EXPERIMENTAL INVESTIGATION TO ENHANCE HEAT TRANSFER CHARACTERISTICS OF VCR SYSTEM USING SiO_2 NANO LUBRICANT WITH R600a AS WORKING FLUID

[1]A. SADDAM HUSSAIN, [2] Dr. K. KALYANI RADHA
[1]PG Research Scholar, [2]Assistant Professor of Mechanical Engineering
[1]Refrigeration and Air conditioning, Mechanical Engineering
JNTUA College of Engineering (autonomous), Ananthapuramu, Andhrapradesh, India.

Abstract: The coefficient of performance (COP) of a refrigeration system can be improved if a reduction in the work of compression (W_C) can be achieved by a suitable technique, for a specified heat removal rate. The present study investigated the effect of dispersing a low concentration of SiO_2 nanoparticles in Polyoester oil and the effects of nano lubricant, on its viscosity and lubrication characteristics, as well as on the overall performance of a Vapor Compression Refrigeration System using R600a (Isobutane) as the working fluid were noticed .

An enhancement in the COP of the refrigeration system has been observed, with low concentrations of nanoparticles suspended in Polyoester oil (POE).The physics involved in the interaction of nanoparticles with the base fluid has been elucidated. In the present work, SiO_2 Nano powder (1% w/v), (2% w/v) and (3% w/v) was mixed with Polyolester (POE) oil. Experiments are done with R600a as refrigerant and it was found that power consumption was decreasing with Polyolester oil lubricants when compared with normal cycle this is due to effective lubrication and thermo physical characteristics of nano lubricant.

***Key words**: Coefficient of performance (COP), work of compression (W_C), R600a, nanoparticles, thermo physical characteristics.*

I.INTRODUCTION

In a vapor compression refrigeration (VCR) system, the refrigerant undergoes phase change from liquid to vapor and then from vapor to liquid in a closed cycle absorbing the heat in the evaporator and rejecting it at the condenser. The coefficient of performance (COP), which is the ratio of heat transfer rate at the evaporator to the power input to the compressor, can be increased either by increasing the heat removal rate or by decreasing the compressor work

The rapid advancement in Nano-technology have lead to emerging of new generation heat transfer fluids called Nano fluids. A nano fluid is the suspension of nanoparticles in a base fluid. Nano fluids are promising fluids for heat transfer enhancement due to their anomalously high thermal conductivity. The Nano fluids are the specific concentration mixtures of the base fluid and the Nno particles. The main base fluid can be lubricating oil, water, refrigerant ,etc. the Nano particles are Al, Cuo, SiO_2 ,TiO_2 etc. mixed together to form a colloid solution called Nano fluid. Recently scientists used Nano particles in the field of refrigeration systems because of its improvement in heat transfer capabilities to enhance the C.O.P and reliability of vapour compression refrigeration system. It reduced the power consumption required to get the refrigeration effect to some extent

.

II. LITERATURE REVIEW

Binit Kumar Jha, et.al. [1] Guided an exploratory examination to consider the COP of VCR system using distinctive refrigerants like R134a and R600a under condition - 5^0C evaporator temperature. The results showed that the elective refrigerant explored in the examination R600a has higher coefficient of execution. Refrigerant property parameters exhibits that R600a has minimum spillage, slightest a risky barometrical deviation potential and low power usage when differentiated and R134a.The cooler worked capably when R600a refrigerant was used as refrigerant as opposed to R134a. At every mode R600a refrigerant yields higher COP than R134a, As well as the setting temperature was lower than that of R134a.

Nilesh Desai et al. [2] has carried out an experimental investigation of a vapor compression refrigeration system using R134a/SiO2/polyester Nano refrigerant as working fluid. In the experiment the Nano-oil with specific concentrations of 1%, 2% and 2.5 % (by mass fraction) were added in the compressor oil. They found that as the nanoparticles concentration in POE oil increases, there is decrease in compressor work and it is optimum at 2%. It has been observed that energy saving can be achieved from a minimum value of 7.03% to a maximum value of 12.30% using Nano lubricant compared to traditional refrigerants. The result shows the COP of system were improved by 7.61%, 14.05% & 11.90%, respectively, when the Nano-oil was used instead of pure oil.

III.PREPERATION OF NANO FLUIDS

The primary stride for experimentation is the arrangement of nano liquids. For the most part, there are two strategies for planning of transformer oil-based nano liquids which can be arranged as one-advance and two-advance techniques. A concise presentation on arrangement forms is given as takes after.

(1) Single-Step Method: In the one-advance technique, the nanoparticles are produced and suspended in the base fluid while; is, the course of drying, stockpiling, and movement of nanoparticles is by-passed with the expectation to lessen the agglomeration and the steadiness of nano particles suspension is upgraded. The hindrances related with one-advance strategy are their staggering expense and issues with an expansive scale creation.

(2) Two-Step Method: For a two-advance strategy, the strong nanoparticles are readied (either by physical or by substance techniques) and after that suspended in the transporter oil ultrasonic course, attractive mixing, high-shear blending, or ball processing.

This technique is extensively utilized to deliver nano liquids on a vast scale due to its lower cost. In any case, there are high odds of agglomeration of nanoparticles amid the two phases of two-advance technique because of an enormous surface region and the substantial surface action of the nano particles. The most widely recognized two-advance process is expounded in Figure 1.

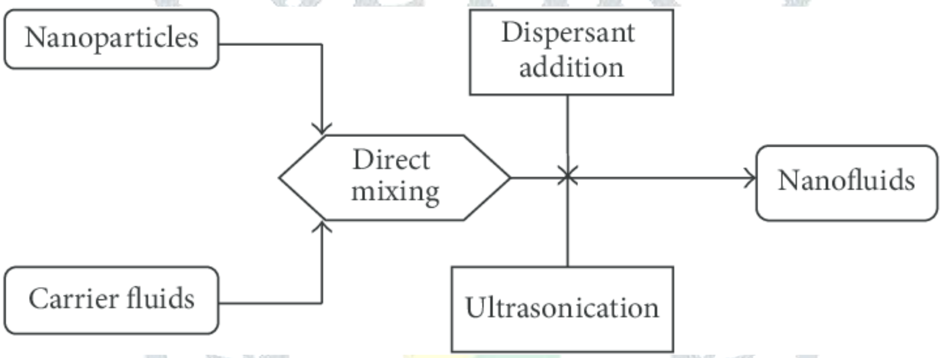

Fig. 1. Readiness of the nano lubricant preparation in two stage technique

The added substance utilized as a part of the mineral oil and POE based ointment was SiO_2 in the nano molecule shape.. The normal size of the nanoparticles had a scope of 50 TO 200 nm. SiO_2 nanoparticles were readied utilizing ultrasonic tumult for accomplishing great scattering of the particles in the base liquid. The required weight of the SiO_2 nanoparticles comparing to the volume portion was precisely estimated utilizing a high accuracy electronic adjust. Uniform scattering of particles in the mineral oil was accomplished by methods for a standard Ultrasonic instigator, by sonicating for a time of 300 min. Traditional strategies for adjustment, for example, the utilization of surfactants was not gone for, as the nearness of such materials would influence the execution of the greasing up oil because of development of foam under proceeded with use in the framework. Rather, the examinations were bound to low volume parts of the nanoparticles, so agglomeration does not happen and the nano liquid is steady with no sedimentation for a generously prolonged stretch of time of a few days after its planning.

Melting point (^0C)	1713
Boiling point (^0C)	2950
Density (Kg/m3)	2500
Specific heat (J/Kg-K)	1000
Thermal conductivity (W/m-K)	1.1 – 1.4
Thermal expansion coefficient (/K)	$5.6*10^{-7}$
Specific surface area (m2/g)	380
Molar mass (g/mol)	60.08

Table 1: Properties of SiO_2

Fig 2: SiO_2 Nano powder

Fig 3: POE oil before mixing with SiO_2

Fig 4:.Mixing process of nano particle

Fig 5: Stirring in ultrasonic vibrator

Fig 6: Nano lubricants of SiO_2

IV.EXPERIMENTAL SETUP

Firstly select the VCR system of 165 L capacity. Separate the compressor from VCR system after cutting suction and discharge lines. and remove, lubricating up oil officially show in it. Fill the POE oil into the Compressor with proper amount. Fix pressure gauges at passage of compressor, exit of compressor and exit of condenser. Set back the compressor in its place and affix it firmly. Join the suction and release as in the past with help of gas welding. Nitrogen gas is dashed into the VCR framework up to 150 psi for the flush out of residue particles and remote follows. Soap bubble test is performed to identify the spillage display at the welded bit of copper tubes.

Air exhibit in the framework is expelled by the vacuuming fixed framework process. After vacuuming, charge the compressor with R600a by using manifolds, hoses, access fittings and quick couplers. Fix the thermocouples at the entry and exit of the components like at the compressor inlet, compressor outlet, and exit of condenser and in the evaporator.

The refrigeration system experiment was carried out with

1. Normal VCR system with R600a as refrigerant and POE oil as lubricating.
2. VCR System with R600a as refrigerant and SiO_2nano lubricant (1% w/v) where base fluid is POE oil.
3. VCR system with R600a as refrigerant and SiO_2 nano lubricant (2% w/v) where base fluid is POE oil.
4. VCR system with R600a as refrigerant and SiO_2 nano lubricant (3% w/v) where base fluid is POE oil.

Experiments are conducted in all cases and the values of pressures and temperatures are tabulated and calculations are done.

V. RESU LTS AND DISCUSSIONS

Experiments are carried out with all conditions. Energy consumption is calculated and charts are drawn. Refrigeration effect is calculated. Coefficient of Performance is calculated and charts are drawn.

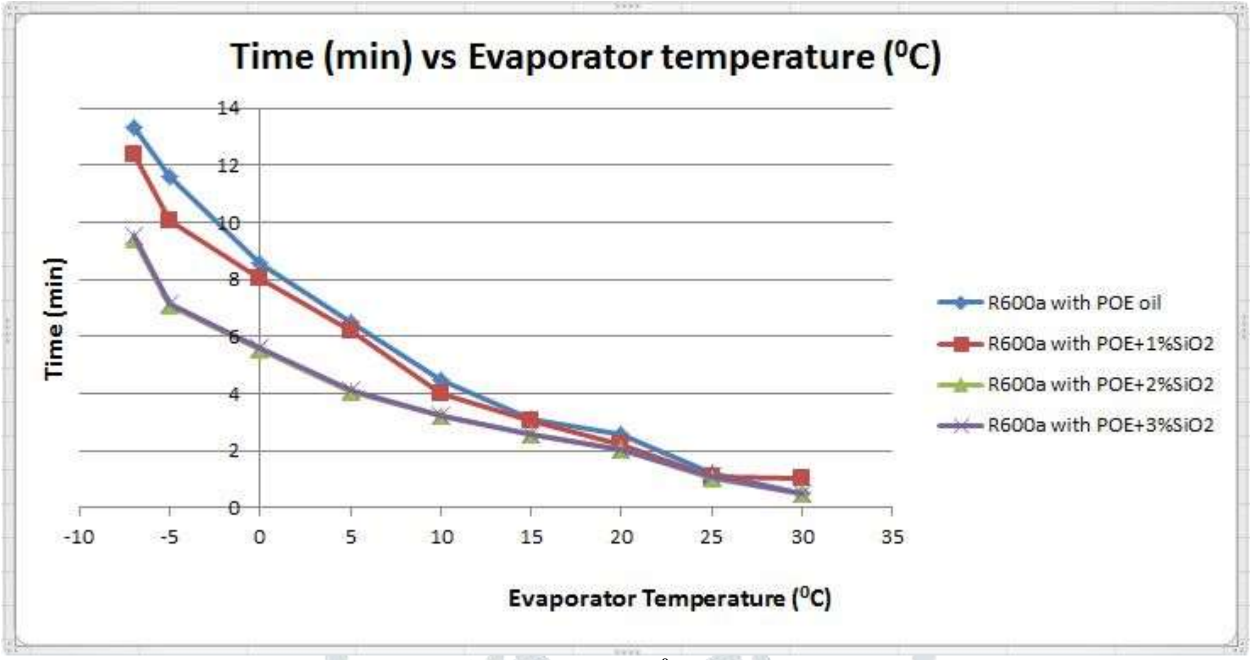

Fig 7: Evaporator temperature (^{0}C) Vs Time(min) graph

Time Time taken for every 5^0 C change in evaporator temperature and line chart shows Time vs. Evaporator temperature

i) Comparison of Compressor Work Required for Ton of Refrigeration:

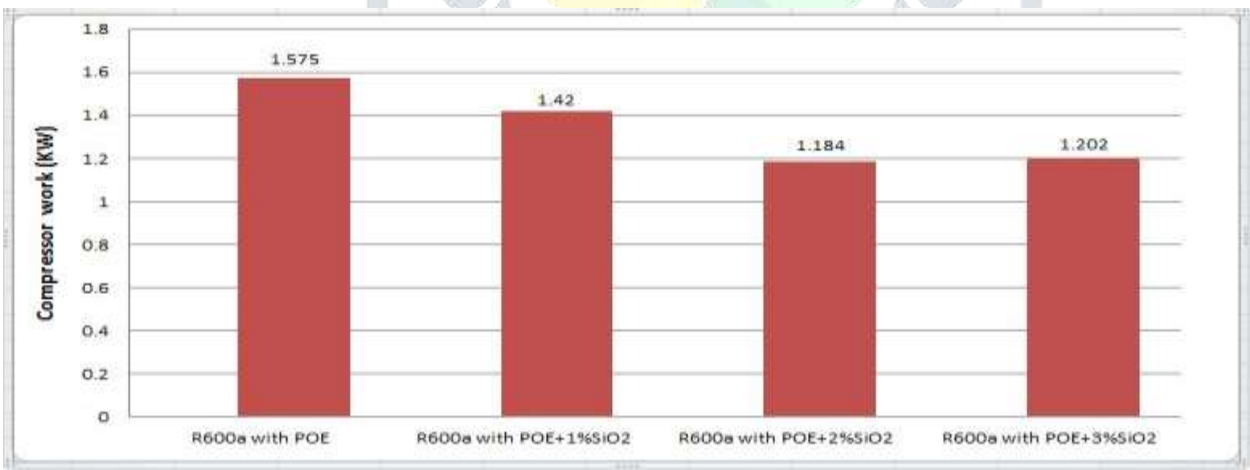

Fig 8: Comparison of compressor work

From SiO_2(2% w/v) increases the heat transfer rate in the compressor. Among all when POE oil mixed with SiO_2(2% w/v) nano particles is showing the optimum. Therefore the specific volume of compressed refrigerant decreases which leads to reduction in compressor work. Therefore the compressor work required per ton of refrigeration is less when compared with R600a refrigerant in all the remaining cases

ii) Comparison of Refrigeration Effect:

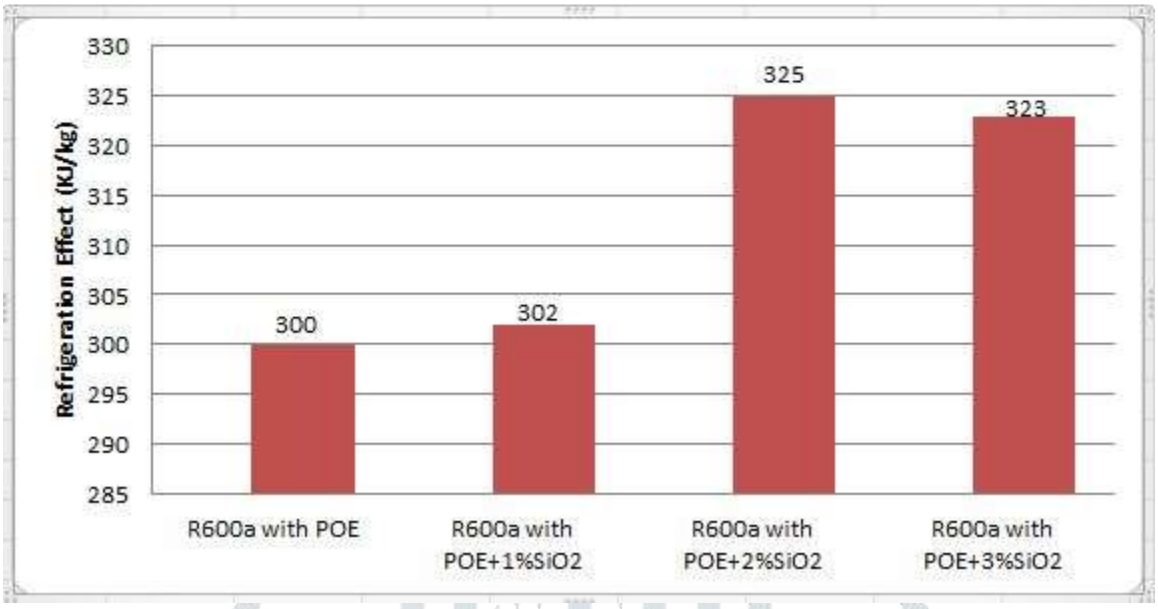

Fig 10: Comparison of Refrigeration Effect

The heat transfer rate in evaporator with POE oil mixed with SiO_2(2% w/v) nano particles is increases the heat transfer rate through the evaporator coil by maintaining of low pressure. Due to this the refrigeration effect increases in the case of R600a using SiO_2(2% w/v) +POE Oil when compared with normal cycle.

iii) Comparison of COP:

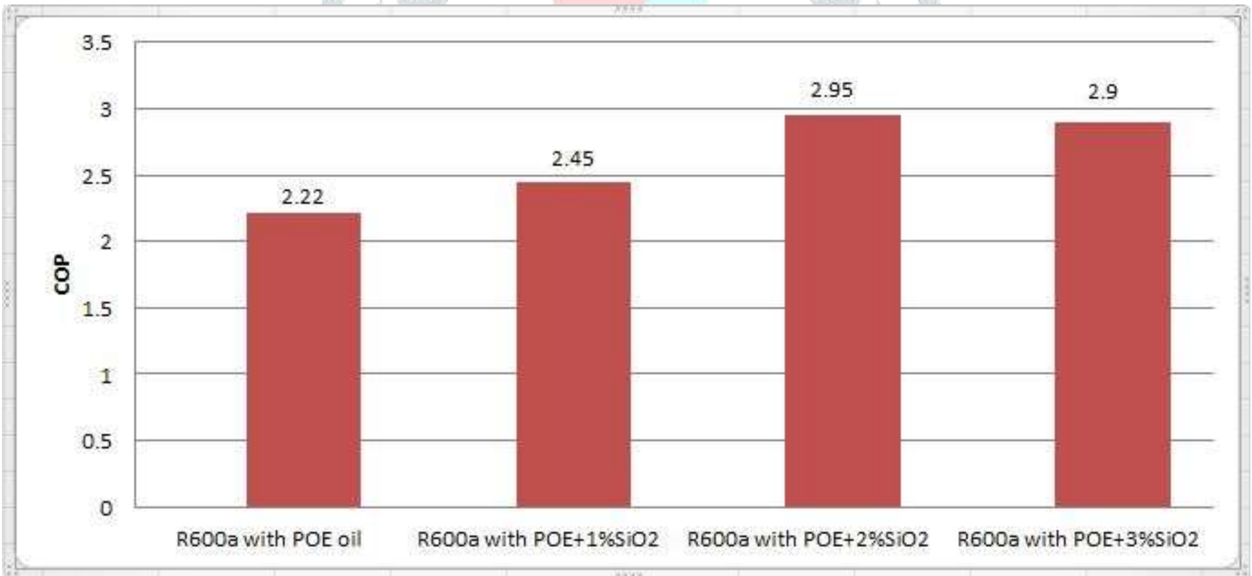

Fig 11: Comparison of Coefficient of Performance

The figure 11 shows that the coefficient of performance for R-600a using SiO_2(2% w/v)+POE Oil is higher than the R600a with POE. The coefficient of performance is more with SiO_2(2%w/v) +POE Oil by increasing refrigeration effect. The increase of COP for SiO_2(2% w/v) +POE Oil cycle when compared with normal cycle is 0.73.

VI. CONCLUSION:

Experimental investigation show that mixing nano particles to lubricating oils improves the thermal characteristics like as thermal conductivity and the heat transfer coefficient, which could mean improving the performance of refrigeration systems. The performance improvement of the refrigeration cycle by applying a nano particle is mainly due to heat transfer enhancement in heat exchangers and reduction of power consumption of the compressor by improvement of lubrication. It was observed that SiO_2(2% w/v) nano lubricant with POE oil as base fluid is optimum. From experimental investigation it is found that the coefficient of performance is more with SiO_2 (2% w/v)+POE Oil by increasing refrigeration effect. The percentage increase of COP for SiO_2 (2% w/v)+POE Oil to the normal cycle is 0.73

REFERENCES:

1. Binit Kumar Jha, NeelamKhandelwal, Prateek Singh, NishthaChaudhary, Hasan Ali, "Performance of Refrigerator Using R-600a as Refrigerant", proceedings of 2015 2nd international conference on recent innovations in science, engineering and management. JNU convention center, New Delhi 2015.
2. Nilesh S. Desai and P.R.Patil, Application of SiO2 Nanoparticles as Lubricant Additive in VCRS: Asian Review of Mechanical Engineering ISSN: 2249 – 6289 Vol. 4 No. 1, 2015, pp. 16.
3. Hague M.E. Bakar Kadirgama K.Noor M M.and Shakaib, Performance of a domestic refrigerator using nano particles based polyester oil lubricant, 2016 J. MECH. Eng. Sci., 1778-1791.
4. Kama raj N, Experimental analysis of vapour compression refrigeration system using the refrigerant with nano particles, 2016 Int journal of mech.engg. 16-25.
5. Rana JN and Pipwala H., A review on Thermodynamic analysis of a Vapour Compression Refrigeration System using Hydrocarbon Refrigerants, 2017 Int. RES. J. Eng. Techno 1794-1797.
6. Adyanshee R.K, Pattanayak Sahoo N and Mishra P, Performance analysis of a domestic refrigerator using SiO2 Nano particles,2016 IOSR J. Mech. Civ.Eng. 2278-1684.
7. Pawel K.P., Jeffrey A.E. and David G.C., 2005. Nano fluids for thermal transport. Materials Today, pp. 36-44.
8. Bi S., Shi L. and Zhang L., 2007. Performance study of a domestic refrigerator using R134a/mineral oil/nano-TiO2 as working fluid. ICR07-B2-346.
9. Jwo et.al, 2009.Effect of nano lubricant on the performance of Hydrocarbon refrigerant system. J. Vac. Sci. Techno. BB, Vol.27, No. 3, pp. 1473-1477.
10. Shenshan Bi, Performance of a Domestic Refrigerator using TiO2-R600a nano-refrigerant as working fluid, Int J of Energy Conservation and Management, Vol, 2011, 733-737.
11. T. Coumaressin and K. Palaniradja. Performance Analysis of a Refrigeration System Using Nano Fluid. IJAME, ISSN 2250-3234 Volume 4, Number 4 (2014), pp. 459-470.
12. Eed Abdel-Hafez Abdel-Hadi et al. Heat Transfer Analysis of Vapour Compression system Using Nano CuO-R134a. International Conference on Advanced Materials Engineering, vol 5 2011.