International Journal of Application or Innovation in Engineering & Management (IJAIEM)
Web Site: www.ijaiem.org Email: editor@ijaiem.org
Volume 5, Issue 7, July 2016 **ISSN 2319 - 4847**

Comparison of Performance of a Domestic Refrigerator using Al_2O_3 Nanoparticles with PAG Oil and Mineral Oil as Lubricant

R K Adyanshee Pattanayak[1] , Prasheet Mishra[2] , Amitava Sarkar[3]

[1,2,3]Mechanical Department, C V Raman College of Engineering/Biju Patnaik University of Technology, India

ABSTRACT

Nano fluid has caught the attention of many researchers for its novel properties which makes it unique and different in the field heat transfer, specifically thermal conductivity. So the present study comprises of the use of nano fluid in enhancement of the performance of a domestic refrigerator. Comparison of performance is analysed between the domestic refrigerator using refrigerant R134a (tetrafluroethane) and PAG Oil with the same refrigerant and Mineral oil with different mass fraction of Al_2O_3 nanoparticles. From the experimental observation it was found that for 0.2% mass fraction of nanoparticles ,the coefficient of performance of the system increases by 7.75% and 19.38% when we take PAG Oil and Mineral Oil as lubricant respectively. As a result of comparison of COP between PAG Oil with 0.2% mass fraction of nanoparticles and Mineral Oil with the same mass fraction of nanoaprticles, Mineral oil mixture gives an increase of 10.79% of COP over PAG Oil mixture. Likewise, for 0.4% mass fraction of nanoparticles the COP of the system increases by 14.48% and 25.3% for PAG Oil and Mineral Oil respectively. Here also Mineral Oil mixture gives an enhanced COP of 9.44% over PAG Oil mixture.

Keywords : Polyalkaline Glycol Oil (PAG Oil) ,Mineral Oil , Mass Fraction, Nanoparticles.

1. Introduction

The total energy used by the human civilisation has increased a lot as compared to past years. One of the energy consumption sources is the domestic energy consumption which comprises of television, refrigerators, air conditioners etc and most of them utilises the electric energy. A vital percentage of electric energy comes from coal and it is a non renewable source of energy. So Researchers are trying to adapt and discover new methods of saving the energy consumption so that can be stored and can be used later on. In our study we have to tried to save the energy of refrigerator which is one of the most important home appliance used worldwide. So the sole idea is to build an energy efficient model. The thermal conductivity plays a vital role in the performance of a refrigerator. So by increasing the thermal conductivity we can improve the performance of the refrigerator. Conventional fluids used as refrigerant in the refrigerator have poor thermal conductivity. And we know that solids have got better thermal conductivity than the fluids. So the suspension of the soild particles in millimetres or micrometers sizes in the base fluid enhances the thermal conductivity of the refrigerator. Lot of work has been done on this but there always has been a problem of the pressure drop due to sedimentation. But the researchers have come with an answer to this and that is nanofluids which has got more surface area which solves the problem of the sedimentation and getting clogged. So in this work we have used nanofluids which is a mixture of the base fluid and the nanoparticles. Nanofuids have played a great role in enhancing the performance of the refrigerator. Lot of work has been done on this area.[4] F S Javadi & R Saidur took R-134a refrigerant with TiO_2 and Al_2O_3 nanoparticles (0.1% mass fraction) and found that the energy saving was greater than that of normal refrigerant. Also it was environmental friendly as it reduces the emission of green house gases, especially carbon dioxide. [5]Meibo Xing et al took nano oil (fullerene C_{60}) instead of pure mineral oil and found that the COP is increased by 5.6% .[3] R Krishna Sabaresh performed experiment taking TiO_2 nanoparticles with mineral oil and R12 as refrigerant and found that the COP of the device increased.[6] M Mahabubul conducted experiment by taking 0.5 to 2% volume concentration of Al_2O_3 nanoparticles with refrigerant R 141b and got the result in form of enhanced thermal conductivity and viscosity. [1]Sheng Shan Bi conducted an experiment by taking 0.5g/L TiO_2 with refrigerant R600a and got a result of reduction of 9.6% of energy consumption.

2. Preparation of Nanofluid

As we are taking two lubricants so we have to prepare the nanofluid separately for Mineral oil and for PAG oil. Starting with Mineral oil, we have to mix the mineral oil with even distribution of nanoparticles for stable suspension.

Agglomeration and chemical change of the mixture is strictly restricted. The mixture is prepared as per the following procedure :

The Al_2O_3 nano particles used in this work have the properties like size less than 50 nm, colour white, density 0.26g/cc, melting point 2040^0C and molecular weight 101.96 . Then required amount of nanoparticles are added with the mineral oil and for uniform distribution of the nanoparticles in the oil, the mixture (Mineral oil and nanoparticles) is placed in an ultrasonic vibrator for 6-7 hours. The nanofluid prepared is of the mass fraction of 0.2% & 0.5% respectively.

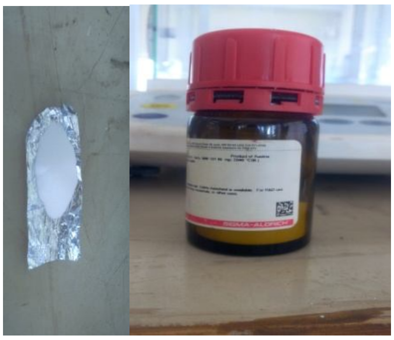


Fig.1 : Al_2O_3 nanoparticles

Fig.2: nanoparticles added to PAG Oil

3. Experimental Set up

The domestic refrigerating system comprises of a hermetic compressor, air cooled condenser, capillary tubes and an evaporator. The temperatures are measured with the help of copper constantan T type thermocouple and the pressure is measured by using pressure gauges fitted at inlet and outlet in the various parts (compressor, condenser & evaporator) of the refrigerator. The temperature and pressure at each point are necessary to obtain in order to calculate the performance of the system.

4. Evacuation of the System

Evacuation of the system is needed before charging as that removes the non condensable materials and water vapour. It is done by using a vacuum pump, pressure gauge and hoses. Hoses are connected with service port to remove the moisture from the system.

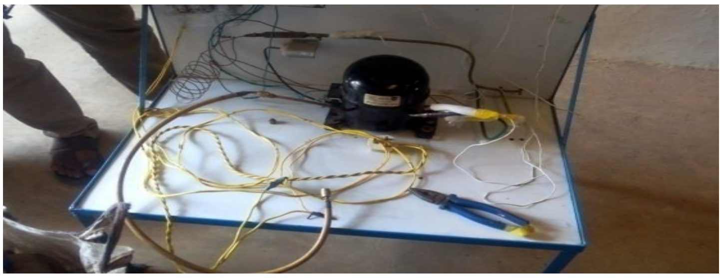


Fig.3: Release of Air if present in the system

Fig.4 : Vacuum Pump is attached to the service Port for evacuation

5. Leakage Test

Here the system is pressurised by nitrogen gas upto (80-90)psi and then the system is checked by soap solution (i.e. prepared by mixing detergent in water). It is the simplest method used and it is also least expensive. If any leakage is present in the system then the nitrogen gas rush out from the leakage portion and burst the soap bubbles, which indicates the presence of leakage. Then the confirmation of the leakage is done from the leakage part.

6. Charging of the System

The mixture of Al_2O_3 nanoparticles and mineral oil is inserted into the compressor and after that the refrigerant R134a is charged into the system while the system is kept in running condition so that the refrigerant flows through all the parts of the system. The same procedure is followed for the mixture of nanoparticles and PAG oil.

7. Result and Discussions

7.1 Stability Criteria

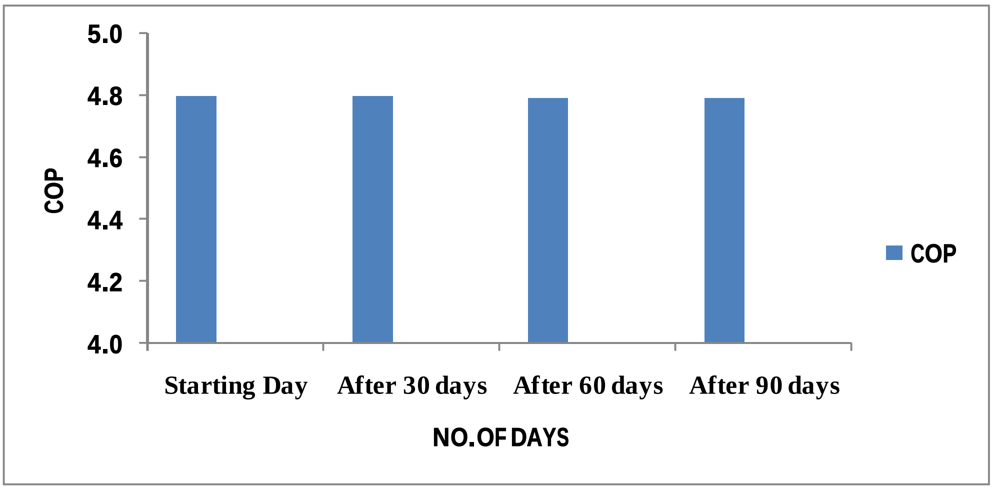


Figure 5: stability of the experimental set up

The nano fluid which we have used in this work is proved to be safe and also it doesn't affect the machinery parts of the refrigerator. So we can say that the system is stable over a period of 90 days.

7.2 Energy Consumption

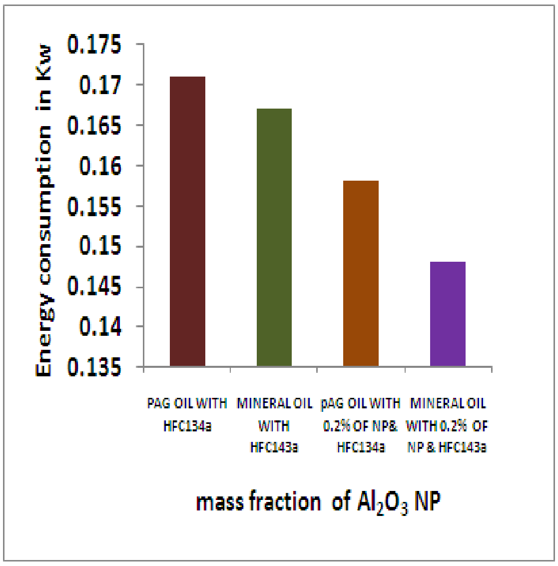


Figure 6: energy consumption for 0.2% of NP

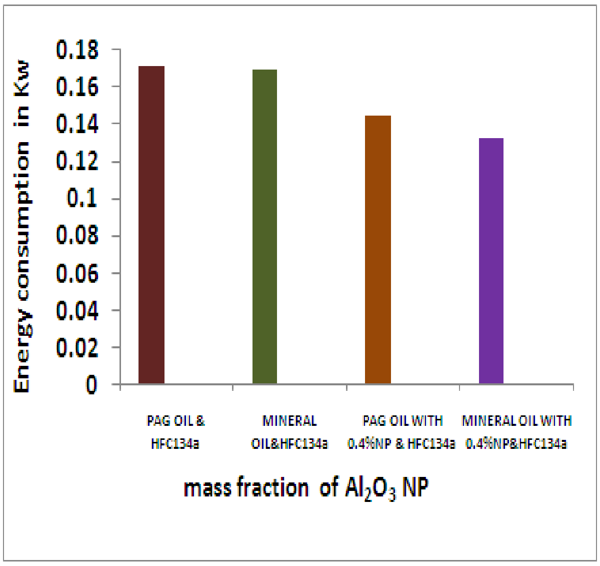


Figure 7: energy consumption for 0.4% of NP

Figure 6 and 7 shows that as the mass fraction of the nanoparticles increases, the rate of energy consumption decreases. It is also observed that the energy consumption is less when mineral oil is used as lubricant as compared to PAG oil.

7.3 Refrigerating Effect

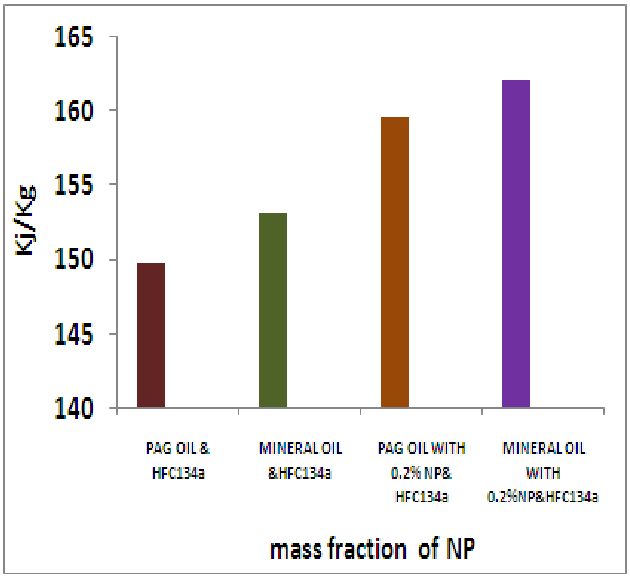


Figure 8: refrigerating effect for 0.2% NP

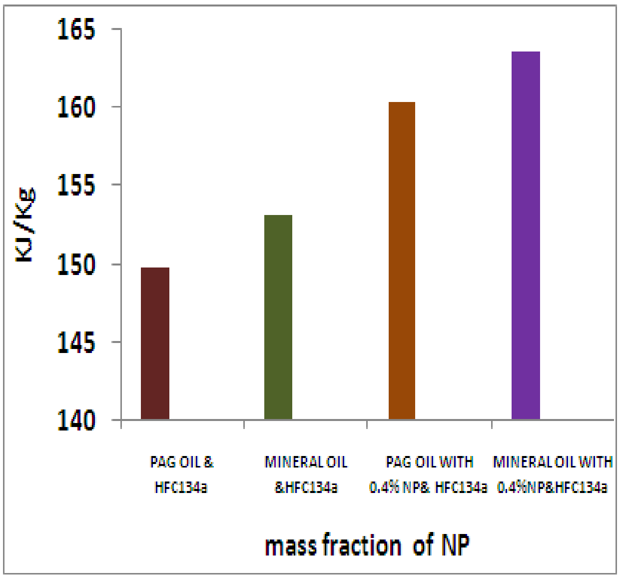


Figure 9.refrigerating effect for 0.4% NP

The most important performance parameter of a refrigerator is its refrigerating effect. The more the refrigerating effect more will be the COP of the refrigerator. With the increase in the percentage of mass fractions of the nanoparticles the refrigerating effect increases.

7.4 Compressor Work

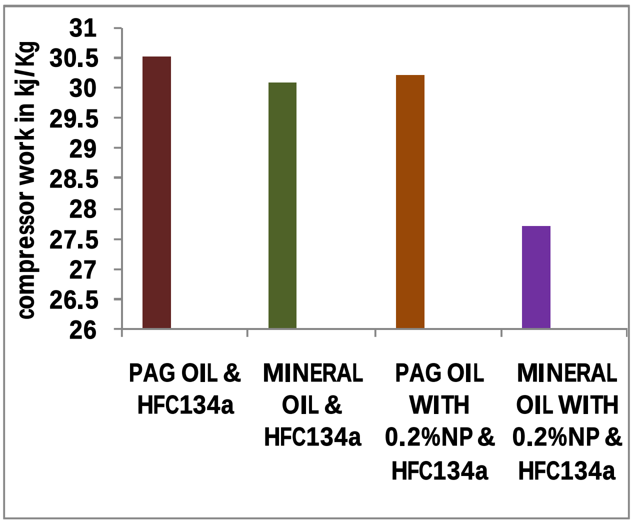


Figure 10: compressor work for 0.2% NP

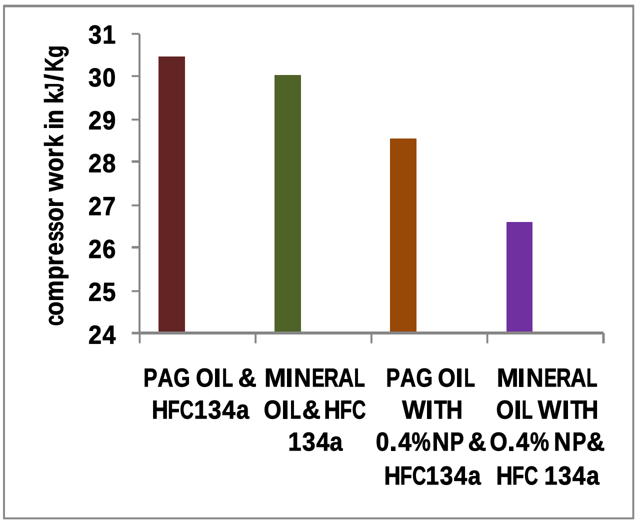


Figure 11:compressor work for 0.4%NP

In an energy efficient model it has been an important factor to reduce the energy consumption which not only makes it energy efficient but also cost effective. With the increase in the percentage of the mass fractions of nanoparticles the compressor work is reduced.

7.5 Coefficient of Performance

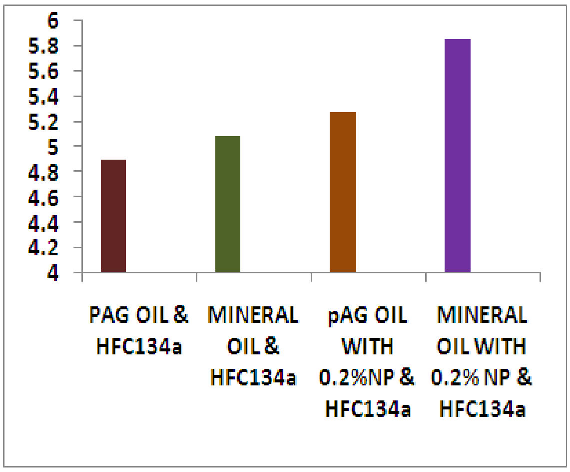


Figure 12: COP for 0.2% NP

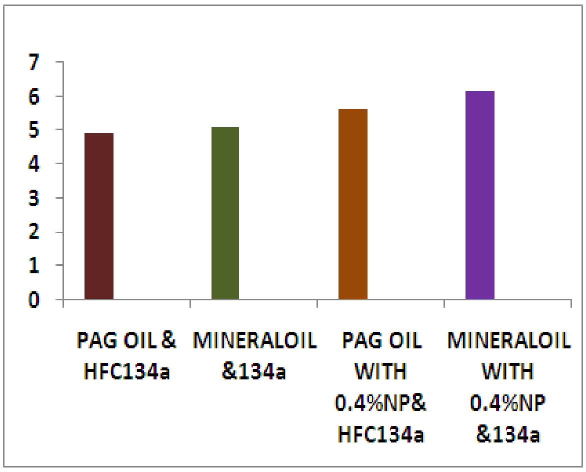
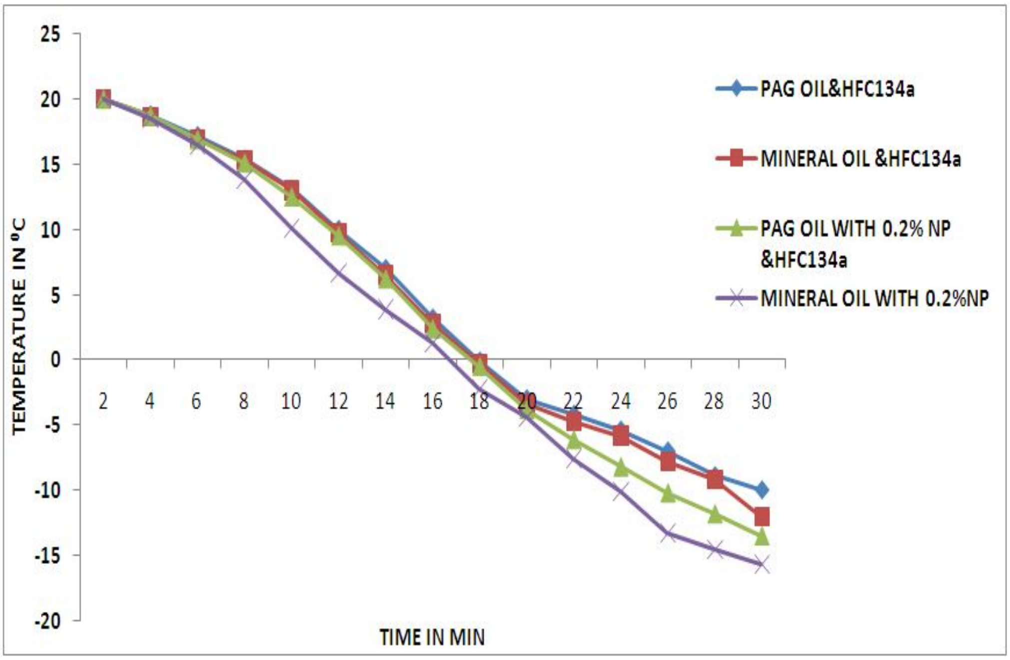


Figure 13:COP for 0.4% NP

The coefficient of performance of a refrigerator is depended on the refrigerating effect and the compressor work. So the sole purpose of this work is to enhance the COP which is obtained by increasing the refrigerating effect and decreasing the compressor work. The percentage increase in the mass fraction of the nanoparticles results in our desired effect i.e enhanced COP.

7.6 Refrigerating Space



We kept the refrigerating space under observation for 30 minutes. Meanwhile we have also taken readings of temperature of the refrigerating space in every two minutes interval and found out that the temperature has reduced from 20^0C to -10^0C , -12^0C , -13.5^0C & -15.6^0C for the mixture of PAG Oil and R134a , Mineral Oil and R134a , PAG Oil with 0.2% mass fraction of nanoparticles and R134a , Mineral Oil with 0.2% mass fraction of nanoparticles and R134a respectively.

8. Conclusion

For 0.2% mass fraction of nanoparticles , the coefficient of performance of the system increases by 7.75% and 19.38% when we take PAG Oil and Mineral Oil as lubricant respectively. As a result of comparison of COP between PAG Oil with 0.2% mass fraction of nanoparticles and Mineral Oil with the same mass fraction of nanoaprticles, Mineral oil mixture gives an increase of 10.79% of COP over PAG Oil mixture. Likewise, for 0.4% mass fraction of nanoparticles the COP of the system increases by 14.48% and 25.3% for PAG Oil and Mineral Oil respectively. Here also Mineral Oil mixture gives an enhanced COP of 9.44% over PAG Oil mixture. So we conclude that Mineral Oil taken with nanoparticles as lubricant gives a significant reduction in power consumption which enhances the performance of the system and also this caters a major requirement from the society point of view.

References

[1]. Sheng-shan Bi, Lin Shi, Li-li Zhang, Application of nanoparticles in domestic refrigerators,Applied Thermal Engineering, 28(14–15), 2008,1834-1843.
[2]. Shengshan Bi, Kai Guo, Zhigang Liu, JiangtaoWu, Performance of a domestic refrigerator using TiO2–R600a nano-refrigerant as working fluid, Energy Convers. Manag. 52 (1) ,2011,733–737.
[3]. R. Krishna Sabareesh, N. Gobinath, V. Sajith, Sumitesh Das, C.B. Sobhan, Application of TiO_2 nanoparticles as a lubricant- additive for vapor compression refrigeration systems – An experimental investigation ,International Journal of Refrigeration, 35(7), 2012,1989-1996.
[4]. F.S. Javadi' , R. Saidur, Energetic, economic and environmental impacts of using nanorefrigerant in domestic refrigerators in Malaysia,Energy Conversion and Management,73,2013,335-339.
[5]. Meibo Xing, Ruixiang Wang, Jianlin Yu3, Application of fullerene C_{60} nano-oil for performance enhancement of domestic refrigerator compressors, International Journal of Refrigeration, 40, 2014, 398-403.
[6]. I.M. Mahbubul, S.A. Fadhilah, R. Saidur, K.Y. Leong, M.A. Amalina, Thermophysical properties and heat transfer performance of Al_2O_3/R-134a nanorefrigerants