International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-3, September 2019

# Effect of Addition of Different Mass Fractions of CuO Nano Particles in Compressor oil upon COP of the Refrigeration System

**Sakshi Mishra, C.G.Harge**

***ABSTRACT*****:** ***Nano fluids are produced by mixing particles of nano dimensions in the standard fluids. Thermal conductivities of the nanofluids are higher than that of the base fluids. These are the properties which makes nanofluids unique and superior to normal solid liquid suspensions. i) heat transfer between the particles and fluid is higher due to the high surface area of the particles ii) enhanced dispersion stability with pre-eminent Brownian motion iii) particle clogging is minimized iv) Power required for pumping is less as compared to the base fluid for proportionate heat transfer. In this project Cu0 nanoparticles of size 20nm-50nm has been used as Nano lubricant for performance study of Refrigeration test rig. CuO nanoparticles are mixed in POE oil (Compressor oil) to form the nanolubricant. The nanolubricant so formed is further stabilized by Ultrasonic agitation. Nano lubricants with specific mass fractions 0.30%, 0.70%, 1.05%, 1.4% are added in the compressor oil and the experimentation is carried out which shows significant improvement in the performance of refrigeration system. Compressor work is reduced and consequently COP of refrigeration system is improved.***

***Keywords*****:** ***Cu0 nanoparticles, Nanolubricant, POE oil, Ultrasonic agitation, Refrigeration system***

## I. INTRODUCTION

Nanofluids are fluids containing particles of nano range. These are two-phase systems with solid phase mixed in liquid phase. Nanofluids are extensively used as they have superior thermophysical properties (thermal conductivity, viscosity, heat capacity, thermal diffusivity and convective heat transfer coefficients) than that of base fluids (oil/water). It has demonstrated pronounced prospective applications in many fields. [1] Different materials being used for preparing nanofluids. $Al_2O_3$, CuO, SiC, TiO, , TiC, Ag, Cu, Au, , and Fe nanoparticles are commonly used in nanofluids studies.[2]

Manuscript published on 30 September 2019
* Correspondence Author
**Sakshi Mishra***, M.Tech Student in Department of Mechanical Engineering, PVPIT, Sangli, Maharashtra,India
**Prof.C.G.Harge**, Faculty in Department of Mechanical Engineering, PVPIT,Sangli, Maharashtra,India



The ongoing researches by scholars to utilize advancements in science and latest technologies across the world are contributing not only in the monetary savings making the systems more energy efficient but also to develop systems that are least harmful to environment and pollution free. Refrigeration systems are not exceptions.

Nanofluids are being used to improve energy competence of VCRS systems. [3] Another problem is of power consumption and heat transfer rate which can be tackled by employing nanofluids. [4] The use of Nanofluids reduces the power consumption and increases the rate of heat transfer and thereby improving the performance of the system. [2]

Refrigerant HFC 134a is extensively used in domestic refrigerators as well as in air conditioners. Adding nanoparticles to the refrigerant improves its thermo physical properties as well as the heat transfer characteristics, and thus improving overall conduct of the refrigeration system. The Nanoparticles are added to the lubricant/compressor oil and mixture of lubricant and nanoparticles is called nanolubricant. Similarly nanoparticles are mixed with refrigerant and the mixture thus formed is known as nanorefrigerant. Nanolubricant-refrigerant can be prepared by mixing pure refrigerant with nanolubricant. Nanolubricant, nanorefrigerant and nanolubricant-refrigerant are type of nanofluids. In refrigeration systems, nanolubricant improves tribological characteristics improving compressor performance; nanorefrigerant improves thermo-physical properties, improving refrigerating effect. Presence of nanoparticles enhances solubility between refrigerant and oil and thus more oil is returned back to compressor. [3] Nanofluid is a colloidal mixture in which the properties of both the nanoparticles and the base fluid add on to the modification in the thermal and transport properties of the base fluid [5], [6]. Water, ethylene glycol and POE oil are mostly employed as the base fluid in Nanofluid preparation since they are used commonly in heat transfer applications. The nanoparticles can be added to the lubricant in a VCR system. [7] One of the major problems encountered in using the nanofluids is its stability. The nanoparticles have a tendency to form clusters that settles and clogs microchannels thus decreasing the thermal conductivity of nanofluids. [1] Various methods are used in order to enhance the stability of nanofluids such as addition of surfactants, Ultrasonic agitation, Surface modification etc. An experiment on VCR test rig was performed to determine the improvement in the COP of refrigeration system upon addition of CuO nanoparticles in compressor oil and compare the results with the performance of system without addition of nanoparticles by calculating the refrigeration effect, compressor work and coefficient of performance.

## II. LITERATURE REVIEW

Many researchers have studied the performance of VCR system with nano-refrigerant as well as with nano-lubricant. Some of those literatures are discussed below:

1. **Kumar,Sridhar& Narasimha (2013)** [8] conducted experimental analysis on the performance of VCR system using R600a as refrigerant. $Al_2O_3$ nanoparticles were added in mineral oil which was used as lubricant .Compressor power consumption is decreased by 11.5% .Freezing capacity is enhanced. The COP of the system is improved by 19.6% when nanoparticles were mixed in mineral oil.
2. **Coumaressin & Palaniradja (2014)** [9] conducted study on refrigeration system using nanofluids by Computational Fluid Dynamics and heat transfer analysis was carried out by using FLUENT software. Mass fraction of CuO (copper Oxide) nanoparticle was varied from 0.05% to 1% and size range from 10nm to 70nm.The experimental investigations indicates improvement in the performance of the refrigeration system. Also, the heat transfer coefficient of evaporator is increased by using CuO nanoparticles.
3. **Kumar & Elansezhian (2012)** [10] conducted an experiment on VCR system with R134a as refrigerant and $Al_2O_3$ nanoparticles was mixed with lubricant PAG oil. 0.2% volume concentration of nanoparticles was used. The result shows that this system using R134a and PAG oil along with $Al_2O_3$ nanoparticles functioned safely and normally. The performance of system with nano-refrigerant was better than pure lubricant. 10.32% less energy was consumed. COP was improved up to 3.5. Length of the capillary tube is also reduced by the use of nano-refrigerant.
4. **Abdel-Hadi, Taher, Mohamed Torki, & Hamad (2011)** [11] conducted experiment on VCR system by using nano-refrigerant as CuO. In this the effect of evaporating heat transfer coefficient is studied experimentally. The nanoparticles used for this purpose were size ranged from 15nm to 70nm and concentration range from 0.05% to 1%. The result shows that heat transfer coefficient is increased up to 0.55% of nanoparticles concentration after that it decreases. The result also indicated that the heat transfer coefficient was most with 25mm size of CuO nanoparticles.
5. **Fadhilah, Marhamad, & Izzat (2014)** [12] considered the effect of suspending CuO nanoparticles in refrigerant R134a and investigated it using mathematical modeling. The investigation comprises of rate of heat transfer, thermal conductivity along with dynamic viscosity of CuO-R134a mixture in single tube of evaporator. The result demonstrates better thermo physical properties than before. The nanoparticles concentration was between 1% and 5%.
6. **A.S.N. Husainy et al (2018)** [13] studied air conditioning system with CuO nanofluids. The CuO Nano lubricants of dimensions 50nm are utilized for analyzing the performance of ducted air-conditioner system. The nano-lubricant with specific concentration of 0.25%, 0.50%, 0.75% and 1% (by mass fraction) were mixed in POE oil and the results obtained indicated the improved COP and decreased compressor work of the system.

## III. EXPERIMENTAL METHODOLOGY

**Nanofluid Concentration:** 0.35%, 0.7%, 1.05% & 1.4 % mass fractions of CuO nanoparticles are mixed in 500ml Compressor oil.

CuO nanoparticles are added to POE compressor oil which is used as lubricant in Refrigeration test rig which is charged with R134a refrigerant. The temperature of t R134a at the inlet and also at the outlet of condenser as well as evaporator is documented. Pressure is also measured across evaporator and condenser of the Refrigeration system. First of all, system's performance is studied with pure POE oil without addition of nano particles and after that CuO nanoparticle in different mass fractions is added to the POE oil to determine the improvement in performance of the system.

**Figure 1: Experimental Test Rig**

**Charging of set-up:**

Removing air from refrigeration unit before charging is necessary. Firstly pressure gauge and vacuum gauge are fitted. The air from condenser, receiver, and evaporator is sucked through valve and it is discharged into atmosphere through the valve after compressing into the compressor. When most of air is removed from the system, sufficiently low vacuum is indicated by the vacuum gauge. The compressor is stopped after the air is removed from the system, valves are released and then compressor is again started. When the adequate quantity of refrigerant is taken into system, the compressor is stopped.

**Figure 2: Charging of setup**

**Preparation of Nano-lubricant:**

The process of preparation of Nano fluid is given below:

1. Weight the mass of POE oil to be used in the compressor on digital electronic balance machine.
2. Consider the mass of nanoparticles on a digital electronic balance for 0.35% of weight of oil.
3. Mix the weighted nanoparticles into the POE oil for preparing the mixture.
4. Agitate this mixture by using an ultrasonic vibrator for 2-3 hours until well- dispersed Nano fluid-lubricant mixture is formed.

Repeat the above steps for preparing the dispersion of 0.7%, 1.05% & 1.4 % nanoparticles in POE oil.

**Figure 3: Ultrasonic agitation of mixture of PoE oil and CuO nanoparticles**

**Experimental Procedure:**

The VCRS system was charged with R134a refrigerant after which different mass fractions of CuO nanoparticles were added to POE oil in compressor. Required temperatures were noted down. The power consumption rate of the compressor was calculated by recording the time took for energy meter to flash ten times. Using above data, the COP of system and the power consumption rate of the compressor could be determined.

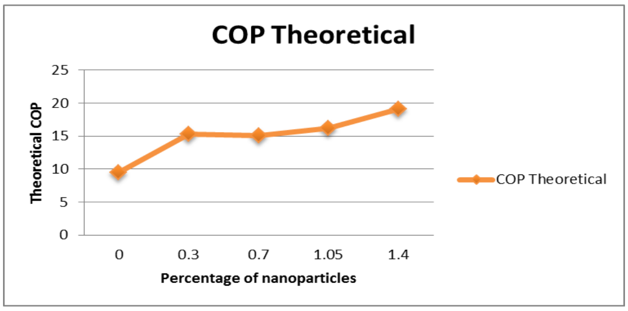
$$\text{Compressor Work} = \frac{Tc \times EMC}{10 \times 3600}$$

COP = Cooling Effect/Work Input = $Q_L/W_{input}$

## IV. RESULTS AND DISCUSSION

After performing the experimentation, we have reached to the conclusion as mentioned below:

**Effect of addition of different mass fractions of nanoparticles on Theoretical COP:**

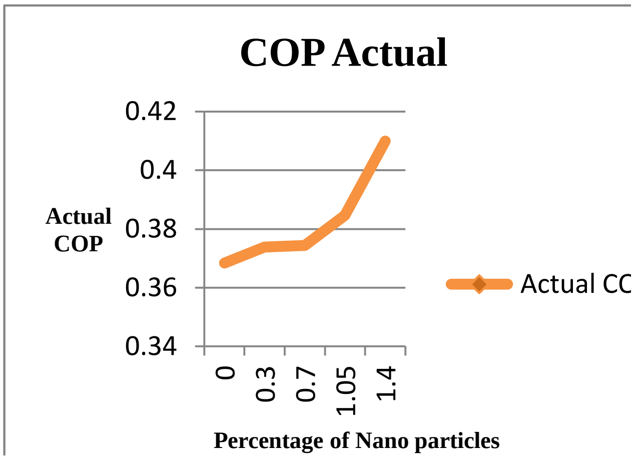



**Graph 1: Effect of different mass fractions of nanoparticles on Theoretical COP**

From the graph above, theoretical COP of the system goes on increasing as the percentage of CuO nanoparticles in the Compressor oil increases. The theoretical COP increases from 9.44 to 19.11.

**Effect of addition of different mass fractions of nanoparticles on Actual COP:**

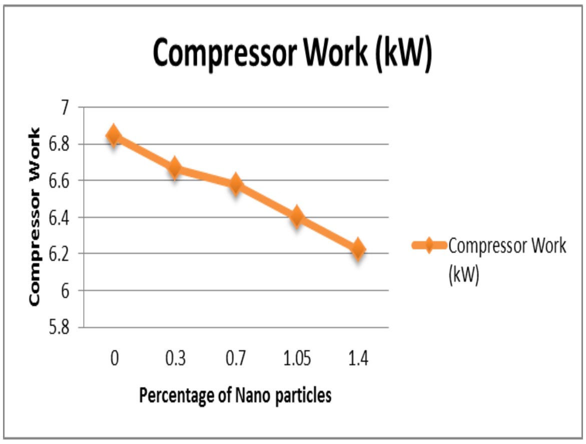
From this graph, we conclude that Actual COP of system becomes maximum i.e. 0.410 at 1.4% CuO nanoparticle concentration i.e.7 grams.




**Graph 2: Effect of different mass fractions of nanoparticles on Actual COP**

**Effect of addition of different mass fractions of nanoparticles on Compressor work:**

The compressor work goes on decreasing as the percentage of CuO nanoparticles in the POE oil increases as shown in Graph .Compressor work decreased from 6.844 kW (system without nanoparticles) to 6.22 kW (with 1.4% nanoparticles concentration).



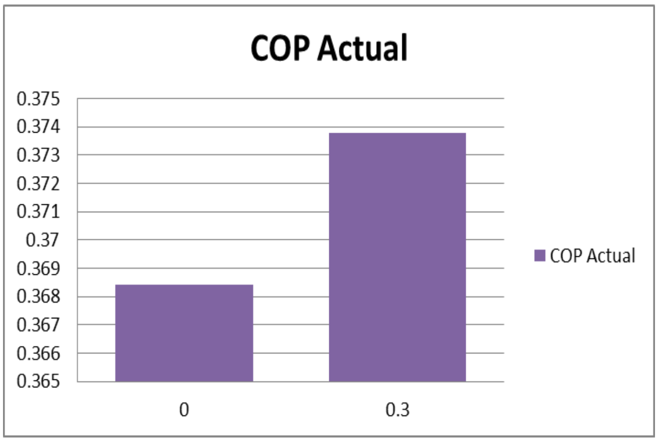

**Graph 3: Effect of different mass fractions of nanoparticles on Compressor work**

As compared to the conventional Refrigeration System without nanoparticles, graphical representation of improvement in COP and reduction in compressor work on adding CuO nanoparticles to compressor oil is given below:

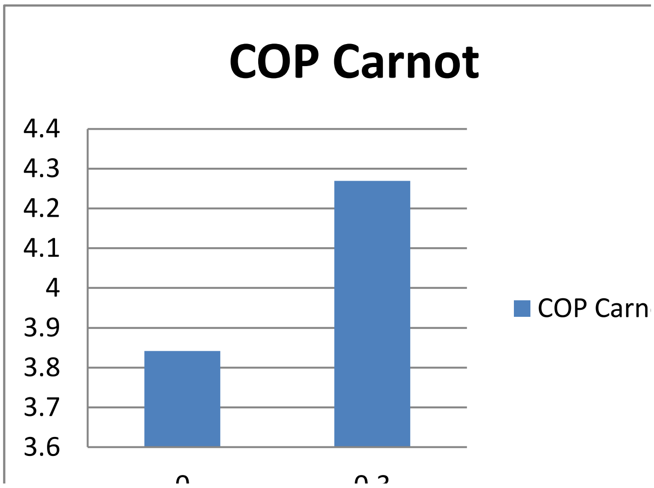
*Retrieval Number C3969098319/2019©BEIESP*
*DOI: 10.35940/ijrte.C3969.098319*
*Journal Website: www.ijrte.org*



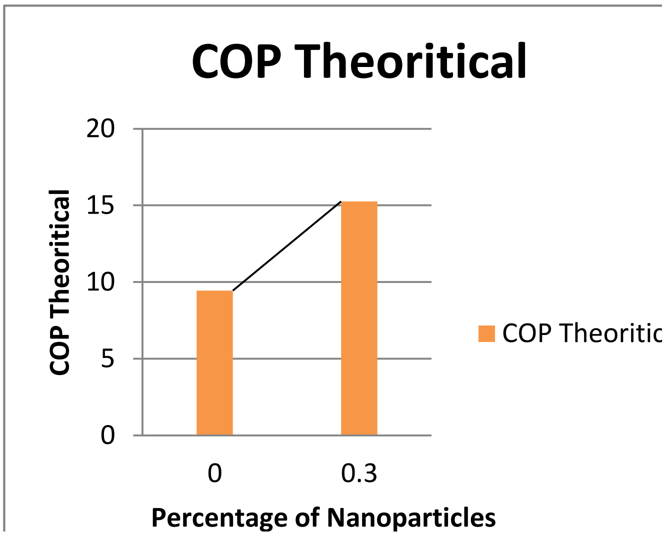
*Published By:*
*Blue Eyes Intelligence Engineering & Sciences Publication*



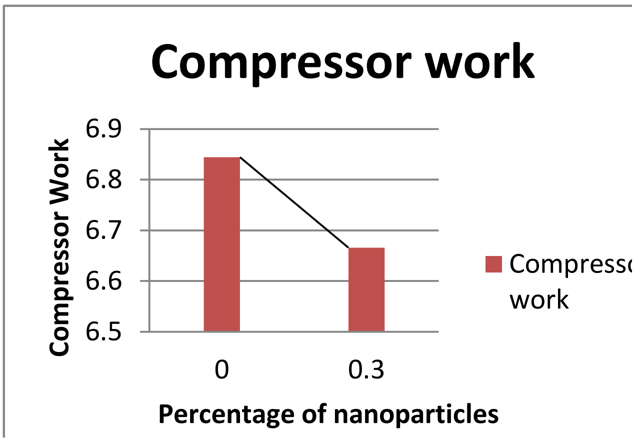

**Graph 4: Graphical representation of Increase in actual COP upon addition of nanoparticles**




**Graph 5: Graphical representation of Increase in Carnot COP upon addition of nanoparticles**




**Graph 6: Graphical representation of Increase in Theoretical COP upon addition of nanoparticles**




**Graph 7: Graphical representation of decrease in Compressor work upon addition of nanoparticles**

## V. CONCLUSION

It is concluded from this experiment that there is improvement in the overall performance of the Refrigeration System upon addition of 0.30% of CuO Nanoparticles in the Polyolester oil in comparison to the pure oil. After calculation it is evident that:

1. The Compressor work is reduced by 2.6%
2. Carnot COP is increased by 10%
3. Theoretical COP is increased by 38.17%
4. Actual COP is increased by 14.44%

Therefore adding nanoparticles improves the performance of the refrigeration system and hence CuO nanoparticle with refrigerant R134a can be used to enhance and improve the heat transfer characteristics of the refrigeration system.

## REFERENCES


1. Yu, Wei & Xie, Huaqing. (2012). A Review on Nanofluids: Preparation, Stability Mechanisms, and Applications. Journal of Nanomaterials. 2012. 10.1155/2012/435873.
2. Ramakoteswaa Rao, LeenaGahane , Ranganayakulu S: Synthesis, Applications and Challenges of Nanofluids – Review. IOSR Journal of Applied Physics (IOSR-JAP) e-ISSN: 2278-4861, PP 21-28 www.iosrjournals.org International Conference on Advances in Engineering & Technology – 2014 (ICAET-2014) 21
3. Amey Majgaonkar.(2016) .Use of Nanoparticles In Refrigeration Systems: A Literature Review Paper. https://docs.lib.purdue.eduirac.International Refrigeration and air conditioning conference.
4. S. U. S.Choi, D. A. Singer and H. P. Wang. "Developments and applications of non-Newtonian flows." ASME FED, Vol. 66, pp. 99105, 1995.
5. E Serrano, G Rus and JG Martı´nez, ―Nanotechnology for sustainable energy,‖ Renewable and Sustainable Energy Reviews, Vol. 13, No. 9, pp. 2373–84, 2009.
6. D.Elcock. Potential impacts of nanotechnology on energy transmission applicationsand needs, Environmental Science Division, Argonne National Laboratory, 2007.
7. T. Coumaressin and K. Palaniradja.(2014) Performance Analysis of a Refrigeration System Using Nano Fluid.International Journal of Advanced Mechanical Engineering. ISSN 2250-3234 Volume 4, Number 4(2014), pp. 459-470.
8. Kumar, R. R., Sridhar, K., & Narasimha, M. (2013). Heat transfer enhancement in domestic refrigerator using R600a/mineral oil/nano-Al2O3 as working fluid. International Journal of Computational Engineering Research, 3(4), 42-50.

9. Coumaressin, T., & Palaniradja, K. (2014). Performance analysis of a refrigeration system using nano fluid. International Journal of Advanced Mechanical Engineering, 4(4), 459-470.
10. Kumar, D.S., & Elansezhian, R. (2012). Experimental Study on Al2O3- R134a Nano Refrigerant in Refrigeration System. International Journal of Modern Engineering Research , 3927-3929
11. Abdel-Hadi, Eed A., S. K. Homeed Taher, Abdel Hamid Mohamed Torki and Samar Sabry Hamad. “Heat Transfer Analysis of Vapor Compression System Using Nano Cuo-R134a.” (2011).
12. Fadhilash, S.A., Marhamah, R.S.,& Izzat,A.H. (2014). Copper Oxide Nanoparticles for Advanced Refrigerant Thermophysical Properties: Mathematical Modeling. Handawi Publishing Corporation Journal od Nanoparticles, 1-5
13. A.S.N. Husainy, Pradnya M. Chougule, Kalyani R. Badade, Shraddha A. Hasure, Aishwarya S. Patil and Shubhangi A. Tukshetti A Glance on Preparation, Stability, Properties and Applications of Nanofluids.Volume 7 No.2 July-December 2018


## AUTHORS PROFILE

**Sakshi Mishra** is M.Tech(Heat Power Engineering) final year student in Department of Mechanical Engineering in PVPIT, Sangli, Maharashtra. She has completed her B.Tech (ME) from KIET, Ghaziabad, India and she was the gold medalist at university level for the year 2015.

C.G.Harge is Head of Department and Associate Professor in Department of Mechanical Engineering in PVPIT, Sangli, Maharashtra. He has over 28 years of teaching experience and has membership of ISTE and MIE.