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Performance Study and Characteristic on a Domestic Refrigeration System with Additive of Zirconium Oxide (Zro_2) Nano-Particle as Nano-Lubricant

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Abstract : ***In this work, the ZrO2 nano-oil is proposed as a promising lubricant to enhance the performance of vapour compression refrigerator compressor. The stability of SiO2 nano particles in the oil is investigated experimentally. It was confirmed that the nano particles steadily suspended in the mineral oil at a stationary condition for long period of time. The application of the nano-oil with specific concentrations of 0.1%, 0.2% and 0.3 %(by mass fraction) were added in the compressor oil. 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.c)***

Keywords –Refrigeration, Nano particles, Energy, Performance, Power

I. INTRODUCTION

Impending energy resource crisis is the need for evolving energy efficient thermal systems. Thermal systems like fridges and air-conditioners consumes enormous amount of electric power. It is necessary to find energy efficient fridges and air-conditioners systemswithnatureresponsiverefrigerants.Thefastdevelopments in nanotechnology have clue to evolving of different generation heat transfer fluids named nano-fluids. Nano-fluids are a fairly new class of liquids which contain a base liquid with nano-sized elements (1–100 nm) suspended inside them. These elements, commonly a metal or metal oxide, rise conduction and convection constants, permitting for added heat transfer out of the coolant, providing exceptional instances of nanometer in contrast with millimeter and micrometer to realize evidently as can be seen in Fig. 1.

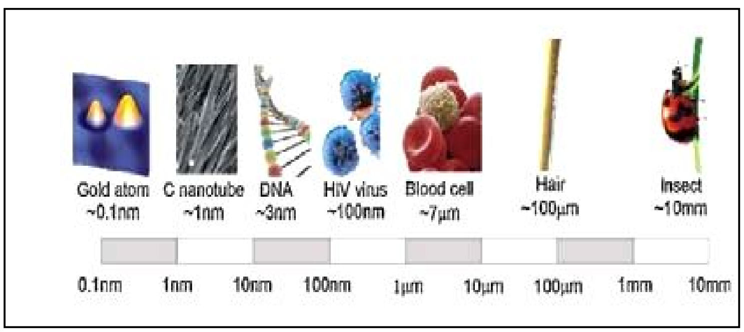

Fig.1 Scale Length

Currently experts used nanoparticles in refrigeration systems since its notable progress in thermo- physical, and heat transfer abilities to improve the efficiency and consistency of refrigeration and air-conditioning system.

II. LITERATURE SURVEY

Many researchers have piloted studies on vapour compression refrigeration systems and to examine the consequence of nanoparticles in the refrigerant and its performance. Pawel et al. steered tests on nano-fluids and noticed that the performance study of a refrigeration system. There is the noteworthy rise in the thermal conductivity of nano-fluid when equated to the base fluid and also noticed the substantial rise in the critical heat flux. Researchers (2-4) piloted studies on a domestic fridge using

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nano-refrigerants. In the study, R134a was utilized as a refrigerant, and a combination of mineral oil TiO_2 was utilized as the lubricant. They noticed that the refrigeration system with the nano-refrigerant functioned usually and efficiently and the energy consumption lessens by 21.2% whenequatedwithR134a/POE oil system.They also pointed out the development in the system performance is owing to improved thermo physical properties of mineral oil and the presence of nano particles in the refrigerant. Henderson et al. showed an experimental study on the flow boiling heat transfer of R134a based nano-fluids in a horizontal tube. They noticed excellent spreading of CuO nano-particle with R134a and POE oil and the heat transfer coefficient rises more than 100% over the baseline R134a/POE oil outcomes.

Bi et al. piloted an investigational study on the performance of a home refrigerator by TiO2- R600a nano-refrigerant and exhibited that the TiO2-R600a system functioned normally and resourcefully in the fridge and an energy saving of 9.6%. Sendilkumar et al. showed an untried study on the performance of a home fridge with Al_2O_3 -R134a nano-refrigerant as working fluid and observedthattheAl2O3-R134asystemperformance wassuperiorthanpurelubricantwithR134aworkingfluidwith 10.30% less energy utilized with 0.2%V of the absorption used and also heat transfer coefficient rises with the practice of nano Al_2O_3. Krishna et al. showed an experimental work on the performance of a home refrigerator by TiO_2 - R12 nano-refrigerant and noticed that the freezing capacity amplified and heat transfer coefficient surges by 3.6 %, compression work condensed by 11% and also coefficient of performance rises by 17% owing to the adding of nano particles in the lubricating oil. Reji et al. directed an investigational study on the performance of a domestic fridgewithR600a/mineral oil/nano-Al_2O_3as working fluid and noticed that the refrigeration system with nano-refrigerant work susually. It is observed that the freezing capacity is high and the power consumptiondecreasesby11.5%whenPOEoilissubstitutedby acombination of mineral oil and Aluminium oxide nano-particles. Meibo et al. run on a fullerene C60 nano-oil & he noticed that C60 nano-oil is projected as a capable lubricant to enrich the performance of home fridge compressors. The steadiness of fullerene C60 nano particles disseminated in a mineral oil and the lubrication possessions of the nano-oil were examined experimentally. The uses of the nano-oil with the exact concentration of 3 g/l to two domestic fridge compressors were tested by compressor calorimeter experiments. The outcomes displays the COPs of two compressorswereenhancedby5.6%and5.3%, correspondingly, when the nano-oil was utilized as an alternative for pure mineral oil.

In the literature survey, a number of assessments on thermal and rheological possessions, dissimilar modes of heat transfer of nano-fluids have been stated by many investigators. Still, to the best of author's facts, there is no complete literature on the nano-particles as additives with conservative refrigerants and oils utilized in refrigeration system.

III. EXPERIMENTAL SETUP

A. Components

The vapour compression refrigeration system experiment consist of a compressor unit, evaporator, condenser, cooling chamber, governing devices and gauging devices those are fixed on a stand and a control panel. Electric control input to the compres sorisspecifiedoverthermostaticswitch.

TABLE I REFRIGERATION SYSTEM SPECIFICATIONS

Capacity	500 watt at rated test condition
Refrigerant	R-134a
Compressor	Hermetically sealed
Condenser fan motor	Induction type
Condenser	Forced convective air cooled
Expansion device	Capillary tube
Drier / filter	Dryall make

B. Instrumentation

The temperatures at dissimilar parts of the investigational setup are measured with resistance thermocouples. Six resistance thermocouples were utilized for the testing. The inlet pressure and outlet pressure at compressor are determined with the aid of pressure gauges. The power consumption of the system was gauged by an energy meter. A digital energy meter is also coupled with the investigational arrangement.

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Fig. 2 Photographic view of experimental set up.

TABLE II MEASUREMENT EQUIPMENT

Refrigerant flow measurement	Rota meter
Pressure indication	Pressure gauges , 2 nos provided
Energy meter	3200 imp/kwh
Heater	1000w
Evaporator for refrigeration test rig	Immersed tube type , direct expansion coil
Temperature indication	Digital led
Insulation for water tank	Puf
Supply	230 volts, 50 Hz, 1 phase , AC.

IV. EXPERIMENTAL PROCEDURE

A. Preparation of nano-Refrigerant

Nano-particles of Zro_2 are supplementary to the refrigeration system by tallying them to the lubricant in the compressor. The ground work and steadiness of this lubricant and nano particle blend is very significant. The lubricant oil, a type usually utilized in cooling and air-conditioning systems was POE oil. This oil is designated owing to its shared procedureandgreaterquality.Ultrasonic vibration is utilized to steady the spreading of the nano-particles. The method of preparation of nano-fluid is as follows:

1) Assess the mass of Zro_2 nano-particles by a numerical electronicweighing scalewithaextentchoiceof10mgto 210 g and extreme error of 0.1 mg;
2) Place Zro_2 nano-particles into the evaluated POE oil and get the Zro_2 /POE oil;
3) Tremble the blend by an ultrasonic processor for 3 hrs and acquire the well spread Zro_2 /POE oil as show in figure 2(a) & (b). No surfactant is additional in this effort as there may be any impact in lessening of thermal conductivity and performance.

B. Nano- RefrigerantConcentration

Nano-particles using 0.1%, 0.2% and 0.3% concentration Zro2 in the POE oil is organized and established in thesetup.

C. Charging of setup

N2 gas at 5 bar to 7 bar pressure is kept for 45 minutes. Thus the system was confirmed for no seepages. A vacuum pump was coupled to the port given in the compressor and the system was totally displaced for the deduction of any layers. This practice was conceded for all the tests. Refrigerant was cautiously added to the system over the service ports. Correctness electronic

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weighing scale with accurateness ±1% was utilized to control a mass of 150 gm. into the system. Every time the system was permitted to calm for 15 min.

V. PERFORMANCE TEST

The system was filled by refrigerant (R 134) and POE oil with dissimilar concentration utilized a charging line devoted to the system. The temperature records were taken constantly, and the readings were booked an interval of 15 min.Itwasconfirmedthatapersistenttemperatureandhumidity overcomes in the neighboring space, when the trial readings were noted. The power ingestion amount of the compressor was measured by stating the time taken by the energy meter for 10 pulses. With these data, the heat transfer rate at evaporator cabin and power consumption rate in the compressor were intended by thestandardterminologiesasfollows.

Work done bycompressor (Wc): $Wc = \frac{3600 \times 10}{EMC \times T}$

Actual Coefficient of performance (C.O.P) ACT:

$(C.O.P)ACT = \frac{\text{Refrigerating effect}}{\text{Work done by compressor}}$

Fig. 3a. Ultrasonic vibrator

Fig. 3b. Before and after mixing of nanoparticles

VI. RESULTS AND DISCUSSION

A. Graph of compressor work done Vs Nanoparticleconcentration

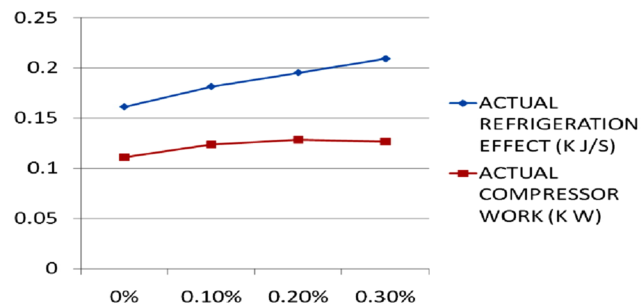


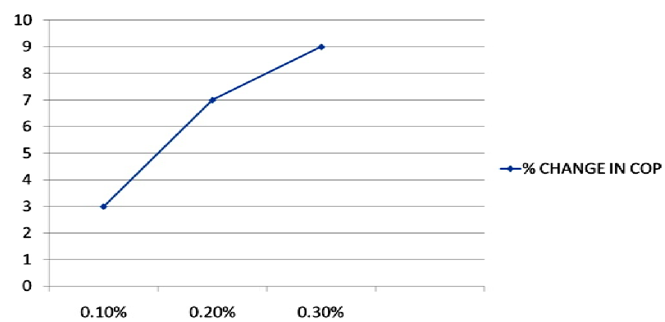
Fig.4. Compressor work done vs. Nanoparticle concentration

From above graph we conclude that as the nanoparticles concentration in POE oil increases, there is decrease in compressor work.Table below shows the all values:

TABLE III COMPRESSOR WORK

Nanoparticles concentration (%)	Compressor work done (kW)
0%	0.484
0.1%	0.45
0.2%	0.4245
0.3%	0.4327

B. Graph of percentage change inCOP



Above graph shows the % increase in COP. Table IV below shows the all values

TABLE IV INCREASE IN COP

Nanoparticles concentration (%)	Increase in COP (%)
0.1%	7.61
0.2%	14.05
0.3%	11.90

VII. CONCLUSION

Based on the studies, it was observed that the thermal conductivities of nano-refrigerants are greater than old-style refrigerants. It was noticed that energy saving can be attained from a lowest value of 7.03% to a higher value of 12.30% with nano-lubricant equatedtoold-stylerefrigerants. Precise mechanism of improved heat transfer for nano-fluids is uncertain as stated by many investigators. Nano-fluids steadiness and its manufacture cost are main factors that delay the commercialization of nano-fluids. By resolving these tasks, it is estimated that nano-fluids can make considerable controlascoolantinheatexchangingdevices.

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