Experimental Investigation of Performance of Domestic Refrigerator Working on R600a With Addition of Tio_2 Nanolubricant

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Abstract— The vapour compression refrigeration test rig compatible to R134a is utilized. In a series of experiments, the environmental friendly refrigerant R600a is used in place of R134a in the identical experimental setup, with no adjustments made to the setup. To create nanolubricating oil, TiO_2 nanoparticles are dispersed by use of ultrasonication and magnetic stirring techniques. COP of system seen to be improved for addition of TiO_2 in oil. Highest COP of the system is noted for the R600a mass charge of 100 grams and the TiO_2 addition in oil is 0.3 g/l, COP is equal to 1.96. COP is seen to be increasing for almost all readings of 0.1g/l, 0.2g/l, and 0.3g/l TiO_2 addition in oil. The mass charge of 90 grams and pure mineral oil showed lowest COP.

I. INTRODUCTION

The energy consumed by Refrigeration systems in houses and businesses is significant. Energy researchers are therefore working to lower the energy consumption of comfort appliances like air conditioners and refrigerators in households. Adding nanofluids to vapour compression systems is one possible way to reduce the excessive energy consumption of refrigeration systems. Numerous experts believe that the addition of nanoparticles to nanolubricant and nanorefrigerant in refrigerators may enhance the appliance's thermal properties. Refrigerants and lubricants containing dispersed nanoparticles are referred to as nanolubricants or nanorefrigerants.

In vapour compression systems (VCRS), natural refrigerants have replaced hydrofluorocarbon (HFC) refrigerants. R600a is one of these because of its zero global warming potential and reduced global warming potential. Due to their high GWP and ODP, CFC refrigerants are no longer permitted for use in residential refrigerators globally. HFC refrigerants are now used instead. Due to its low ODP, R134a and HFC refrigerant were chosen to replace R12 in home refrigerators. R134a's GWP is still very high, though. The Montreal and Kyoto Protocols identified HFC refrigerants as one of the substances that contribute to global warming.

As a result, the United Nations ratified a convention limiting the use of HFCs, phase-out of HFCs by industrialized nations by 2020, and global phase-out of HFCs by 2030. In Europe, the use of HFCs in residential VCRS has currently been fully phased out. Since then, efforts have been made to convert the refrigeration system to using natural refrigerants. Isobutene (R600a), a hydrocarbon refrigerant, is one of the ones that has been embraced. A lot of research has been done to replace and enhance the hydrocarbon refrigerant in VCRS.

Recently, there have been many promising developments with nanofluid uses in home freezers. When dispersed in an appropriate base fluid (such as engine oil, compressor lubricants, ethylene glycol, water, refrigerant, etc.), stable suspensions of nanoparticles are known as nanofluids. These suspensions are guaranteed to be homogenous. Solids with a maximum size range of 1–100 nm are known as nanoparticles, and thermal system efficiency are increased by their small size and huge specific surface areas. When nanoparticles are used in fluids, many base fluids' thermodynamic characteristics are improved, which triggers the start of molecule scale thermophoresis and Brownian motion. Improved fluids known as nanolubricants are created when solid nanoparticles—which have higher thermal conductivities than liquids or gaseous fluids—are combined with one another. In contrast, compressor lubricant oil and nanoparticles combine to form nanolubricant.

II. LITERATURE REVIEW

1) T. O. Babarinde, S. A. Akinlabi, and D. M. Madyira conducted research By adjusting the mass charge of R 600a, the use of R600a with MWCNT Nano lubricant as a drop-in substitute for R134a refrigerant in residential refrigerators. In comparison to R134a, which has a lower evaporator temperature of -11 c, a higher system COP, and a power consumption of 0.0639 kw, the results showed that R600a and MWCNT perform better in terms of COP, Power Consumption, and Cooling Capacity. Therefore, it can be used in place of R134a in residential refrigerators. [1]
2) D. S. Adelkhan et al. had performed experiments on an R134a home refrigeration system under various test settings, including changing the mass charges of R600a refrigerant by 40, 50, 60, and 70 g and the concentrations of TiO2 nanolubricant by 0, 0.2, and 0.4 g/L. The outcomes demonstrated that, under ideal ambient temperature and R600a mass charge settings, the refrigeration system's performance improved at 0.2 and 0.4 g/L concentrations of TiO2 nanolubricant. [2]
3) Md. Imteaz Ahmed and Jamal Uddin Ahmed conducted experimental work using TiO2 nanolubricant. Three different refrigerant blends were utilized in this experiment to compare the thermo-physical performance with R22: Blend 1 (B1) of R32 and R22 (75:25 wt%), Blend 2 (B2) of R32 and R600a (75:25 wt%), and R32 refrigerant.TiO2 nanolubricant with volume concentrations of 0.01% and 0.02% has been utilized. The chosen blends with nanolubricant have higher COP than R22, according to the results. Blends including nanolubricant have also seen a decrease in energy usage. [3]
4) A. Senthilkumar, A. Anderson, and Manigandan Sekar evaluated CuO/Al2O3 hybrid nanolubricants in order to examine the performance of the R600a VCR system. Three different hybrid nanolubricant concentrations (0.2, 0.4, and 0.6 g/L) were considered for this. Researchers have used 70 g of R600a refrigerant for the investigation. When CuO/Al2O3 hybrid nanoparticles were added to compressor lubricating oil, the system's performance increased by 27% from 1.17 to 1.6, its cooling capacity increased by 20% from 160 to 200 W, and its compressor's power consumption decreased by 24% from 158 to 120 W. [4]

III. VCR SET UP INFORMATION

Fig. No.01 VCR Test Rig

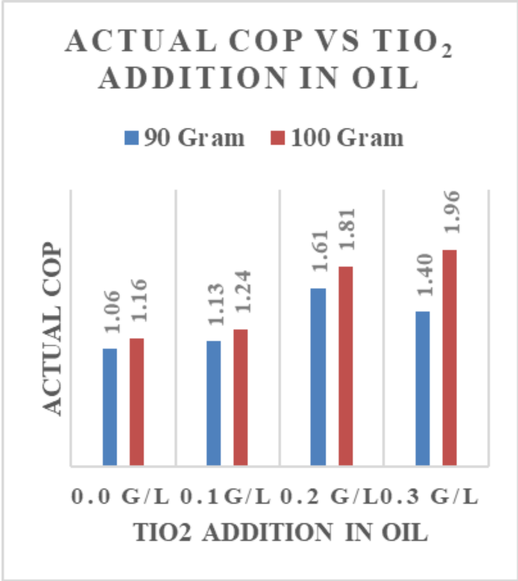
Pressure gauges are fitted at suction & discharge line of compressor to measure suction & discharge pressure. Thermocouples are fitted at condenser inlet & Outlet, evaporator inlet & outlet for measurement of temperature of refrigerant. Two Energy meter is provided to measure energy consumption by compressor & water heater. High Pressure & Low pressure cut out is provided for safety purpose. Accumulator is installed after evaporator to separate liquid & vapour refrigerant. Refrigerant charging set up is made available. Also compressor mineral oil replacing facility is made available. Hermetically sealed compressor is required to remove from set up by cutting suction &discharge lines. After oil change suction & discharge lines are brazed to system. Ultrasonicator & magnetic stirrer is made available to make nanolubricant. Evaporator is placed at backside to cool water. Hermatically sealed compressor is used. Fan based fin & tube type condenser is used. Copper tube type of expansion device is used in set up.

IV. EXPERIMENTAL PROCEDURES

Vapour Compression Refrigeration System is recovered by R134a gas and the test rig's suction and discharge lines are broken in order to recover the POE oil that was previously in the compressor. The compressor is tilted, the POE oil is taken out and placed in a different container, and then the compressor is reconnected to the VCR system. Subsequently, the system was evacuated using a vacuum pump to eliminate any trace amounts of moisture, air, and oil found within the VCR system. First set of reading pure lubricating oil is obtained by manually adding 250 cc of pure mineral oil to the compressor. Next, a digital weighing machine weighs the R600a refrigerant, and a mass charge of 90 grams is taken for the first set of readings. The required charging hose pipes and valves are used to charge the gas. For completing the upcoming reading assignments Different mass charges of R600a—100, obtained by accurately measuring and weighing the VCR system's performance.

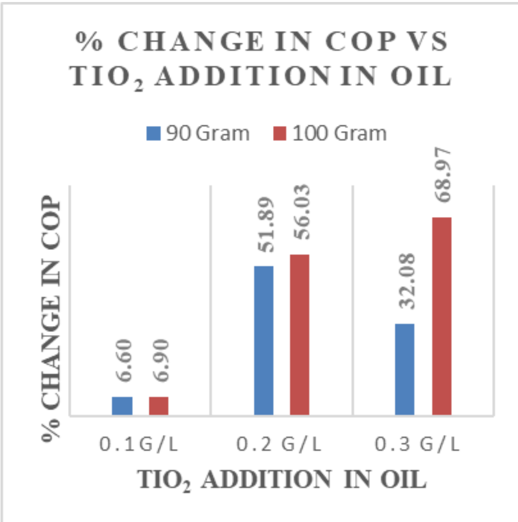
by employing a balance for weighing. The mass of the nanopowder is accurately measured, with 0.025, 0.050, and 0.075 grams taken for each set of readings. 250 ml of 0.025 gram (0.1 g/l) mineral oil is combined with nanopowder to create lubricating oil. Using a magnetic stirrer and ultrasonicator, a homogenized mixture is created along with the nanolubricant. Additionally, a vacuum pump is attached to the VCR test setup to eliminate air and oil from the system. Manual addition of nano lubricating oil is done in the compressor. The VCR test rig is then connected to the compressor's suction and discharge lines. A 90-gram mass charge is applied to the VCR system after the R600a gas is measured with an accurate weighing balance. The VCR system obtains a reading and computes the COP once it has reached a stable position. Next, different sets of measurements are obtained by altering the mass charge of R600a by 100. To acquire the subsequent set of measurements, the R600a's mass charge and compressor are removed from the VCR system. Tilting the compressor allows for the extraction of compressor oil. The previously mentioned traditional approaches are used to make nanolubrication. Currently, 0.2 and 0.3 g/l of TiO2 are added to mineral oil twice through the same process. Additionally, a vacuum pump is utilized to remove any air from the VCR system prior to reading

V. RESULTS & DISCUSSION



Graph No.01 % COP Change Vs Mass Charge

In comparison to pure lubricating oil, the addition of TIO_2 to lubricating oil improved the VCR system's COP for mass charges of 90 gram & 100 gram and for all compositions of TiO2 in lubricating oil (Mineral Oil) When 0.3 g/l of TiO2 Nanopowder is added to oil with a 100 gram mass charge of refrigerant, the system's COP is higher for taken sets of readings. when compared to all other mass charges and TiO2 additions in oil. The COP of 90 grams of mass charge with pure lubricating oil is 1.06, the lowest of all the readings. According to the above sets of readings, the VCR system's COP rises as the mass charge of refrigerant increased from 90 gram to 110 gram.



Graph No. 02 % Change in COP Vs TiO_2 Addition in Oil

TiO_2 addition tends to increase COP. For 0.1 g/l of TiO_2 addition in oil increased COP by 6.60 % for 90 gram mass charge & by 6.90 % for 100 gram. For 0.2 g/l of TiO_2 addition increased COP by 51.89 % & 56.03 % for 90 gram & 100 gram respectively. For 0.3 g/l of TiO_2 addition shows that increment in COP by 32.08 % & 68.97 % for 90 gram & 100 gram respectively.

CONCLUSION

Without altering the test rig that was previously used with R134a refrigerant, an experimental examination on a vapour compression refrigeration test rig was conducted for this study. On the test apparatus, mass charge of 90 gram & 100 Gram of refrigerant R600a were tested. Mineral oil is combined with TiO_2 nanoparticles in amounts of 0.1 g/l, 0.2 g/l, and 0.3 g/l respectively. These findings were drawn for R600a refrigerant with TiO_2 mixed nanolubricant based on experimental findings and the operation of a home refrigerator test rig.

1) Without requiring any changes to the VCR test rig, R600a refrigerant can be simply and safely substituted in vapour compression refrigeration test rigs operating on R134a. Mineral oil should be used in place of POE oil.
2) The COP of the VCR system tends to grow with the addition of TiO_2 to lubricating mineral oil for almost all readings. For given sets of readings Highest COP of the system is noted for the R600a mass charge of 100 grams and the TiO_2 addition in oil is with 0.3 g/l, COP is 1.96. This COP value is 68.97% greater than without TiO_2 addition in oil.
3) Lowest change of COP is observed at reading of 90 Gram of mass charge & no any addition of nanolubricant in oil. Cop is equal to 1.06.

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