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EXPERIMENTAL INVESTIGATION ON REFRIGERATION SYSTEM USING SiO2 NANOPATICLES WITH R600a REFRIGERANT

[1]Prof. J. S. Pachbhai, [2]N. P. Satange, [3]N. M. Bagde, [4]A. M. Nimje, [5]S. S. Sevatkar, [6]S. I. Harinkhede

[1]Assistant Professor, JD College of Engineering and Management, Nagpur-441501, Maharashtra, India.
[2,3,4,5,6]UG. Scholar, Department of Mechanical Engineering, J D College of Engineering and Management, Nagpur-441501, Maharashtra India.

Abstract : The test mechanical assembly was worked by the public principles of India. The presentation of the refrigeration framework relies on the warmth move limit of the refrigerant. R600a utilized as a refrigerant. This refrigerant warmth move limit is slightly below average and increment power utilization. Because of these impediment nanofluids are improved with the ordinary grease and expands the warmth move limit and lessens the force utilization. Silicon dioxide nanoparticles were utilized for upgrading the warmth move limit of the refrigerant in the refrigeration System. In this analysis heat move improvement was examined mathematically on the outside of a cooler by utilizing SiO2 nano-refrigerants, where nanoparticles could be a huge factor in keeping up the surface temperature inside a necessary range. The expansion of nanoparticles to the refrigerant outcomes in enhancements in the thermophysical properties and warmth move attributes of the refrigerant, in this manner improving the presentation of the refrigeration framework. Stable nanoparticles have been ready for the examination. The test considers demonstrate that the refrigeration framework with nano-refrigerant works typically. It is discovered that the freezing limit is higher and the force utilization diminishes by 3% when R600a refrigerant blended in with Silicon dioxide nanoparticles. Consequently, utilizing Silicon dioxide nanoparticles in refrigeration framework is achievable.

INTRODUCTION

In past time just refrigerants were utilized in refrigeration cycle and they were having a dangerous atmospheric deviation coefficient at elevated level. Presently, as time change the cutting-edge methods are appearing with the assistance of them the refrigeration cycle become more effective and more secure as contrast with past in climatic forthcoming. Nanofluid is a serious sort of liquid, which contain nanometre measured (10-9 m) strong particles known as nanoparticles. Nanoparticles upgrade the property of ordinary liquid. In recent years, nano-refrigerant has gotten more famous for huge number of exploratory fume pressure frameworks on account of lack in accessibility of vitality and ecological contemplations. Late headways in nanotechnology have started the new developing warmth move liquids called nano-liquids. Nano-liquids are set up by scattering and stable suspending nanometre estimated strong particles in customary warmth move liquids. Past explores have demonstrated that an extremely limited quantity of suspending nanoparticles can possibly improve the thermo physical, transport and radiative properties of the base liquid. Because of improved properties, better warmth move execution is gotten in numerous vitality and warmth move gadgets when contrasted with conventional liquids which open the entryway for another field of logical exploration and imaginative applications.

The expansion of nanoparticles to the refrigerant outcomes in upgrades in the thermophysical properties and warmth move attributes of the refrigerant, in this manner improving the presentation of the refrigeration framework. Nanoparticles coordinated the imaginative world into another heading by its capacity to impact working properties of liquid. Nanofluids are progressed class of liquids with particles of nano size (1-100 nm). The idea depends on the way that solids have high warmth limit when contrasted with liquid. So nano estimated particles or nanoparticles are scattered into a base liquid so as to upgrade physical properties of base liquid. The nanoparticle materials are generally of metal, non-metal and their oxides, which improve the warmth move execution of base liquids. Thus, there is enormous extent of its application in heat move territory. As of late, a few examinations uncovered the utilization of nanoparticles in refrigeration frameworks and critical improvement in execution has been watched.

In refrigeration frameworks the nanoparticles can be either added to blower greasing up oil or to refrigerant. Scattering of nanoparticles into greasing up oil (Nano oil) improves the oil of blower or abatement erosion of moving parts. Also, the on the off chance that airtight fixed blower fragmentary measure of grease oil is diverted by refrigerant in blower arch. Along these lines, by this implies the warmth move attributes can be improved and henceforth execution of the refrigeration framework. On other hand when nanoparticles are scattered in refrigerant (named as nano-refrigerant), at that point it straightforwardly upgrades the refrigerant warm properties and along these lines execution of refrigeration framework is discovered to be improved. The regular refrigerants have significant part in a worldwide temperature alteration and consumption of the ozone layer. Subsequently, there is have to improve the exhibition of fume pressure refrigeration framework with the assistance of reasonable refrigerant.

LITERATURE SURVEY

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 of heat exchanger.

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.

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.

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.

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.

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 in the year. In their project, they used Al_2O_3 nano oil which was proposed as a good lubricant in vapor compression refrigerator compressor. They experimentally studied the mobility of Al_2O_3 nanoparticles 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.

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_3 nano 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_3 nanoparticles 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.

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_3 as a working fluid. They used Al_2O_3 nanoparticles 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_3 nanoparticles lubricant with concentration of 0.06%. Their experiment concluded that R600a refrigerant and mineral oil+ Al_2O_3 nanoparticles oil mixture has highest COP as compared to other cases. The cooling capacity of the refrigeration system with mineral oil+ Al_2O_3 oil 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%.

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.

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%.

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_3 had 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_3 nanoparticles with refrigerant was smaller than that of CuO nanoparticles with refrigerant.

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_2 nanoparticles 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.

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.

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.

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_3 nanoparticles 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.

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%.

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 kW 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.

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.

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_3 density 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.

Aly M. A. Soliman et al. [20] (2015) presented a paper on Performance Enhancement of Vapor compression 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%.

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.

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.

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.

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 characteristics of pressure drop and increases with con-
centrations of volume and quality of vapour.

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.

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_2 nanoparticles as compared to POE oil and R134a refrigerant.

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.

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%.

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.

N. Subramani et al. [30] (2011) published a paper on Experimental Study on Vapour 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 oil. 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.

EXPERIMENTAL SETUP

The experimental setup following devices were used:

1) Refrigeration system
2) Compressor (R600a suitable only)
3) R600a Refrigerant
4) Compound pressure gauge (Qty- 2)
5) Thermocouple (Qty- 5)
6) Heater and heater temperature controller
7) Switches
8) Energy meters (Qty- 2)
9) Etc.

Experimental setup was made as per Indian standards. Two compound pressure gauges were used and were connected at the inlet and outlet pipe of the compressor. At the same time, 5 thermocouples were also connected which were named as T1, T2, T3,T4 and T5. Along with it two separate energy meters were connected and were named as E1 (for measuring total load) and E2 (for measuring only compressor load). And set looks like as shown in the figure.

Figure 1 : experimental setup

Figure 2: setup for adding nanparticles with refrigerant

Name of component	Specification
Refrigeration system	Videocon refrigeration system of 180 lit cooling space
Compressor	Single stage compressor (R600a)
Condenser	Fined type natural convection
Filter	Copper mater filled with silicon gel ball
Capillary tube	1.5 m and of 1mm diameter
Copper tube	10 feet long of 1\4-inch diameter
Pressure gauge	Compound pressure gauge (NO. 2 PROVIDED)
Thermocouple	J type thermocouple (NO. 5 PROVIDED)
Heater	Cell tube type heater with heat controller

Preparation of nanoparticles:

Nanoparticles were set up by following advances:

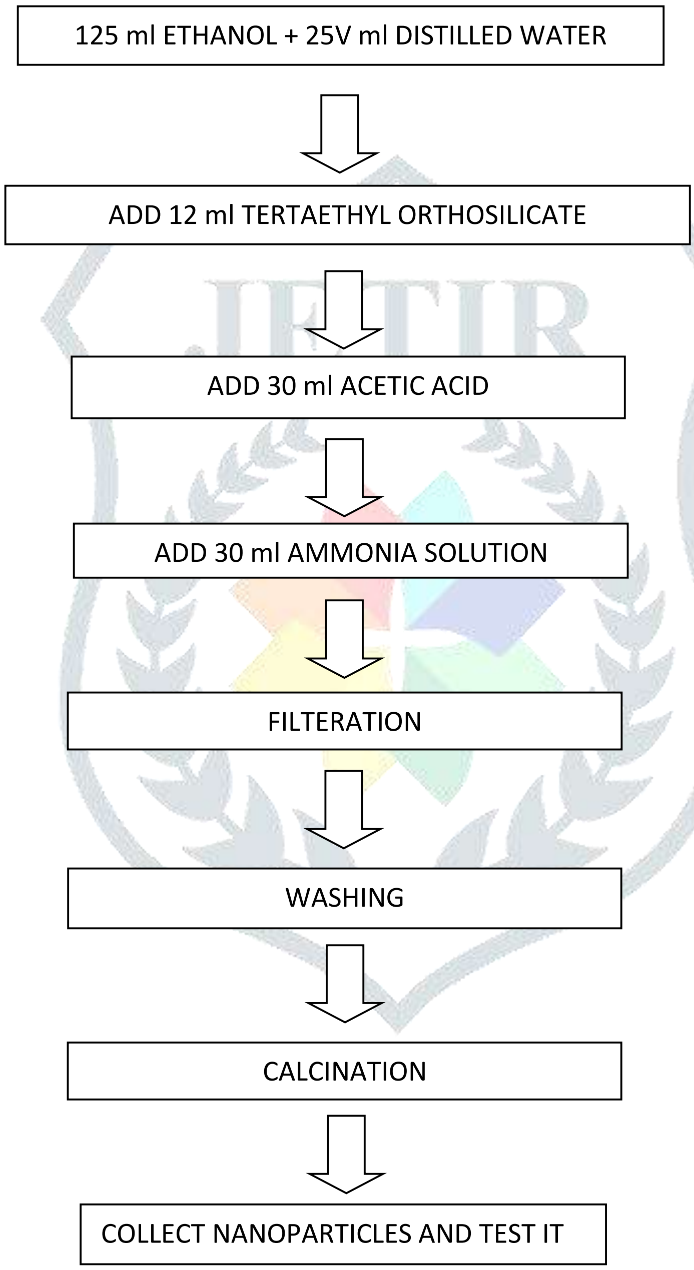
Directly off the bat, clean all the mechanical get together mindfully and clean it with care. Wash them all with refined water. By then take 125ml ethanol in the cone like carafe and incorporate 25 ml refined water with it. Mix it well for just about 15 minutes by hand or by shaking or with the help of alluring stirrer at 400C at 600rpm. By then incorporate 12ml Tetraethyl Orthosilicate in a comparative conelike carafe and continue with the mixing cycle for around 2 hours. Starting there ahead, add 30 ml destructive to it and set the temperature at 400C at 1000 to 1100 rpm for next 4 hours.

After the opposition of that blending cycle, include 30 ml alkali fluid arrangement in the flagon at the temperature of 600C at 1400 to 1600rpm. The arrangement in the cup will begin to shape a thick coagulated liquid. This will demonstrate that the response is begun and worked out in a good way. Proceed with the blending cycle for 60 minutes. At that point set the temperature of the stirrer at 300C and at 1100 rpm and proceed with the blending cycle for 8 to 9 hours till it turns into a thick gel like liquid. As the thick gel is formed, it indicated that the reaction is completed. Now collect that in a glass which is cleaned and cover it with a watmon paper. Now hydrolysis is required to remove excess water and chemicals from that solution. For this, filtration is required and can be done by using circular filter paper of fine grade. Put a filter paper on the glass conical funnel and put this setup in the tripod stand and collect the remaining fluid in another flask.

After the filtration is finished, gather a strong gel dreg in a perfect glass cup. Presently the washing of that gel arrangement is required. Take a warm water in a marsh vessel and a moment pored fibre net. Take a gel arrangement in it and wash it with hand. Likewise wear elastic gloves. In the wake of washing. Gather the gel arrangement in a silica pot and put it in a suppress heater at 1000C for 60 minutes. After that take it out from the heater.

Presently, calcination of that thick gel arrangement is needed to frame granules like structure. For this, take a spatula and gather a little bit of that arrangement is a silica cauldron. Furthermore, put it in the heater at 6000C for 2 hours. Check it oftentimes on the grounds that occasionally, because of the presence of smelling salts it blasts. After 2hours, take out the cauldron from the heater cool it at room temperature. Gather the granules in the mortar and pound it as fine as could reasonably be expected.

Presently gather fine measured nanoparticles and put it in the stifle heater for 4 to 5 hrs for calcination. It will eliminate all the dampness and the various synthetic concoctions from it and SiO_2 nanoparticles will be shaped. Presently eliminate it from the heater and do its testing.



Methodology

Firstly, simple test on the refrigeration system were done. Pure POE oil was added as a lubricant in the compressor of the refrigeration system. Then we have taken readings of pressure gauges (P1 and P2) at the same time we have taken readings of the thermocouples connected at different places. And calculated refrigeration effect, work required for compressor, and COP. After that, added 0.035 gm (0.1% by mass of refrigerant charged in the refrigeration system) of nanoparticles with the refrigerant and similar testing were performed. Same tastings were taken for 0.070, 0.105, 0.140 and 0.175 gm of nanoparticles with refrigerant.

Calculation

1. Theoretical Coefficient of performance (COP) = $\frac{\text{Refrigeration effect (R.E.)}}{\text{Work done(WD)}}$
2. Theoretical Refrigerant effect (R.E) = h1- hf3 (or) h1- h4
3. Theoretical Work done by compressor (WD) = h2- h1
4. Actual Refrigeration Effect = $\frac{m \times C_p \times (T_{5(@initial)} - T_{5(@final)})}{\text{Time (sec)}}$
5. Actual Work done by compressor = $\frac{10 \times 3600}{\text{Time} \times 3200}$
6. Actual Coefficient of Performance = $\frac{\text{Actual Refrigeration Effect}}{\text{Actual Work done by compressor}}$
7. Tonnage Refrigeration Capacity = $\frac{\text{Actual Refrigeration Effect}}{251}$

Observation

Table 1: Pure R600a

TIME	T1	T2	T3	T4	T5	T6	P1	P2	E1	E2
12:00	15.4	38.4	30.1	13.5	29.8	33	25	100	35	37
12:05	14.4	40	34.5	12.8	28.5	33	25	100	35	37
12:10	13.6	48	37.2	10.7	27.9	33	25	97	34	37
12:15	12.2	54	40.8	8.4	26.4	33	24	97	34	36
12:20	11.6	58	41.3	7.8	25.7	33	24	97	34	37
12:25	10.3	60.1	42.3	7.2	24.2	34	23	97	34	35
12:30	9.8	60.4	42.8	6.9	22.3	34	23	97	34	35

T1= 9.8 ^{0}C = 282.95 K its H1 = 557.50 kJ/kg	R.E.(theoretical) = 206.10 kJ/kg
T2= 60.4 ^{0}C = 333.55 K its H2 = 636.75 kJ/kg	Compressor work (theoretical) = 79.25 kJ/kg
T3= 42.8 ^{0}C = 315.95 K its H3 = 351.40 kJ/kg	Theoretical COP = 2.6
T4= 6.9 ^{0}C = 280.05 K its H4 = 351.40 kJ/kg	R.E. (actual) = 0.0651 kW
T5= 22.3 ^{0}C = 295.45 K	Compressor work (actual) = 0.321 kW
P1= 23 psi = 1.587 bar	Actual COP = 0.202
P2= 97 psi = 6.687 bar	Tonnage refrigeration capacity = 0.018 tonn

Table 2: R600a + 0.1% (by mass) SiO^2

TIME	T1	T2	T3	T4	T5	T6	P1	P2	E1	E2
12:00	14	38.4	30	13.5	29.6	33	25	100	35	37
12:05	13.8	40	33.2	12.8	28.5	33	25	100	35	37
12:10	12.3	48	37	10.7	27.7	33	25	97	34	37
12:15	11.7	54	40	8.4	25.8	33	24	97	34	36
12:20	10.6	57	41	7.8	25.3	33	24	97	34	37
12:25	10.2	60	42.1	7.2	24.2	34	23	97	34	35
12:30	10	60.8	42.5	6.9	22.3	34	23	97	34	35

T1= 10 ^{0}C = 283.15 K its H1 = 557.8 kJ/kg	R.E.(theoretical) = 208.07 kJ/kg
T2= 60.8 ^{0}C = 334.00 K its H2 = 637.83kJ/kg	Compressor work (theoretical) = 80.03 kJ/kg
T3= 42.5 ^{0}C = 315.65 K its H3 = 349.02kJ/kg	Theoretical COP = 2.6
T4= 6.9 ^{0}C = 280.05 K its H4 = 349.02kJ/kg	R.E. (actual) = 0.0689kW
T5= 22.3 ^{0}C = 295.45 K	Compressor work (actual) = 0.319kW
P1= 23 psi = bar	Actual COP = 0.216
P2= 97 psi = bar	Tonnage refrigeration capacity = 0.0191tonn

Table 3: R600a + 0.2% (by mass) SiO^2

TIME	T1	T2	T3	T4	T5	T6	P1	P2	E1	E2
12:00	14	38.4	30	13.5	29.8	33	25	100	35	37
12:05	13.9	40	33.2	12.8	28.5	33	25	100	35	37
12:10	12.3	48	37	10.7	27.9	33	25	97	34	37
12:15	11.7	54	40	8.4	26.4	33	24	97	34	36
12:20	10.6	57	41	7.8	25.7	33	24	97	34	37
12:25	10.4	60	42.1	7.2	24.2	34	23	97	34	35
12:30	10.3	60.6	42.1	6.5	22	34	24	95	33	33

T1= 10.3 ^{0}C = 283.45 K its H1 = 560.73 kJ/kg	R.E.(theoretical) = 222.92 kJ/kg
T2= 60.6 ^{0}C = 333.75 K its H2 = 640.12 kJ/kg	Compressor work (theoretical) = 79.39 kJ/kg
T3= 42.1 ^{0}C = 315.25 K its H3 = 337.81 kJ/kg	Theoretical COP = 2.8
T4= 6.5 ^{0}C = 279.65K its H4 = 337.81 kJ/kg	R.E. (actual) = 0.0751 kW
T5= 22 ^{0}C = K	Compressor work (actual) = 0.237 kW
P1= 24psi = bar	Actual COP = 0.316
P2= 95psi = bar	Tonnage refrigeration capacity = 0.0196 ton

Table 4: R600a + 0.3% (by mass) SiO^2

TIME	T1	T2	T3	T4	T5	T6	P1	P2	E1	E2
12:00	14	38.4	30	13.5	29.8	33	25	100	35	36
12:05	13.9	40	33.2	12.8	28.5	33	25	100	35	36
12:10	12.3	48	36.8	10.7	27.9	33	25	97	34	36
12:15	11.7	54	40	8.3	26.4	33	24	97	34	35
12:20	10.6	56.3	41	7.8	25.7	33	24	97	34	34
12:25	10.4	60	42.1	7.2	24.2	34	23	97	34	34
12:30	10.3	60.3	41.7	6.2	21	34	23	97	34	33

T1= 10.3 ^{0}C = 283.45 K its H1 = 573.37 kJ/kg	R.E.(theoretical) = 225.36 kJ/kg
T2= 60.3 ^{0}C = 333.45 K its H2 = 648.49 kJ/kg	Compressor work (theoretical) = 75.12 kJ/kg
T3= 41.7 ^{0}C = 314.45 K its H3 = 348.01 kJ/kg	Theoretical COP = 3
T4= 6.2 ^{0}C = 279.35 K its H4 = 348.01 kJ/kg	R.E. (actual) = 0.0778 kW
T5= 21 ^{0}C = K	Compressor work (actual) = 0.231 kW
P1= 23 psi = bar	Actual COP = 0.337
P2= 97 psi = bar	Tonnage refrigeration capacity = 0.0221 tonn

Table 5: R600a + 0.4% (by mass) SiO^2

TIME	T1	T2	T3	T4	T5	T6	P1	P2	E1	E2
12:00	14	38.4	30	13.5	29.8	33	25	100	35	34
12:05	13.9	40	33.2	12.8	28.5	33	25	100	35	34
12:10	12.3	48	36.8	10.7	27.9	33	25	97	34	33
12:15	11.7	54	40	8.3	26.4	33	24	97	34	33
12:20	10.6	56.3	41	7.8	25.7	33	24	97	34	33
12:25	10.4	60	42.1	7.2	24.2	34	23	97	34	33
12:30	10.3	60.3	41.7	6.2	21	34	23	97	34	33

T1= 10.3 ^{0}C = 283.45 K its H1 = 564.28 kJ/kg	R.E.(theoretical) = 247.11 kJ/kg
T2= 60.3 ^{0}C = 333.45 K its H2 = 649.49 kJ/kg	Compressor work (theoretical) = 85.21 kJ/kg
T3= 41.7 ^{0}C = 314.85 K its H3 = 317.11 kJ/kg	Theoretical COP = 2.9
T4= 6.2 ^{0}C = 279.35 K its H4 = 317.11 kJ/kg	R.E. (actual) = 0.0781 kW
T5= 21 ^{0}C = K	Compressor work (actual) = 0.239 kW
P1= 23 psi = bar	Actual COP = 0.327
P2= 97 psi = bar	Tonnage refrigeration capacity = 0.022tonn

Table 6: R600a + 0.5% (by mass) SiO^2

TIME	T1	T2	T3	T4	T5	T6	P1	P2	E1	E2
12:00	14	38.4	30	13.5	29.8	33	25	100	35	37
12:05	13.9	40	33.2	12.8	28.3	33	25	100	35	37
12:10	12.3	47.4	36.8	10.7	27.9	33	25	97	34	37
12:15	11.7	54	40.5	8.3	26.3	33	24	97	34	36
12:20	10.6	56.3	41	7.8	25.7	33	24	97	34	37
12:25	10.4	60	42.1	7	24.2	34	23	97	34	35
12:30	10.3	60.3	41.7	6.2	21	34	23	97	34	35

T1= 10.3 ^{0}C = 283.45 K its H1 = 561.82 kJ/kg	R.E.(theoretical) = 206.71 kJ/kg
T2= 60.8 ^{0}C = 333.98 K its H2 = 638.34 kJ/kg	Compressor work (theoretical) = 76.56 kJ/kg
T3= 41.7 ^{0}C = 314.85 K its H3 = 355.11 kJ/kg	Theoretical COP = 2.7
T4= 6.2 ^{0}C = 333.35 K its H4 = 355.11 kJ/kg	R.E. (actual) = 0.0774 kW
T5= 21 ^{0}C = K	Compressor work (actual) = 0.287 kW
P1= 23 psi = bar	Actual COP = 0.27
P2= 97 psi = bar	Tonnage refrigeration capacity = 0.021tonn

Results and Discussion

COP is proportion of refrigerating impact and work input. In this examination, COP has been determined with assistance of exploratory information. Refrigeration impact is assessed by methods for vitality meter associated with radiator. At last the warmer is providing warmth to evaporator by methods for warming water and same measure of warmth is taken out by refrigerant in the wake of accomplishing consistent state. Hypothetical COP is assessed as 2.6 for unadulterated R600a. Then again, with R600a +0.1% SiO2 and for R600a +0.2% SiO2 hypothetical COP is discovered to be 2.6 and 2.8 individually. R600a +0.3% SiO2 shows the increase in hypothetical COP by 8.2% and R600a +0.3% SiO2shows the decrease in hypothetical COP by around 15.10%. Genuine COP is assessed as 2.69 for unadulterated R600a. Then again, with R600a +0.5% SiO2 and for R600a +1% SiO2 real COP is discovered to be 3.52 and 2.92 individually. R600a +0.4% SiO2 shows the improvement in genuine COP by 20.28% and R600a +0.5% SiO2 shows the decrease in real COP by around 8.55%.

Conclusion

From the exploratory outcomes unmistakably, we can utilize SiO2 nanoparticles in the refrigeration framework. Additionally, we can expand the coefficient of execution of the refrigeration framework can be expanded by including nanoparticles with refrigerant. Nanoparticles have the properties to be upgrade the thermophysical properties of the base liquid. Thus, they can utilized attainably for the improvement in the presentation of the warmth exchanger gadgets like refrigeration framework, cooling, radiator, and so forth.

Future scope

- We can investigate the same experiment with the air conditioning system
- We can experimentally investigate the performance of R600a in an air conditioning system
- We can also mix sio2 nanoparticles with lubricant and investigate its performance in heat exchanging devices.
- We can also use nanoparticles with lubricating oil used in suspension of automobiles
- We can also use nanoparticles with barking fluids used in hydraulic brakes.
- We can also investigate and use nanoparticles with engine oil in the automobile engines and other moving devices

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