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# PERFORMANCE ANALYSIS OF A VCR SYSTEM USING R600A DOPED WITH NANO – LUBRICANTS

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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 (WC) can be achieved by a suitable technique, for a specified heat removal rate. The present study is to be investigated on the effect of dispersing a low concentration of AL2O3 & TiO2 hybrid nano particles in Polyolester (POE) oil as base fluid and the effects of hybrid 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 Polyolesteroil (POE). In the present work, AL2O3 & TiO2 Nano powder (0.5% w/v), (0.75% w/v) and (1% 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 Polyoester oil lubricants when compared with normal cycle this is due to effective lubrication and thermophysical characteristics of nano lubricant.

## 1.INTRODUCTION

"Refrigeration is the science of providing and maintaining temperature below that of surrounding (ambient) temperature". The term 'maintain' implies, the continuous extraction or removal of heat from a body which is already at lower temperature than its surroundings. Removal of heat from a body at lower temperature is possible only with the aid of external agency according to the Second Law of Thermodynamics.

## 2.LITERATURE REVIEW

**Binit Kumar Jha, et.al. [1]** Conducted an experimental investigation to compare the COP of VCR system using various refrigerants like R134a and R600a under condition -5$^0$C evaporator temperature. The results showed that the alternative refrigerant investigated in the analysis R600a has higher coefficient of performance. Refrigerant property parameters shows that R600a has minimum leakage, minimum global warming potential and low power consumption when compared with R134a.The refrigerator worked efficiently when R600a refrigerant was used as refrigerant instead of R134a. At every mode R600a refrigerant yields higher COP than R134a, As well as the freezing temperature was lower than that of R134a.

**Mohd. Asim, Nazeer Ahmad, [2]** investigated an experimental study of isobutene (R-600a), an environment friendly refrigerant with zero ozone depletion potential (ODP) and very low global warming potential (GWP), to replace R-134a in domestic refrigerators. A refrigerator designed to work with R-134a was tested, and its performance using R-600a was evaluated and compared its performance with R-134a. The average COP using R-600a was 27% higher than R-134a respectively. The power consumption was reduced by 3.7% with R-600a refrigerant. The compressor ON time ratio was lowered by 6.98% with R-600a compared with R-134a. The experimental results showed that R-600a can be used as replacement for R-134a in domestic refrigerator. Hence, it can be concluded that R-600a can be used as a replacement to R-134a with better performance lesser energy consumption, pull down time and ON time ratio.

**M.A. Sattaret, [3]** Investigated and compared the performance of the refrigerator using R600a, R600 and a

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ternary mixture of R290/R600a/R600 as refrigerants with theR134a. The effects of evaporator and condenser temperatures on COP, refrigerating effect, compressor power and heat rejection ratio were investigated. The results show that the compressor consumed 3% and2% less energy than that of R134a at 28°C ambient temperature whenR600a and R600 was used as refrigerants respectively. The COP and other results obtained from the experiments show a positive indication of using HC as refrigerants in a domestic refrigerator.

**S. Saboor, G. Kiran Kumar. [4]** Developed a new cycle with nozzle at evaporator inlet in VCR system using R134a as a refrigerant to enhance the performance of the cycle. Results obtained and showed that there was increase of 5.12% in coefficient of performance of the new

## 3.EXPERIMENTAL SETUP & METHODOLOGY

### 3.1 DESCRIPTION OF EXPERIMENTAL SET UP:

The experimental set up consists of a domestic refrigerator of 220 litres capacity, designed to work with R-600a refrigerant and having main components.


**Fig 3.1 experimental refrigerator**

**Domestic Refrigerator specifications:**

| Component | Parameter | Specification |
|---|---|---|
| **Refrigerant** | Type | R600a (Isobutane) |
| **Refrigerator** | Storage | 220 Liters |
| **Capacity** | Volume | |
| **Compressor** | Capacity | 0.14 HP |
| **Condenser** | Length | 9.35 m |
| | Tube Diameter | 6.35 mm |
| **Capillary Tube** | Length | 2.355 m |
| | Diameter | 0.925 mm |
| **Evaporator** | Length | 7.75 m |
| | Tube Diameter | 6.35 mm |

COMPONENTS USED IN THE EXPERIMENT:

The major components used in experiment are as follows.

1) Reciprocating Compressor
2) Air Cooled Condenser
3) Filter
6) Expansion device (capillary tube) and
7) Evaporator

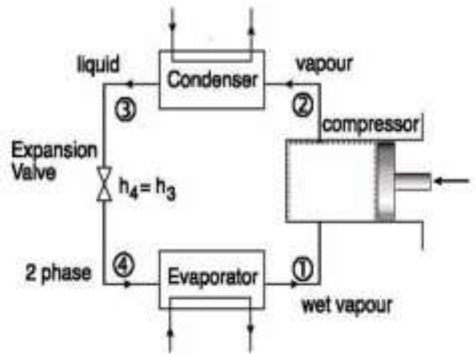



Fig 3.2.1 Line Diagram for experimental refrigerator

**1) Reciprocating Compressor:**

- The refrigerator compressor is both a motor and a pump that move the refrigerant through the system. Temperature sensors signal the compressor to start when the temperature inside the refrigerator rises above its set point.

- As the compressor starts, it sucks the low temperature and low-pressure gas refrigerant from the evaporator. Refrigerators are used the refrigerants like, low boiling temperature refrigerant which is going to convert gas form easily at low temperatures from liquid form. The compressor then puts pressure on the gas compressing it. As the gas is compressed, its temperature rises sharply.
- The compressor pushed out the hot, compressed gas through the outside metal coils (tubes) on the back or bottom of the refrigerator. These coils are made to dissipate heat into the surrounding air. Because it is under pressure, the gas

changes Into liquid and cools.

- The liquid gas continues to flow through the system until it reaches the expansion valve. The expansion valve forces the liquid through a very small hole, having high friction turning it into a very cold mist, which evaporates as it moves through the freezer coils.

**Fig 3.2.2 R600a Compressor**

1) **Condenser:**

Fig. 3.2.3 Condenser

Fig. 3.2.4 Filter

2) **Filter:**

Fig. 3.2.5 Capillary Tube

Fig. 3.2.6 Evaporator

**a) Discharge (or) High Pressure Gauges:** As the name suggests, this gauge is employed on the high-pressure side of the vapour compression system. It is equipped with dial for measuring pressures from 0 to 3.5MPa.

**Fig. 3.3.1** Suction and Discharge pressure gauges

**1.1.1 Thermocouples:**

Temperature Indicators are used for measuring the temperature of the refrigerant. In the present experimental work, five Temperature indicators are used. Digital temperature indicators are used to find temperatures

- At inlet of compressor
- At outlet of compressor
- At Exist of condenser
- At exit of expansion valve and exit nozzle
- In freezer box

Fig. 3.3.2 Thermo couples

**Tube Cutter:**

The copper tubing to be used in refrigeration and air-conditioning system may be cut in two ways:

1) By a tube cutter
2) By a hacksaw

Normally the smaller machines utilize soft copper tubing, this tubing can easily be installed because it can be bent around obstructions and elimination of many elbows is possible. While cutting soft copper tubing an easy and quick method is to apply a tube cutter. The tube to be cut is held in between the “Roller” and “Cutter wheel” and a high pressure is put on the lead screw. Revolve the cutter slowly around the tubing so that the sharp cutting wheel feeds gradually into the tubing, making a clean right angle cut. Hard copper tubing can be cut by a hacksaw when it is held in the flaring block.

Fig. 3.3.3 Tube cutter

Fig. 3.3.4 Flaring tools

**3.4 Flaring tool:**

A flaring tool consists of two bars held together by a wing nut and bolt; the bars are provided with holes for various sizes of tubing. A yoke containing the forming die is slipped on the bars and the handle is rotated to produce a flare. This tool finds a wide use because of its simplicity, ease of performing **the flaring operation.**

Fig. 3.3.5 Magnetic Stirrer

Fig. 3.3.6 Ultrasonic Vibrator

**Magnetic stirrer and Ultrasonic vibrator:**

Magnetic stirrer is used to disperse the nanoparticles in lubricant and ultrasonic vibrator is used to uniformly distribute the nanoparticles in the lubricant.

**REFRIGERANT USED IN THE EXPERIMENT:**

R600a is used as refrigerant in the present experiment setup with following properties as shown in table 3.4.1

**R-600a (isobutene): Table 3.4.1** Properties of R600a

| REFRIGERANT | R600a |
|---|---|
| Name | Isobutane |
| Formula | $(CH_3)_3CH$ |
| Critical temperature in $^0$C | 135 |
| Molecular weight in kg/kmol | 58.1 |
| Normal boiling point in $^0$C | -11.6 |
| Pressure at -25 $^0$C in bar (absolute) | 0.58 |
| Vapour density at $t_0$-25/+32 $^0$C in kg/m$^3$ | 1.3 |
| Volumetric capacity at -25/55/32 $^0$C in kJ/ | 373 |
| Enthalpy of vaporization at -25 $^0$C in kJ/kg | 376 |

**a) Merits of R600a:**

- Zero ozone depletion potential.
- Negligible Global Warming Potential.
- Hydro carbon mixture possesses nontoxic risk.
- Hydro carbon mixtures are much lighter and can extend component life significantly..
- Totally compatible with all known equipment and oils used in refrigeration.
- No negative reaction to moisture in the system.

**b) Demerits of R600a:**

- Flammable.

**$TiO_2$ & $Al_2O_3$ Nano Particles mixed with POE oil:**

Conventional thermo fluids are responsible for poor thermal conductivity. So improving its thermal conductivity will enhance the heat transfer characteristics of the conventional fluid. As we know that metal particles have larger thermal conductivity than the base fluid, so suspension of the metal particles in the base fluid is expected to enhance the thermal conductivity. Researchers have developed a new standard fluid called the nanofluid which has got high surface area which prevents the particles being clogged. So we have replaced the conventional fluid with the nanofluid which is made by the use of nanotechnology, engineered to possess unique thermal properties which can improve the heat transfer and is energy efficient is thermal systems.

Fig. 3.4.1

Fig. 3.4.2(a)

Fig. 3.4.2(b)

In this study $TiO_2$ & $Al_2O_3$ Nano Particles mixed with POE oil is used as lubrication in order to increase the heat transfer rate at all the components of refrigerator. The POE oil lubricant was replaced with the nano-lubricant in the compressor. This mixture gives better heat transfer properties over POE oil lubrication.

**a) Properties of POE oil:**

Properties of POE oil is used in this experiment a as shown in table 3.4.2

**Table 3.4.2** Properties of POE oil

| | |
|---|---|
| Viscosity | 32 $m^2$/sec |
| Flash point | 258 $^0$C |
| Pour point | -46 $^0$C |
| Miscibility temperature | -42.2 $^0$C |
| Density | 0.977 g/ml |
| Acid value | <0.05 |

**Table 3.4.3 Properties of $Al_2O_3$ & $TiO_2$ Nano Particles**

| Property | $TiO_2$ | $AL_2O_3$ |
|---|---|---|
| Density (g/cm$^3$) | 4.23 | 3.6 |
| Crystalline structure | Tetragonal | FCC |
| Appearance | White Solid | White Solid |
| Young's Modulus (Gpa) | 244 | 380 |
| Average Size | 50 | 50 |
| Melting Point $^0$C | 1870 | 2054 |
| Thermal Conductivity(W/m$^0$K | 8 | 29 |

**Preparation of the $TiO_2$ and POE oil nano-fluid:**

A two-step method of nanofluid preparation is used in this study. The first step involves in the drying, storage, and transportation of nanoparticles into a conical flask. $SiO_2$ with step the nanoparticles $SiO_2$ are directly mixed in the base fluid POE oil and thoroughly stirred with a hot plate stirrer to become POE- $SiO_2$ nano-lubricant, followed by ultrasonic homogenization for about 3-4 hours. Frequent use of ultra-sonication or stirring is required to reduce particle agglomeration. Sedimentation was conducted after the homogenization process in order to check the stability of the POE- $TiO_2$ nano-lubricant. The preparation process is as shown in figure3.4.3

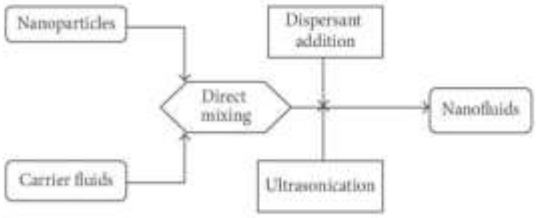



**Fig.3.4.3** Two-step preparation method

**Preparation of $TiO_2$ and $Al_2O_3$ nano particles mixture with POE oil using digital balance and Magnetic stirrer**.

**Preparation of $TiO_2$ and $Al_2O_3$ nano particles mixture**

**POE Samples of $TiO_2$ and $Al_2O_3$ nano particles mixture with oil using**

**REFRIGERANT CHARGING:**

After the evacuation, various leakage tests like nitrogen and bubble tests and water submersion methods are done to confirm no leakage in the system. Then 400ml of nano-fluid is inserted to the compressor through the service port and allowed to stabilize for 15-20 minutes. After that vacuum is created, 20gms of R600a is charged into the system. The amount of refrigeration effect produced is very less. After that 40gms of R600a is charged, the amount of refrigeration effect produced is less. After that 60gms of R600a is charged, the amount of refrigeration effect is very good. After that 70gms of R600a is charged, the amount of refrigeration effect produced is decreased. So 60gms of R600a is charged in the refrigeration.

**Fig 3.5.1 Charging of Refrigerant R600a**

**3.6 EXPERIMENTAL PROCEDURE:**

The following procedure is adopted for experimental setup of the vapour compression refrigeration system.

1. The domestic refrigerator is selected, working on vapour compression refrigeration system.
2. Pressure gauges and thermocouples are installed at each entry and exit of the components.
3. First a amount of 60gm R134a refrigerant is charged in to the vapor pressure refrigeration system
4. Leakage test is done by using soap solution, and conformed that there are no leakages.
5. Temperature and pressure readings are taken for each $5^0$C fall in evaporator temperature by using thermocouples and pressure gauges respectively at each section of the normal cycle
6. Then an amount of 60gm R600a refrigerant is charged in to the vapor pressure refrigeration system
7. Leakage test is done by using soap solution, and conformed that there are no leakages.
8. Temperature and pressure readings are taken for each $5^0$C fall in evaporator temperature by using thermocouples and pressure gauges respectively at each section of the normal cycle
9. Then the refrigerant is discharged out and nano-fluid oil charged in to the compressor through service port which is used as lubricating oil. And then charged again with the same refrigerant R600a.
10. Again conducted the same test for remaining two nano-fluids and taken all temperature and pressure gauge readings at every section.
11. Finally after taking all the values and observations

then investigate the performance analysis in each case of the experiment.

**Table 3.7 COST ESTIMATION:**

| | |
|---|---|
| **Refrigerator** | Rs.6,000 |
| Thermocouples | Rs.1800 |
| POE oil | Rs.1400 |
| $TiO_2$ and $Al_2O_3$ Powder | Rs.2,400 |
| Fabrication Work | Rs.3,500 |
| **Estimated Budget** | **Rs.15100** |

## 4.EXPERIMENTAL OBSERVATIONS

Performance Calculations Test For R600a Using $Al_2O_3$ & $TiO_2$ (0.5% W/V) Nanolubricant With Poe Oil:

Table 4.3 Observations for R600a with $Al_2O_3$ & $TiO_2$ (0.5 %w/v) nano lubricant in POE oil

| S. No | Pressure (bar) | | Temperature (T °C) | | | | Time (Minutes) |
|---|---|---|---|---|---|---|---|
| | $P_1$ | $P_2$ | $T_1$ | $T_2$ | $T_3$ | $T_4$ | |
| 1 | 2.041 | 2.241 | 33 | 30.6 | 29.5 | 33 | 0 |
| 2 | 1.99 | 2.17 | 30.5 | 30.5 | 29.6 | 28 | 1 |
| 3 | 1.9 | 2.08 | 30.2 | 30.2 | 29.7 | 23 | 2.1 |
| 4 | 1.78 | 2.06 | 38 | 38 | 31 | 18 | 8.5 |
| 5 | 1.74 | 2.05 | 39.5 | 39.5 | 31.2 | 13 | 10.2 |
| 6 | 1.6 | 2.04 | 40 | 40 | 31.5 | 8 | 11.8 |
| 7 | 1.46 | 2.02 | 40.3 | 40.3 | 31.6 | 3 | 13.5 |
| 8 | 1.42 | 2 | 40.6 | 40.6 | 31.8 | 0 | 14.8 |
| 9 | 1.2 | 2 | 40.4 | 40.4 | 32 | -5 | 16.5 |
| 10 | 1 | 2 | 40.8 | 40.8 | 31.8 | -10 | 23.5 |

**Temperatures:**

| | | | |
|---|---|---|---|
| Compressor suction temperature | T1 | = | 40.8° C |
| Compressor discharge temperature | T2 | = | 40.8° C |
| Condenser temperature | T3 | = | 31.8° C |
| Evaporator temperature | T4 | = | -10°C |

**Enthalpies**:

From pressure-enthalpy chart for R-600a using **$AL_2O_3$ & $TiO_2$** (0.5 w/v) nanoparticles in POE oil , enthalpy values at state points 1,2,3,4.

| | | | |
|---|---|---|---|
| Enthalpy at point | h1 | = | 408 kJ/kg |
| Enthalpy at point | h2 | = | 440 kJ/kg |
| Enthalpy at point | h3 | = | 253 kJ/kg |
| Enthalpy at point | h4 | = | 253 kJ/kg |

**Calculation Performance Parameters**

1. Net Refrigerating Effect (NRE) = h1-h4
= 408-253
= 155kJ/kg
2. Mass flow rate to obtain one TR, kg/min. mf = 210/NRE = 210/155 = 1.35 kg/min.
3. Work of Compression $W_C$= h2-h1 = 440-408
4. Heat Equivalent of work of compression per TR mfx (h2-h1) = 1.35*32 =43.2 kJ/min
5. Theoretical power of compressor $T_C$ = 43.2/60 = 0.72 kW
6. Coefficient of Performance (COP) = h1-h4 / h2-h1 = 155/32 = 4.25
7. Heat to be rejected in condenser $H_C$ = h2-h3 = 440-253

### 3.2 PERFORMANCE CALCULATIONS TEST FOR R600a USING $AL_2O_3$ & $TiO_2$ (0.75 % w/v) NANO LUBRICANT WITH POE OIL:

**Table 4.4 Observations for R600a with $Al_2O_3$ & $TiO_2$(0.75 %w/v) nano lubricant in POE oil**

| S. No | Pressure (bar) | | Temperature (T °C) | | | | Time (Minutes) |
|---|---|---|---|---|---|---|---|
| | $P_1$ | $P_2$ | $T_1$ | $T_2$ | $T_3$ | $T_4$ | |
| 1 | 2.041 | 2.241 | 33 | 30.6 | 29.5 | 33 | 0 |
| 2 | 1.98 | 2.16 | 30.2 | 30.2 | 29.4 | 27 | 0.8 |
| 3 | 1.88 | 2.06 | 29.8 | 29.8 | 29.5 | 21 | 1.8 |
| 4 | 1.74 | 2.04 | 37.5 | 37.5 | 30.8 | 16 | 7.2 |
| 5 | 1.7 | 2.03 | 39 | 39 | 31 | 11 | 8.8 |
| 6 | 1.55 | 2.02 | 39.5 | 39.5 | 31.3 | 6 | 10 |
| 7 | 1.42 | 2.01 | 39.8 | 39.8 | 31.4 | 2 | 11.5 |
| 8 | 1.38 | 2 | 40 | 40 | 31.6 | 0 | 12.8 |
| 9 | 1.15 | 2 | 39.8 | 39.8 | 31.8 | -5 | 14.2 |
| 10 | 0.95 | 2 | 40.2 | 40.2 | 31.5 | -10 | 20.5 |

**Temperatures:**

| | | | |
|---|---|---|---|
| Compressor suction temperature | T1 | = | 40.2°C |
| Compressor discharge temperature | T2 | = | 40.2°C |
| Condenser temperature | T3 | = | $31.5^O$ |

| | | | |
|---|---|---|---|
| | | | C |
| Evaporator temperature | T4 | = | -10°C |

**Pressures:**

| | | | |
|---|---|---|---|
| Compressor suction pressure | P1 | = | 0.950 bar |
| Compressor discharge pressure | P2 | = | 2.000 bar |
| Condenser pressure | P3 | = | 2.000 bar |
| Evaporator pressure | P4 | = | 0.950 bar |

**Graph 4.4 p-h diagram of R600a using $AL_2O_3$ & $TiO_2$( 0.75 %w/v) nano lubrication with POE**

**Enthalpies:**

From pressure-enthalpy chart for R-600a using $AL_2O_3$ & $TiO_2$( 0.75 %w/v) nanoparticles in POE oil , enthalpy values at state points 1,2,3,4. Enthalpy at point $h_1$ = 404 kJ/kg

Enthalpy at point $h_2$ = 438 kJ/kg

Enthalpy at point $h_3$ = 252 kJ/kg

Enthalpy at point $h_4$ = 252 kJ/kg

**Calculation Performance Parameters:**

1. Net Refrigerating Effect (NRE) = $h_1$-$h_4$ = 404-252 = 152 kJ/kg
2. Mass flow rate to obtain one TR, kg/min.$m_f$ = 210/NRE = 210/152 =1.38 kg/min.
3. Work of Compression $W_C$ = $h_2$-$h_1$ = 438-404 = 34 kJ/kg
4. Heat Equivalent of work of compression per TR, $m_f$x($h_2$-$h_1$) = 1.38*34 =46.92kJ/kg
5. Theoretical power of compressor $T_C$ = 46.92/60 = 0.782 kW
6. Coefficient of Performance (COP) = $h_1$-$h_4$ / $h_2$-$h_1$ = 152/34 = 4.47
7. Heat to be rejected in condenser $H_C$ = $h_2$-$h_3$ = 438-252 = 186 kJ/kg

**3.3 PERFORMANCE CALCULATIONS TEST FOR R-600a USING $AL_2O_3$ & $TiO_2$ (1 %w/v) NANO LUBRICANT WITH POE OIL**

**Table 4.5 Observations for R600a with $AL_2O_3$ & TiO2 (1 %w/v) nano lubricant in POE oil**

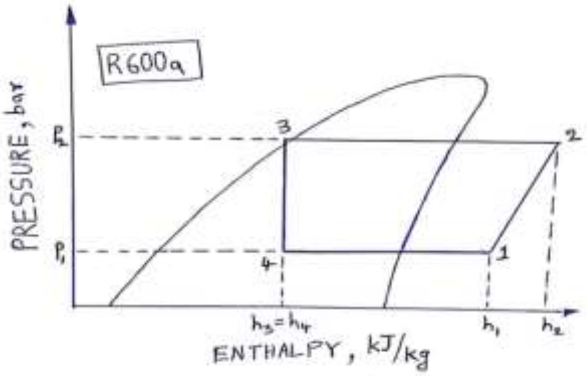
| S. No | Pressure (bar) | | Temperature (T oC) | | | | Time (Minutes) |
|---|---|---|---|---|---|---|---|
| | P1 | P2 | T1 | T2 | T3 | T4 | |
| 1 | 2.041 | 2.241 | 33 | 30.6 | 29.5 | 33 | 0 |
| 2 | 1.97 | 2.15 | 30 | 30 | 29.2 | 26 | 0.7 |
| 3 | 1.85 | 2.04 | 29.5 | 29.5 | 29.3 | 20 | 1.5 |
| 4 | 1.7 | 2.02 | 36.8 | 36.8 | 30.5 | 14 | 6 |
| 5 | 1.65 | 2.01 | 38.2 | 38.2 | 30.8 | 9 | 7.5 |
| 6 | 1.5 | 2 | 38.8 | 38.8 | 31 | 4 | 8.8 |
| 7 | 1.35 | 2 | 39.2 | 39.2 | 31.2 | 1 | 10.2 |
| 8 | 1.3 | 2 | 39.5 | 39.5 | 31.4 | 0 | 11.5 |
| 9 | 1.1 | 2 | 39.3 | 39.3 | 31.6 | -5 | 12.8 |
| 10 | 0.9 | 2 | 39.8 | 39.8 | 31.3 | -10 | 18 |

**Temperatures:**

| | | | |
|---|---|---|---|
| Compressor suction temperature | T1 | = | 39.8°C |
| Compressor discharge temperature | T2 | = | 39.8C |
| Condenser temperature | T3 | = | 31.3°C |
| Evaporator temperature | T4 | = | -10°C |

**Pressures:**

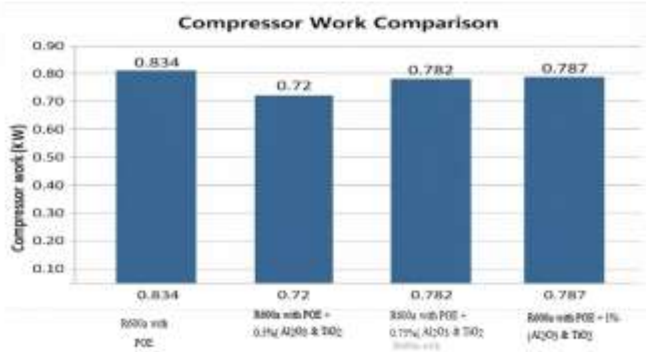
| | | | |
|---|---|---|---|
| Compressor suction pressure | P1 | = | 0.900 bar |
| Compressor discharge pressure | P2 | = | 2.000 bar |
| Condenser pressure | P3 | = | 2.000 bar |
| Evaporator pressure | P5 | = | 0.900 bar |




**Graph 4.5 p-h diagram of R600a using Al2O3 & TiO2 (1%**

CHAPTER-5 RESULTS AND DISCUSSION

**5.1 Comparison of compressor work required for ton of refrigeration (kW):**

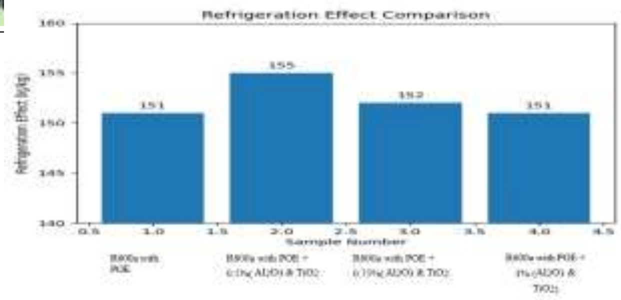



Comparison of COP throughout the experiment:

**<u>Comparison of compressor work (kW) required for ton of refrigeration</u>**

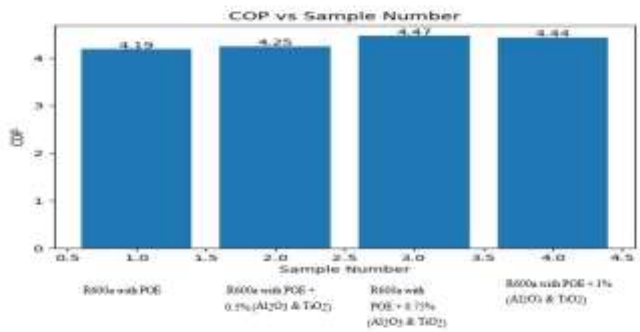
The graph shows that compressor work required for ton of refrigeration is lees in R600a with POE oil+ Al2O3 & TiO2 (0.75% w/v) when compared with normal cycle. Because the increase of heat transfer rate of compressor oil. Therefore, the specific volume of compressed refrigerant decreases which leads to reduction in compressor work. The compressor work saved due to POE oil+0.5% Al2O3 & TiO2 nano lubricant cycle when compared with normal cycle is 9.84%. The compressor work saved due to POE oil+0.75% Al2O3 & TiO2 nano lubricant cycle when compared with normal cycle is 24.82%. The compressor work saved due to POE oil+1% Al2O3 & TiO2 nano lubricant cycle when compared with normal cycle is 23.68%.

**5.2 Comparison of refrigeration effect throughout the experiment:**




**Comparison of refrigeration effect (kJ/kg)**

This bar chart compares the refrigeration effect across four samples, measured in kJ/kg, which represents the heat absorbed by a refrigerant during the evaporation process. Sample 2.0 demonstrates the peak performance at 155 kJ/kg, while Samples 1.0 and 4.0 show a baseline of 151 kJ/kg, and Sample 3.0 sits in between at 152 kJ/kg. In a practical cooling cycle, these values are determined by the enthalpy change across the evaporator, defined as q = h1 – h4, where a higher value indicates a greater capacity for the system to remove heat per unit of refrigerant circulated. The relatively tight range of results suggests these samples were likely tested under similar pressure and temperature conditions, with Sample 2.0 being the most efficient at heat absorption.




**Comparison of Coefficient of Performance**

The graph shows that the coefficient of performance. The COP of R600a with POE oil normal cycle is 4.19, The COP of R600a with POE oil+0.5% AL2O3 & TiO2 nano lubricant cycle is 4.25, The COP of R600a with POE oil+0.75% AL2O3 & TiO2 nano lubricant cycle is 4.47, The COP of R600a with POE oil+1% AL2O3 & TiO2 nano lubricant cycle is 4.40. Due to the reduction in compressor work, increase in refrigeration effect, the coefficient of performance for R600a with POE oil+ AL2O3 & TiO2 (0.75% w/v) is 4.40. Hence the coefficient of performance for R600a with POE oil+ AL2O3 & TiO2 (0.75% w/v) is optimum. The increase of COP for R600a with POE oil+0.75% AL2O3 & TiO2 nano lubricant cycle when compared with normal cycle is (4.19). If the concentration of nano lubricant is increase then the viscosity of lubricant oil is also increased.

## CONCLUSION

The experimental work is carried out and performance of domestic refrigerator capacity is evaluated with R-600a refrigerant when Polyester oil (POE oil) is lubricant Based on the literatures, it has been found that the thermal conductivities of nano lubricant are higher than traditional lubricants. It was also observed that increased thermal conductivity of nano lubricant is comparable with the increased thermal conductivities of other nanofluids. Further the experimental work has been taken up to compare the compressor work (Wc), refrigeration effect (RE) and

Coefficient of performance (COP) using three concentrations of nano lubricant (0.5% w/v) Al2O3 & TiO2 nano lubricant, (0.75% w/v) AL2O3 & TiO2 nano lubricant,( 1% w/v) AL2O3 & TiO2 nano lubricant are using in this experiment. From the obtained results following conclusions are made:

- The coefficient of performance of R600a is more because of low discharged pressure and also R600a has very low global warming potential.
- The COP of R600a with POE oil normal cycle is 4.19, The COP of R600a with POE oil+0.5% w/v Al2O3 & TiO2 nano lubricant cycle is 4.25, The COP of R600a with POE oil+0.75% w/v Al2O3 & TiO2 nano lubricant cycle is 4.47, The COP of R600a with POE oil+1% w/v Al 2O3 & TiO2 nano lubricant cycle is 4.44.
- If the concentration of nano lubricant is increase, then the viscosity of lubricant oil is also increased.
- Hence the thermal conductivity of lubricant oil is optimum at 0.75% w/v AL2O3 & TiO2 nano lubricant cycle implies refrigeration effect is more, coefficient of performance is also more at this condition.

### FUTURE SCOPE

- Exact mechanism of enhanced heat transfer for Nano fluids is still unclear as reported by many researchers.
- Nano fluids stability and its production cost are major factors that hinder the commercialization of Nano fluids. By solving these challenges, it is expected that Nano fluids can make substantial impact as coolant in heat exchanging devices.

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