work to reduce the energy consumptions.
- Nanofluid finds the promising application as primary fluid in the sector of lubrication, refrigeration, etc.
- Nanofluid can also be used as a secondary fluid in the e vaporator and condenser sides as a nanofluid to i- mprove heat transfer characteristics.
- We can also use nanoparticles for the enhancement in performance of air conditioning system.
- We can also develop new and simple process to make nanoparticles.
- We can also use nanofluids to enhance the thermal characteristics of coolant used in radiator used in various automobile sector.
- We can also use nanoparticles to enhance the properties of cutting fluids used in CNCs and other machineries.
- We can enhance the properties of braking fluid by mixing nanofluid.
- We can also use nanofluid with suspension oil used in various automobiles and hydraulics fluids.

IV. CONCLUSION

From the above literature survey, we can conclude that we can use nanofluids and nanoparticles to enhance the performance of heat exchanging devices and refrigeration system.

Nanofluids are of particular importance because the y can be used in different heat transfer applications.

1) We can use refrigerant nanofluids to increase the coolin g system's COP

2) We can use nanofluids with lubricating oil in compressor to increase the performance of compressor.
3) We can increase the cooling effect of the system by adding nanofluid with the refrigerant in the refrigeration system.
4) We can reduce the cooling system's energy consumptio n by adding nanofluids to the compressor with refrigera nt and lubricating oil and the entire cooling system.
5) By combining very small quantities of nanofluid with re frigerant, we can improve the thermal properties of refrigerant.
6) Nanofluids are safe to use with the refrigeration system.

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