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"Experiment analysison VCR System with CuO Nanoparticles in POE Lubricant"

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ABSTRACT

Nano lubricants are a special type of fluids which are mixtures of nano particles and lubricants. The addition of nano particles to the lubricant, results in improvement of the thermo physical properties and heat transfer characteristics of the lubricant. Thereby improving the performance of the refrigeration system. R134a is most widely used refrigerant in refrigeration equipment, such as domestic refrigerators and air conditioners. Nano fluids are prepared by suspending nano sized particles (1-100nm) in conventional fluids and have higher thermal conductivity than the base fluid. In present work nano particles of CuO at different proportions (with volume fraction 0.1, 0.2 and 0.3% by mass) are dispersed in POE lubricant and in VCR system for better performance. The COP of vapour compression refrigeration system is improved by increasing the refrigeration effect in terms of cooling load capacity and by reducing work done. Result shows that COP of experimental system is increased by

Keywords: Lubrication, Nano particles, Vapour Compression Refrigeration

1. Introduction

Bi and Shi (2007) [1] studied the energy consumption of a refrigerator using the R134a/TiO_2 mixture as working fluid, experimentally. Results showed that using nanofluids leads to lowering the energy consumption of the system by about 7%.

Bi et al. (2008) [2] researched the domestic refrigerator performance which uses R134a as the working fluid and TiO_2/Al2O_3nanoparticles-addicted mineral oil as the lubricant instead of POE oil, experimentally. Energy consumption of the system with 0.1% mass fraction TiO_2 nanofluid was 26.1% lower than the POE oil state. Al2O_3 addicted nanofluids also showed nearly the same performance. Their results also showed that using the mixture of nanoparticles-mineral oil mixture instead of POE oil will increase system efficiency.

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Jwo et al. (2009) [3] conducted studies on a refrigeration system replacing R-134a refrigerant and polyester lubricant with a hydrocarbon refrigerant and mineral lubricant. The mineral lubricant included added Al_2O_3 nanoparticles to improve the lubrication and heattransfer performance. Their studies show that the 60% R134a and 0.1 wt % Al_2O_3 nanoparticles were optimal. Under these conditions, the power consumption was reduced by about 2.4%, and the coefficient of performance was increased by 4.4%.

Ching-Song Jwo, Lung-Yue Jeng, Tun-Ping Teng, and Ho Chang (2009) [4] studied the Effects of nanolubricant on performance of hydrocarbon refrigerant system The results of the test that was performed for a long period indicated that 10 h after the stable state, adding 0.1 wt % nanoparticles yielded the lowest power consumption in kWh—about 2.4% lower than that using R-134a.

Henderson et al. (2010) [5] conducted an experimental analysis on the flow boiling heat transfer of R134a based nanofluids in a horizontal tube. They found excellent dispersion of CuO nanoparticles with R134a and POE oil and the heat transfer coefficient increases more than 100% over baseline R134a/POE oil results.

Padmanabhan and Palanisamy (2012) [6] intended to increase COP and the energy efficiency of a vaporcompression refrigeration system by using the mixture of refrigerant, TiO2, and lubricant (mineral oil (MO) and Polyolester (POE) oil). They used R134a, R436A, (R290/R600a-56/44-wt.%) and R436B (R290/ R600a52/48-wt.%) as refrigerant. They investigated irreversibility at different processes. The COP of vapor-compression refrigeration systems using R134a/TiO2/MO nanorefrigerant showed a higher COP value when compared to R436A/TiO2/ MO and R436B/TiO2/MO nanorefrigerant. The COPs of vapor compression refrigeration systems using both R436A/POE oil and R436B/POE oil mixtures were higher when paralleling the R134a/POE oil mixture. In addition, it is observed that the energy efficiency of the R134a/TiO2/MO mixture was lower than the R436A/TiO_2/MO and R436B/TiO2/MO/mixtures at lower air temperatures inside the freezer.

Bi et al. (2011) [7] conducted an experimental study on the performance of a domestic refrigerator using TiO2R600a nanorefrigerant as working fluid. They showed that the TiO2-R600a system worked normally and efficiently in the refrigerator and an energy saving of 9.6%.

Sendilkumar and Elansezhian (2012) [8] conducted an experimental study on the performance of a domestic refrigerator using Al_2O_3-R134a nanorefrigerant as working fluid. They found that the Al_2O_3-R134a system performance was better than pure lubricant with

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R134a working fluid with 10.30% less energy used with 0.2%V of the concentration used and also heat transfer coefficient increases with the usage of nano Al_2O_3

Krishna Sabareesh et al (2012) [9] conducted an experimental study on the performance of a domestic refrigerator using TiO_2 - R12 nanorefrigerant as working fluid. They found that the freezing capacity increased and heat transfer coefficient increases by 3.6 %, compression work reduced by 11% and also coefficient of performance increases by 17% due to the addition of nanoparticles in the lubricating oil.

Rejikumar and Sridhar (2013) [10] conducted an experimental study on the performance of a domestic refrigerator using R600a/mineral oil/nano-Al2O3 as working fluid nanorefrigerant as working fluid. They found that the refrigeration system with nano-refrigerant works normally. It is found that the freezing capacity is higher and the power consumption reduces by 11.5 % when the nanolubricant is used instead of conventional POE oil.

Meibo Xing et al. (2014) [11] worked on a fullerene C60 nano-oil & he found that C60 nano-oil is proposed as a promising lubricant to enhance the performance of domestic refrigerator compressors. The stability of fullerene C60 nanoparticles dispersed in a mineral oil and the lubrication properties of the nano-oil were investigated experimentally. The applications of the nano-oil with the specific concentration of 3 g/l to two domestic refrigerator compressors were examined by compressor calorimeter experiments. The results shows the COPs of two compressors were improved by 5.6% and 5.3%, respectively, when the nano-oil was used instead of pure mineral oil.

T. Coumaressin and K. Palaniradja (2014) [12] conducted an experimental study on the Performance Analysis of a Refrigeration System Using Nanofluids. CuO nanoparticles with R134a refrigerant can be used as an excellent refrigerant to improve the heat transfer characteristics in a refrigeration system

2.METHODOLOGY

2.1 Synthesis of nanoparticles by Sol-gel process:

The sol-gel process is a wet-chemical technique (also known as chemical solution deposition) widely used recently in the fields of materials science and ceramic engineering. Such methods are used primarily for the fabrication of materials (typically a metal oxide) starting from a chemical solution (*sol*, short for solution), which acts as the precursor for an integrated network (or *gel*) of either discrete particles or network polymers.

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Typical precursors are metal alkoxides and metal chlorides, which undergo hydrolysis and polycondensation reactions to form either a network "elastic solid" or a colloidal suspension (or dispersion) – a system composed of discrete (often amorphous) sub micrometer particles dispersed to various degrees in a host fluid. Formation of a metal oxide involves connecting the metal centers with oxo (M-O-M) or hydroxo (M-OH-M) bridges, therefore generating metal-oxo or metal- hydroxo polymers in solution. Thus, the sol evolves toward the formation of a gel-like diphasic system containing both a liquid phase and solid phase whose morphologies range from discrete particles to continuous polymer networks.

In the case of the colloid, the volume fraction of particles (or particle density) may be so low that a significant amount of fluid may need to be removed initially for the gel-like properties to be recognized. This can be accomplished in a number of ways. The simplest method is to allow time for sedimentation to occur, and then pour off the remaining liquid Centrifugation can also be used to accelerate the process of phase separation.

Removal of the remaining liquid (solvent) phase requires a drying process, which is typically accompanied by a significant amount of shrinkage and densification. The rate at which the solvent can be removed is ultimately determined by the distribution of porosity in the gel. The ultimate microstructure of the final component will clearly be strongly influenced by changes implemented during this phase of processing. Afterward, a thermal treatment, or firing process, is often necessary in order to favor further poly condensation and enhance mechanical properties and structural stability via final sintering, densification, and grain growth. One of the distinct advantages of using this methodology as opposed to the more traditional processing techniques is that densification is often achieved at a much lower temperature. The precursor sol can be either deposited on a substrate to form a film (e.g., by dip-coating or spin-coating), cast into a suitable container with the desired shape (e.g., to obtain a monolithic ceramics, glasses, fibers, membranes, aerogels), or used to synthesize powders (e.g., microspheres, nanospheres). The sol-gel approach is a cheap and low temperature technique that allows for the fine control of the product's chemical composition. Even small quantities of dopants, such as organic dyes and rare earth metals, can be introduced in the sol and end up uniformly dispersed in the final product. It can be used in ceramics processing and manufacturing as an investment casting material, or as a means of producing very thin films of metal oxides for various purposes. Sol-gel delivered materials have diverse applications in optics, electronics, energy, space,(bio) sensors, medicine (e.g., controlled drug release) and separation (e.g., chromatography) technology.

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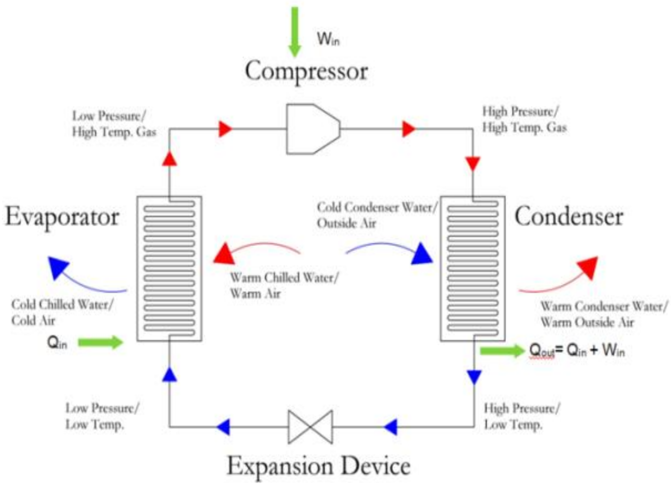
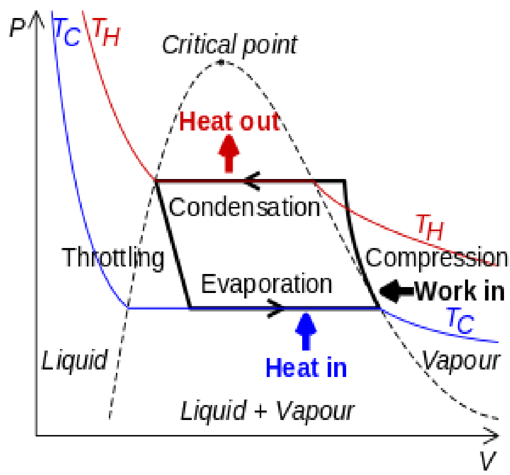
2.2 Dispersion of CuO nanoparticles by probe sonicator

High frequency vibrations are produced by the S.S. Velocity Horn which is immersed into the liquid to be processed. The vibrations give raise to millions to Intense Microscopic Vacuum Bubbles which form & implode at a very high rate (twenty thousand times per second). This phenomenon is known as 'CAVITATION'. Cavitation gives raise to intense Local Pressure Waves & Micro Streaming of liquid round the points of collapse. This in turn produces high shear gradients which are responsible for proper dispersion of nanoparticles.

3.3 Experimental setup

Figure 2.1: Experimental Setup of the refrigeration test rig





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3. Experimental Calculations:

CuO Nanoparticles Concentration in POE lubricant: 0%

Time(min)		Temperatures(^{0}c)					Energy meter(KW)	Pressure(Bar)	Enthalpy(KJ/Kg) From P-H chart			COP		
		T_1	T_2	T_3	T_4	T_5			h_1	h_2	h_3	Actual	Theoretical	Carnot
30	Initial	20.4	55.3	25.5	-28.3	11.2	151.05	4.82	407	437	250	0.891	5.23	5.58
	Final	20.5	58.3	26.1	-28.0	8	151.2	8.95						

Table-3.1: Results of 0% CuO concentration in POE lubricant (wt.%)

Model calculations:

Net Refrigeration Effect = m_r (h_1-h_4) = 4.488(407-250) =704.6 KJ

Work Done = m_r (h_2-h_1) = 4.488(437-407) = 134.64 KJ

$COP_{theoretical} = (h_1-h_4)/(h_2-h_1) = (407-250)/(437-407) = 5.23$

$COP_{carnot} = T_{low} / (T_{high} - T_{low}) = (8 + 273) / (58.3-8) = 5.58$

CuO Nanoparticles Concentration in POE Lubricant: 0.1%

Time(min)		Temperatures(^{0}c)					Energy meter(KW)	Pressure(Bar)	Enthalpy(KJ/Kg) From P-H chart			COP		
		T_1	T_2	T_3	T_4	T_5			h_1	h_2	h_3	Actual	Theore tical	Carnot
30	Initial	21.9	49.5	24.2	-10.3	16.1	151.6	5.5	411	434	252	0.195	6.91	7.6
	Final	22.7	53.1	25.3	-11.6	15.4	151.75	9.6						

Table - 3.2: Results of 0.1% CuO concentration in POE lubricant(wt.%)

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CuO Nanoparticles Concentration in POE Lubricant: 0.2%

Time(min)		Temperatures(^{0}c)					Energy meter(KW)	Pressure(Bar)	Enthalpy(KJ/Kg) From P-H chart			COP		
		T_1	T_2	T_3	T_4	T_5			h_1	h_2	h_3	Actual	Theoretical	Carnot
30	Initial	22.5	49.0	25.6	-31.3	16.5	152.1	5.8	412	433	254	0.292	7.52	8.1
	Final	23.0	51.5	26.1	-31.8	15.8	152.2	9.99						

Table – 3.3: Results of 0.2% CuO concentration in POE lubricant(wt.%)

CuO Nanoparticles Concentration in POE in lubricant: 0.3%

Time(min)		Temperatures(^{0}c)					Energy meter(KW)	Pressure(Bar)	Enthalpy(KJ/Kg) From P-H chart			COP		
		T_1	T_2	T_3	T_4	T_5			h_1	h_2	h_3	Actual	Theoret	Carnot
30	Initial	23.2	48.4	25.8	-9.1	16.4	153.0	6.2	413	433	254	0.25	7.95	8.25
	Final	24.1	51.2	26.0	-10.0	15.8	153.1	10.3						

Table – 3.4: Results of 0.2% CuO concentration in POE lubricant(wt.%)

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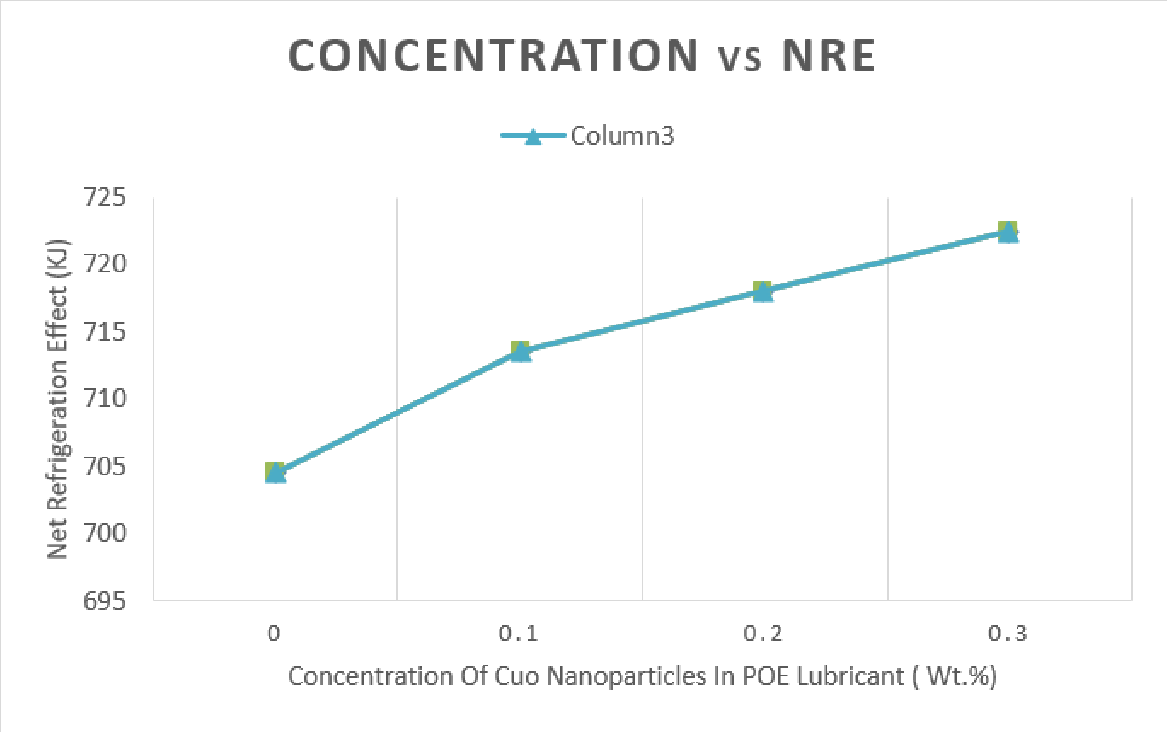

Figure –3.1Graph-1Concentration vs NRE

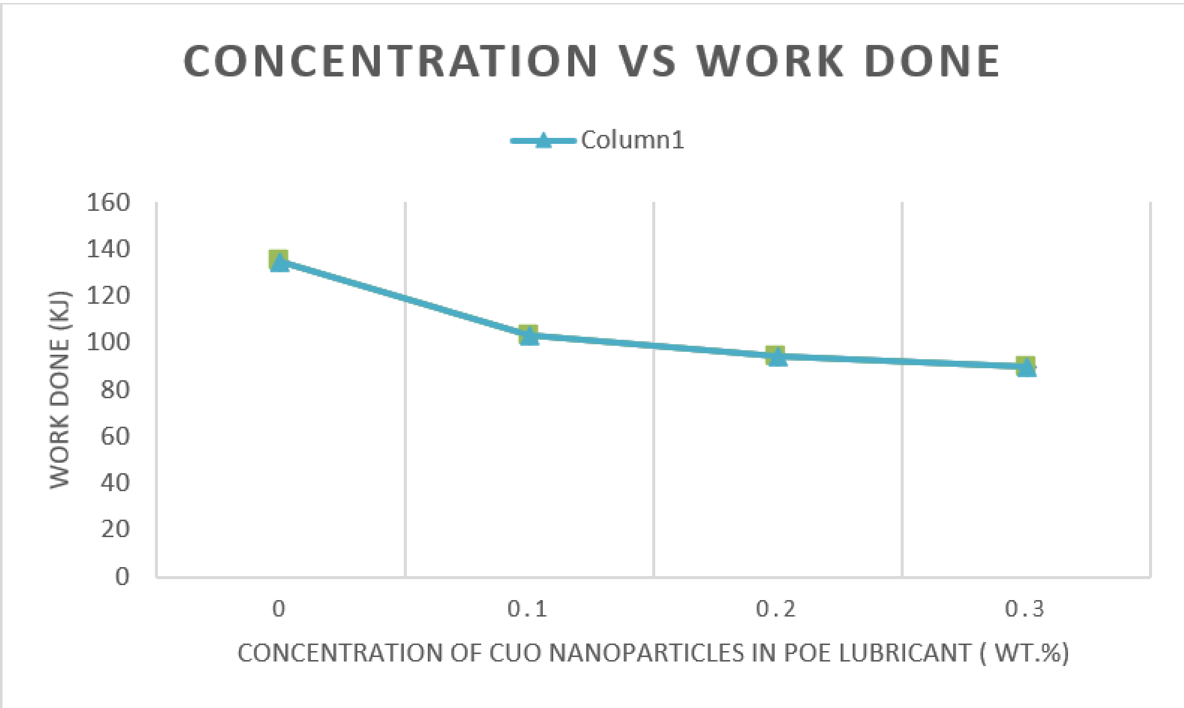

Figure-3.2: Graph-2 Concentration vs work done.

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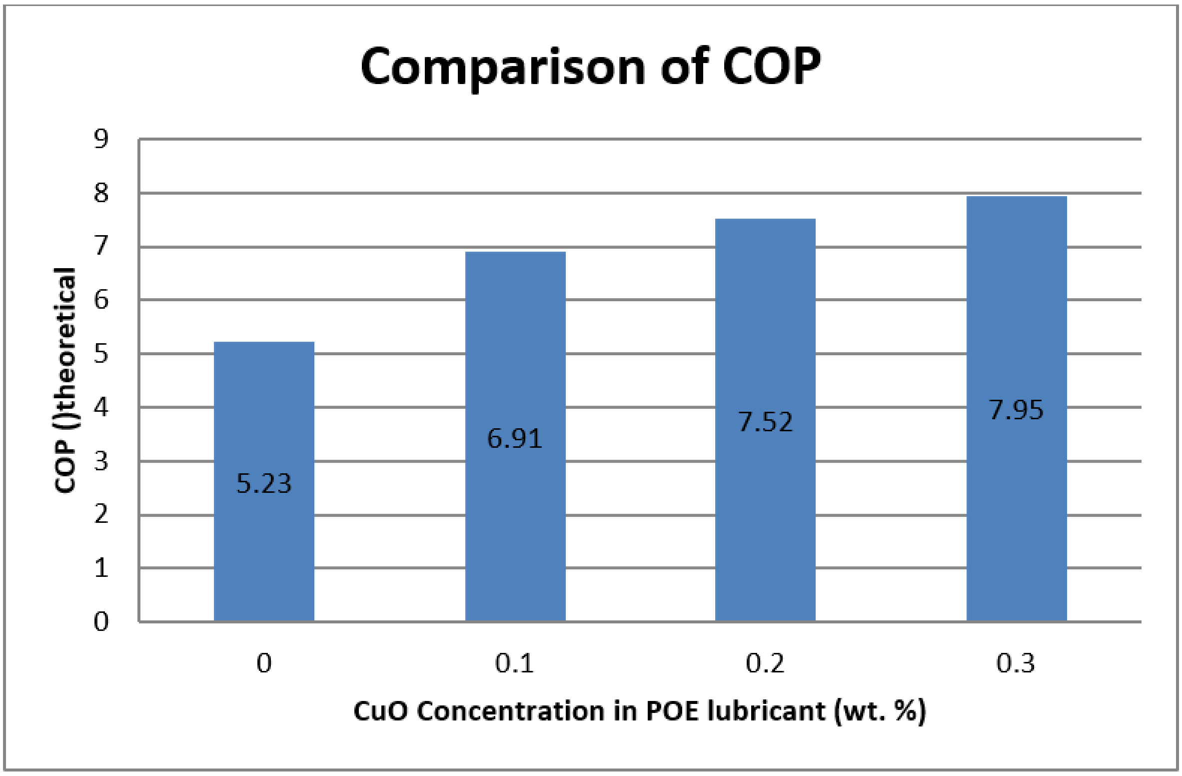

Figure -3.3: Graph-3 Comparison of COP

RESULTS

The following table shows theoretical and Carnot COP‘s at different CuO nanoparticle concentrations in POE lubricant.

S.No	Concentration of CuO Nano particles in POE Lubricant	Theoretical COP	Carnot COP
1	0	5.23	5.58
2	0.1	6.91	7.6
3	0.2	7.52	8.1
4	0.3	7.95	8.25

Table -4.1: Comparison of COP

CONCLUSION

In this experimental study the nano particles of CuO (30-60 nm) are used as additive in lubricating oil. Nanoparticles of CuO are added in the POE lubricant to prepare nano lubricant with volume fraction 0.1, 0.2 and 0.3% by mass. Experimentation results shows that

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COP of experimental system for 0.1 %, 0.2% and 0.3% of nano lubricant are increased by 24.3%, 9.8% and 5.3% respectively.

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