EXPERIMENTAL INVESTIGATION TO ENHANCE HEAT TRANSFER CHARACTERISTICS OF VCR SYSTEM USING Al_2O_3 NANO LUBRICANT WITH R600a AS WORKING FLUID

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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 Al_2O_3 nanoparticles in the mineral oil as well 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 the mineral oil and Polyoester oil (POE).The physics involved in the interaction of nanoparticles with the base fluid has been elucidated. In the present work. Al_2O_3 (Alumina) Nano powder (1% W/V) was mixed with Polyolester (POE) oil and Mineral oil separately. Experiments are done with R600a as refrigerant and it was found that power consumption was decreasing with Polyolester oil and Mineral 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 Nano particles. The main base fluid can be lubricating oil, water, refrigerant ,etc. the Nano particles are Al, Cuo, Al2O3 ,TiO2, SiO2 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.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.

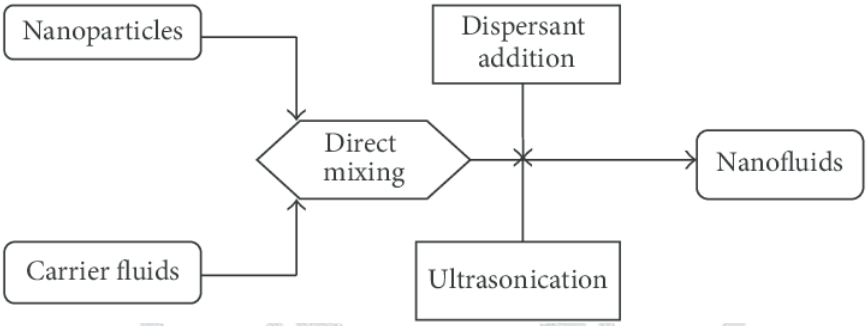


Fig. 1. Readiness of the nano lubricant preparation in two stage technique

The added substance utilized as a part of the mineral oil and POE based ointment wasAl2O3 in the nano molecule shape.. The normal size of the nanoparticles had a scope of 50 TO 200 nm. Al2O3 nanoparticles were readied utilizing ultrasonic tumult for accomplishing great scattering of the particles in the base liquid. The required weight of the Al2O3 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 (°C)	2977
Boiling Point (°C)	2072
Density (Kg/m3)	3987
Specific heat (J/Kg K)	745
Thermal Conductivity (W/m K)	5.43
Molecular Mass (g/mol)	101.96
Specific Surface Area (SSA)(m2/g)	70

Table 1: Properties of Al_2O_3

Fig 2: Al_2O_3 Nano powder

Al_2O_3 nanoparticle**s** are white coloured powder. The average particle size is50–200 nm and 3.9 g/cm^3 density and melting point of 2977^{0}C

Fig 3: POE & Mineral oil before mixing with Al_2O_3

Fig 4.Mixing process of nano particle

Fig 5 : Stirring in ultrasonic vibrator

Fig 6: Nano lubricants of Al_2O_3

III.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 $Al_2 0_3$nano lubricant where base fluid is POE oil.
3. VCR system with R600a as refrigerant and $Al_2 0_3$ nano lubricant where base fluid is mineral oil.

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

IV. RESULTS 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.

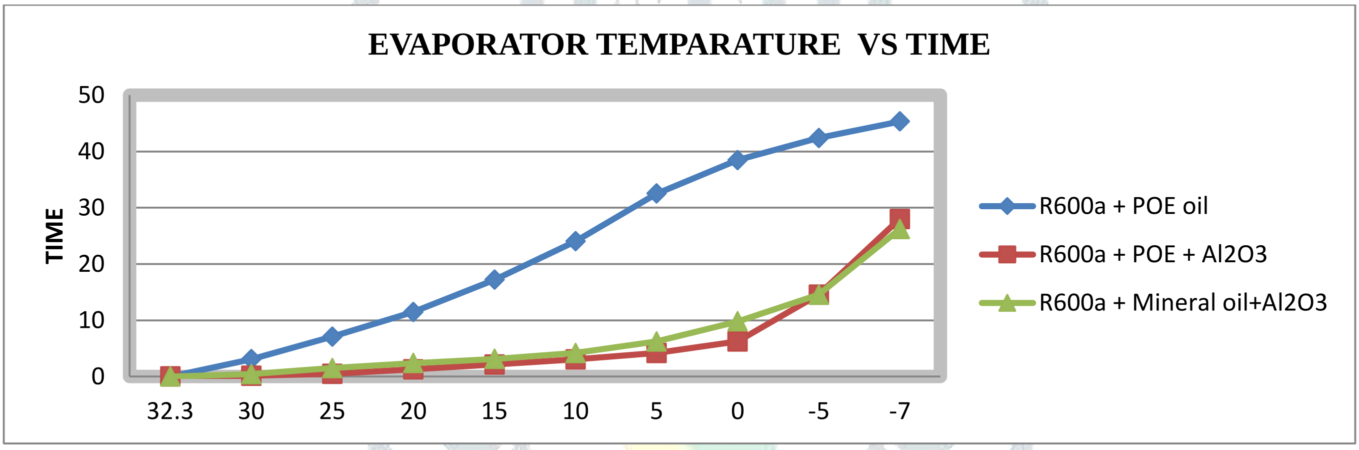


Fig 7: Evaporator temperature vs

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

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

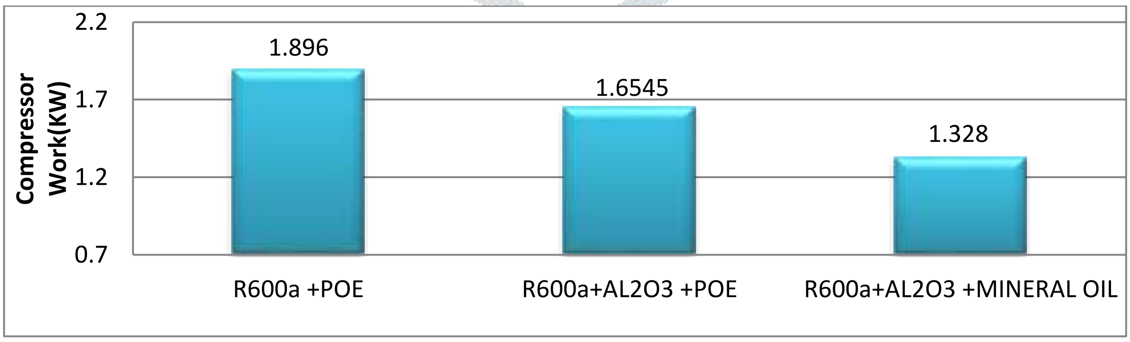


Fig 8: Comparision of compressor work

The Al_2O_3+Mineral Oil increases the heat transfer rate in the compressor. 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:

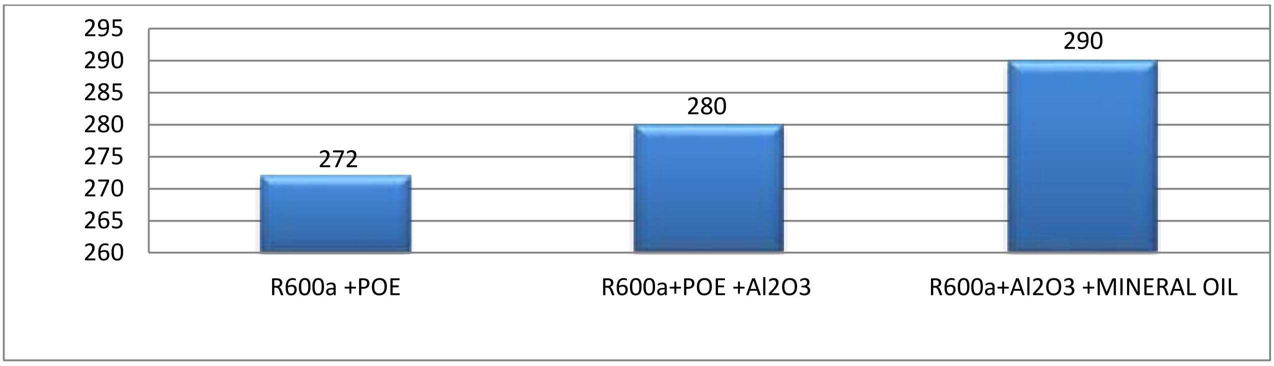
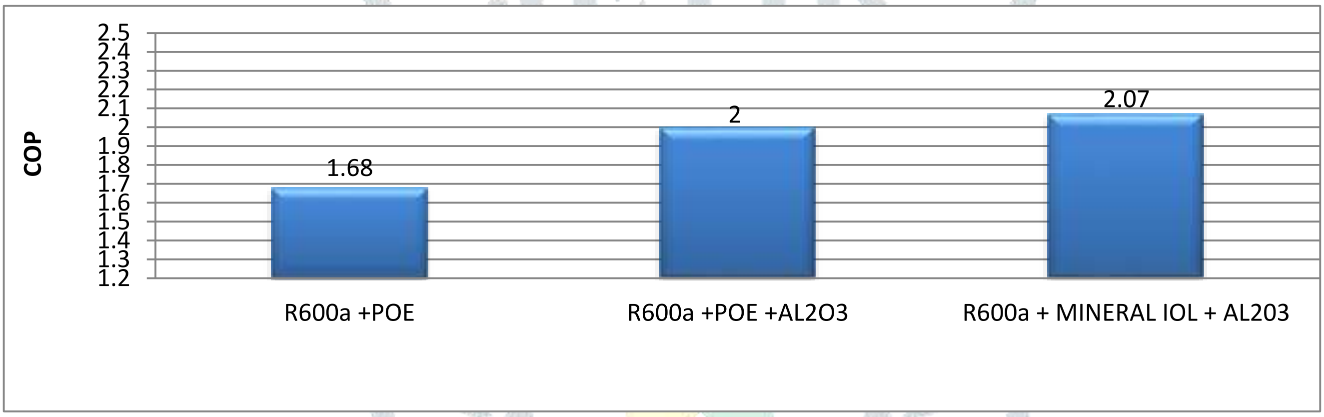


Fig 10: Comparison of Refrigeration Effect

The heat transfer rate in evaporator along with Al_2O_3+Mineral Oil 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 Al_2O_3+Mineral Oil when compared with normal cycle.



iii) Comparision of COP:

Fig 11: Comparison of Coefficient of Performance

The figure 11 shows that the coefficient of performance for R-600a using Al_2O_3+Mineral Oil is higher than the R600a with POE. The coefficient of performance is more with Al_2O_3+Mineral Oil by increasing refrigeration effect. The percentage increase of COP to the normal cycle is 23.21%. The percentage increase of COP for Al_2O_3+POE Oil cycle when compared with normal cycle is 19.04%.

V. 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 1.0% Al_2O_3 nano lubricant with mineral oil as base fluid is better choice over the 1.0% R-600a using Al_2O_3+POE Oil. From experimental investigation it is found that the coefficient of performance is more with Al_2O_3+Mineral Oil by increasing refrigeration effect. The percentage increase of COP to the normal cycle is 23.21%. The percentage increase of COP for Al_2O_3+POE Oil cycle when compared with normal cycle is 19.04%.

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