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EXPERIMENT EVALUATION FOR HEAT TRANSFER ENHANCEMENT IN DOMESTIC REFRIGERATOR USING R600a, MINERAL OIL, NANO-Al_2O_3 AS WORKING FLUID

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Abstract: **Presently the requirement of refrigeration is too high at the minimum usage of input energy and cost with higher output results. The performance of the refrigeration system depends upon the heat transfer capacity of the refrigerant. Normally R12, R22, R600, R600a, and R134a are used as a refrigerant. This refrigerant heat transfer capacity is not so good and increases power consumption. Due to these limitations, a nanofluid is enhanced with the normal lubricant, increases the heat transfer capacity, and reduces power consumption. Aluminum oxide nanofluid is used for enhancing the heat transfer capacity of the refrigeration system. In this experiment heat, transfer enhancement was investigated numerically by using Al_2O_3 nano refrigerants, where nanofluids could be a significant factor in maintaining the surface temperature within a required range. In this experiment, we are going to calculate the coefficient of performance and other factors of the system**

1. REFRIGERATION:

Refrigeration is the process of creating and maintaining a temperature lower than the surrounding temperature but not necessary to maintain a temperature below atmospheric temperature. The term refrigeration is like cooling but the main difference between cooling and refrigeration is the use of external energy to remove heat from the substances. Cooling may be achieved is natural, spontaneous, or artificial, but refrigeration is only possible with aid of external energy. Energy as heat always transfers from a higher temperature body to a lower temperature body. The reverse of this is possible with the aid of external energy. According to the second law of thermodynamics, heat cannot transfer from a lower-temperature body to a higher-temperature body without the involvement of external energy. The refrigeration systems work on the principle of the second law of thermodynamics. The device used to produce refrigeration is a refrigerator. In the refrigerator to remove heat from the lower temperature body(Q1) to the higher temperature body(Q2) the work is to be done on the system. According to the First Law of Thermodynamics Work is done on the system.

$$WR = Q2 - Q1$$

The Performance of the refrigerator is expressed by the ratio of the refrigeration effect or amount of heat removed from the cold body (Q1) to the work required (WR) to be done on the system. This ratio is called as Coefficient of Performance of refrigerators.

2. INTRODUCTION to VCRS:

A vapor Compression Refrigeration system is a type of mechanical refrigeration denoted as VCR. In the Vapor Compression Refrigeration system, refrigerant can change the phase continuously in a cyclic process with some external force. vapor Compression Refrigeration systems can use in domestic refrigerators, large-scale warehouses for chilled and storage for foods, meats, refrigerated trucks, in many industries, etc., and are working in the same principle of Vapor Compression Refrigeration system.

3. COMPONENTS in VCRS

Basic parts in vapor compression refrigeration system are of four components namely as

- compressor
- condenser
- expansion valve
- evaporator

a) Compressor:

The purpose of the compressor is to increase the pressure from discharge pressure to suction pressure and to increase the temperature from lower to higher.

b) Condenser:

The purpose of the condenser is to extract heat from the refrigerant to the outside air. The temperature in the condenser is the same as in the compressor.

c) Expansion Valve:

The purpose of the expansion valve is to decrease the pressure from high temperature to low temperature.

d) Evaporator:

The purpose of the evaporator is to extract the heat from the products placed in the refrigerator

4. VCR SYSTEM: Basic definitions of the VCR system

a) Refrigeration:

Refrigeration is defined as the process of achieving and maintaining a temperature lower than the surrounding temperature.

b) Refrigerant:

Refrigerant is a substance that may or may not undergo a phase change to produce lower temperatures.

c) Refrigeration Effect:

The refrigeration effect is defined as the amount of heat removed from the storage space per ton of refrigerant to maintain a lower temperature.

d) Work done:

Work is the work to be done by the compressor on the system.

e) Heat Rejection:

The amount of heat rejected by the refrigerant in the condenser is known as Heat rejection.

f) Coefficient of Performance:

Coefficient of Performance (COP) is defined as the ratio of the Refrigeration effect to Work Done on the system by the Compressor.

COP = Refrigeration Effect /Work Done For refrigerator

COP = TL / (TH – TL)

For Heat Pump COP = TH / (TH-TL)

Where TL = Lower temperature

TH = Higher temperature

5. Analysis of ideal VCR System with P-h Diagram:

The Pressure – Enthalpy (P-h) diagram of the Vapor compression refrigeration system is shown in fig. The analysis is carried out by using a steady flow energy equation.

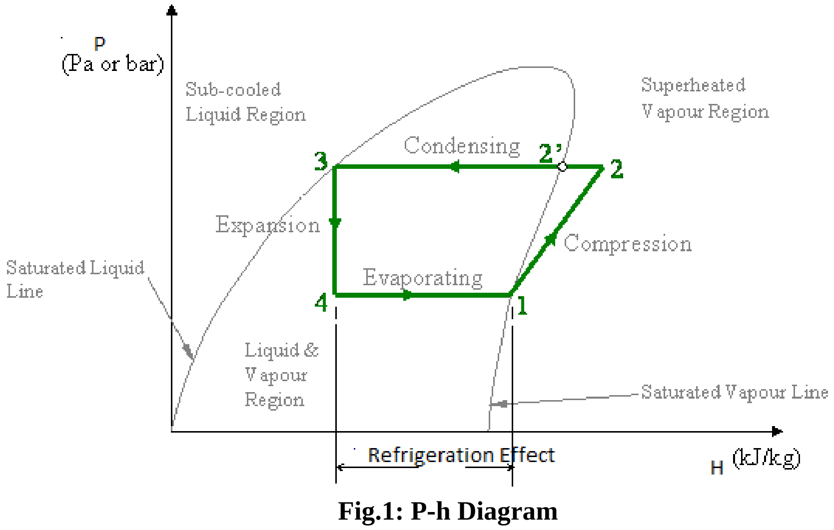

Fig.1: P-h Diagram

The VCR system consists of four processes

Process 1-2 Isentropic compression

Process 2-3 Constant pressure heat rejection

Process 3-4 Isenthalpic expansion throttle valve

Process 4-1 Constant pressure heat absorption

a) Isentropic Compression: Process 1-2 in the P-h diagram represents the isentropic compression process. In the compressor the pressure of Vapor refrigerant raises entropically from state 1 to state 2 simultaneously the temperature also increases. The pressure and Enthalpy of Vapor refrigerant at state 1 are represented as P1&h1, and the Pressure and Enthalpy at state 2 after isentropic compression are represented as P2&h2.

Work done by compressor Per kg of refrigerant,

WC = h2 - h1 in KJ/Kg

Where h1 is the enthalpy of low-pressure Vapor refrigerant before compression

h2 is the enthalpy of high-pressure Vapor refrigerant after compression

b) Constant pressure Heat Rejection: The process 2-3 in the P-h diagram represents the constant pressure heat rejection in the condenser. During condensation, the refrigerant losses its latent heat of vaporization and undergoes a phase change. The high-pressure high-temperature Vapor refrigerant is converted into high-pressure high-temperature liquid refrigerant. At state 3 the pressure is denoted as P3 and Enthalpy are denoted as h3.

Amount of Heat rejected in Condenser,

Qr = h2 - h3 in KJ/Kg

Where h3 is the enthalpy of saturated liquid refrigerant after condensation

c) Throttling in expansion valve: Process 3-4 in the P-h diagram represents the throttling process. During throttling the saturated liquid refrigerant flows through the mass flow-controlled capillary tube, thus the isenthalpic expansion of refrigerant takes place, and the pressure decreases from P3 to P4. The enthalpy remains constant for state 3 and state 4. Therefore, the work done during the throttling process is Zero.

For isenthalpic expansion or throttling process, h = constant

h3 = h4

Work done during throttling process,

W3-4 = 0

d) Constant Pressure Heat Absorption: The process 4 – 1 in the P-h diagram represents the constant pressure heat extraction process in the evaporator. During constant pressure heat extraction, the saturated liquid refrigerant gains its latent heat of Vaporization and undergoes phase change thus it is converted into saturated Vapor refrigerant. the amount of heat extracted by the refrigerant in the evaporator is known as the refrigeration effect.

Therefore, the amount of Heat Absorbed per kg mass flow of refrigerant is denoted as Qa.

Qa = h1 -h4 in KJ/Kg

Coefficient of performance:

$$COP = \frac{\text{Refrigeration Effect}}{\text{Work Done}}$$

6. REFRIGERANT

A) Definition of refrigerant:

Any substance which can absorb or extract heat from another substance is known as a refrigerant. Refrigerants may be any one such as Air, Water, Brines, etc.…

B) Classification of refrigerants:

Refrigerants are classified into two types, they are.

a. Primary refrigerants

b. Secondary refrigerants

a. Primary refrigerants:

Primary refrigerants are those which can directly undergo phase change while absorbing or dissipating heat from the refrigeration system.

Ex: Azeotropes, Hydrocarbons, Inorganic compounds, Oxygen compounds, nitrogen compounds, etc. …

b. Secondary refrigerants:

Secondary refrigerants are those which can be first cooled by primary refrigerant and then used for cooling purposes.

Ex: Air, Water, Brines, Antifreeze solutions, etc. …

C) Selection of refrigerant:

The selection of refrigerant for a particular application depends on the following criteria,

i. Thermodynamic and Thermo-physical properties

ii. Environmental and safety properties

iii. Economics

i. Thermodynamic and thermophysical properties:

A good refrigerant should possess good thermodynamic and thermophysical properties such as low boiling point, low freezing point, high latent heat of vaporization, positive evaporator, and condenser pressures but not very high as the high pressures lead to high capital and operating costs, high COP, leak tendency, miscibility with lubricating oils. lower viscosity, high thermal conductivity, low specific heat, etc.….

ii. Environmental and safety properties:

The refrigerant should be selected such that it should be eco-friendly and non-hazardous. To say the selected refrigerant is safe it should be non-toxic, chemically stable, non-corrosive, non-flammable, odorless, should possess low global warming potential (GWP), possess non- ozone depleting properties, etc.... iii. Economics: While selecting the refrigerant the most important criterion is cost. The refrigerant should be selected in such a manner that the cost of the refrigerant should not exceed the operating cost. The refrigerant should be easily available and inexpensive.

Designation of refrigerants:

Designation of refrigerant is very important as many refrigerants have been developed over the many years depending on the variety of applications.

I. **For fully saturated hydrocarbons:** These refrigerants are derived from alkanes such as methane (CH4) and ethane (C2H6). These refrigerants are designated by Rxyz.

The refrigerant formulae: CmHnFpClq

X+1 = m

Y-1 = n

Z = p

Condition: n + p + q = 2m + 2

Where m indicates the no of Carbon (C) items

n indicates the no of Hydrogen (H) atoms, and

p indicates the no of Fluorine (F) atoms.

II. **For unsaturated hydrocarbons:**

These refrigerants are designated by **R**1xyz.

The refrigerant formulae: CmH2n

Condition: n+ p + q = 2m

III. **Inorganic refrigerants:** These are designated by the number 7 followed by the molecular weight of the refrigerant (rounded off).

Ex: Ammonia, the molecular weight is 17 and it is designated as R717.

IV. **Mixtures:**

Azeotropic mixtures are designated by 500 series, whereas zeotropic mixtures are designated by 400 series.

V. **Hydrocarbons:** The following are examples of hydrocarbons.

- Propane (C3H8): R290
- N – butane (C4H10): R600
- Isobutane (C4H10): R600a

6. Ozone Depletion Potential (ODP) and Global Warming Potential (GWP) of CFC refrigerants:

The earth's ozone layer in the stratosphere is very important for the absorption of harmful ultraviolet rays coming from the sun. In past years scientists had identified a large hole above Antarctica in the stratosphere that protects the earth from ultraviolet rays. The scientists got shocked after identifying the reason for the depletion of the ozone layer, the CFCs had been involved in the depletion of the ozone layer. The chlorine present in the CFCs quickly reacts with the ozone and thus separated into two compounds, the equation is.

$$CL + O3 = O2 + CLO$$

At least one atom of chlorine is required for the reaction, the more chlorine atoms the faster the destruction of the Ozone layer. As Chlorine is unstable it breaks down and reacts continuously with ozone molecules until a stable compound is created. The CFCs are also acting as greenhouse gases; hence they have global warming potential also. ODP is defined as the ratio of impact on the Ozone of a chemical compound compared with the impact of a similar mass of CFC.

GWP is defined as the ratio of warming caused by a substance to the warming caused by a similar mass of carbon dioxide.

Substitute for CFCs:

Hydrochlorofluorocarbons (HCFCs) are the hydrogenated halocarbons from which not all the hydrogen atoms are removed at least one hydrogen atom is contains and the number of chlorine atoms is zero thus the HCFs have less life in the atmosphere. Therefore, the effect of HCFCs in the atmosphere is less.

The ODP and GWP of hydrochlorofluorocarbons are very less compared to CFC and the cycle time of HCFCs in the atmosphere is also very few years. Therefore, the use of HCFCs is preferred as a refrigerant in refrigeration systems.

7. NANOPARTICLES

Nowadays Nanotechnology is growing very rapidly as it has numerous applications almost in every industry. A nanoparticle has the size of the order of a billionth of a meter. Thus, the size range of nanoparticles ranges from 1- 100 nanometers. One nanometer is equal to 1x10-9 meters. After the development of nanotechnology, people have realized that certain materials can exhibit different properties based on their size and shape. Nanoparticles are available in various sizes and shapes depending upon the requirement one must choose the right size and shape.

Aluminum oxide nanoparticles can be synthesized by many techniques. Laser ablation is the most used technique to produce nanoparticles as it can be synthesized in a gas, vacuum, or liquid. The chemical formulae for aluminum oxide are Al2O3, the molar mass is 101.960 g.mol-1, the density is 3.987 g/cm3 the melting point temperature is 2072oC and the boiling point temperature is 297oC. below are the structural formulae of aluminum oxide. The appearance of aluminum oxide is white solid, and the aluminum oxide is odorless

8. EXPERIMENTAL SETUP

In the Vapor compression refrigeration system, the pressure of the Vapor refrigerant coming from the evaporator is increased in the compressor by undergoing the compression process. In this present work, a copper spiral condenser is incorporated in between the compressor and expansion device to further increase the rate of heat transfer from the system. In the actual refrigeration cycle the Vapor refrigerant after compression directly enters the condenser, the condenser cools the refrigerant, and the refrigerant becomes changes its phase from vapor to liquid state at constant pressure. The high-pressure liquid refrigerant is expanded in the expansion device until the pressure reaches the initial state. The low-pressure refrigerant takes heat from evaporated space and the refrigerant changes its state from liquid to vapor, the vapor refrigerant again enters the compressor, and the process repeats so….on.

In this project heat, transfer enhancement was investigated numerically by using refrigerant R600a, mineral oil and nano lubricants (AL_2O_3) added to the compressor for reducing the noise, increasing the rate of heat transfer from the system, reducing power consumption, and increase COP.

9. CALCULATIONS

Table No1: Experimental data observed for an existing system using R600a refrigerant under full load conditions without Al_2O_3 Nanoparticles at different time intervals after running for 2 hours.

S.NO	PRESSURE (Psi)		TEMPERATURE (^OC)				TIME (min)
	Suction	Discharge	Evaporator (min) Outlet	Compressor Outlet	Condenser Outlet	Evaporator inlet	
1	16	210	30.6	36.9	30.2	15	5
2	15	205	27.5	41.2	31.1	12	10
3	15	200	25.2	48.3	32.7	7	15
4	14	195	23.6	54.2	33.6	5	20
5	13	190	20.3	62.5	34.2	-1.5	25
6	13	185	17.6	65.3	35.5	-3.1	30
7	12	180	11.1	68.1	37.4	-3.8	35
8	12	175	9.4	74.2	42.9	-4.6	40
9	11	170	8.5	75.4	43.8	-6.0	45
10	10	165	8.3	77.5	47.2	-6.9	50

Experimental setup with R600a:

Compressor Suction Pressure Ps = 10 Psi
Compressor Discharge Pressure Pd = 165 Psi
Compressor Outlet Temperature T2 = 77.5^{O}C
Condenser Outlet Temperature T3 = 47.2^{O}C
Evaporator Outlet Temperature T1 = 8.3^{O}C

From the p-h chart of R134a Enthalpy values are:

h_1=392 kJ/kg

h_2=476 kJ/kg

h_3=266 kJ/kg

h_4=266 kJ/kg

Calculation Performance Parameters:

1. Net Refrigeration Effect (NRE) = h_1-h_4 = 411 - 266 = 126 kJ/kg
2. Mass flow rate to obtain one TR, kg/min. $m_r = \frac{210}{NRE} = \frac{210}{126}$ = 1.666 kg/min
3. Work of Compressor = h_2-h_1= 455 – 411 = 84 KJ/Kg
4. Heat Equivalent work of compression per TR =m_r x (h_2 -h_1) = 1.666x (84) = 139.94 kJ/min
5. Theoretical power of compressor =$\frac{139{\cdot}444}{60}$ = 2.3324 kW
6. Coefficient of performance (COP) = $\frac{h_1-h_4}{h_2-h_1}$– = $\frac{399-266}{476-392}$= 1.5
7. Heat to be rejected in condenser = h_2-h_3= 476– 266 = 210 kJ/kg
8. Heat rejection per TR = (210/NRE) x (h_2-h_3) = $\frac{210}{126}$ x (210) = 350kJ/min
9. Heat rejection Ratio = $\frac{350}{210}$ =1.6667
10. Compressor pressure Ratio = $\frac{\text{Discharge pressure}}{\text{Suction pressure}}$ = P_d/P_s = $\frac{165}{10}$ = 16.5

Table: No 2: Experimental data observed for R600a refrigerant under no load condition with mineral oil and Al_2O_3 Nanoparticles at different time intervals after running for 2 hours.

S.NO	PRESSURE (Psi)		TEMPERATURE (^OC)				TIME (min)
	Suction	Discharge	Evaporator (min) Outlet	Compressor Outlet	Condenser Outlet	Evaporator inlet	
1	16	210	25.5	35.7	27.2	15.3	5
2	15	205	22.1	39.3	29.7	11.2	10
3	14	200	18.3	45.6	30.4	5.7	15
4	13	195	16.7	54.2	31.1	-0.4	20
5	12	190	15.3	60.4	32.4	-1.8	25
6	11	185	12.6	62.1	34.3	-4.8	30
7	10	180	9.4	65.0	35.2	-5.6	35
8	9	175	7.5	66.3	36.7	-6.8	40
9	8	170	6.7	67.4	37.0	-8.0	45
10	7	165	3.3	68.8	40.1	-8.5	50

Experimental setup with R600a:

Compressor Suction Pressure	Ps = 7 Psi
Compressor Discharge Pressure	Pd = 160 Psi
Compressor Outlet Temperature	T2 = 68.8^{O}C
Condenser Outlet Temperature	T3 = 40.1^{O}C
Evaporator Outlet Temperature	T1 = 3.3^{O}C

From p-h chart of R134a Enthalpy values are:

h_1=412 kJ/kg

h_2=462 kJ/kg

h_3=250 kJ/kg

h_4=250 kJ/kg

Calculation Performance Parameters:

1. Net Refrigeration Effect (NRE) = h_1-h_4 = 412 - 250 = 162 kJ/kg
2. Mass flow rate to obtain one TR, kg/min. $m_r = \frac{210}{NRE} = \frac{210}{162}$ = 1.296 kg/min
3. Work of Compressor = h_2-h_1= 462 – 412 = 50 kJ/kg
4. Heat Equivalent work of compression per TR =m_r x (h_2 -h_1) = 1.296 x (50) = 64.80 kJ/min
5. Theoretical power of compressor =$\frac{64.8}{60}$ = 1.08 kW
6. Coefficient of performance (COP) = $\frac{h_1-h_4}{h_2-h_1}$– = $\frac{412-250}{462-412}$= 3.24
7. Heat to be rejected in condenser = h_2-h_3= 462– 250 = 212 kJ/kg
8. Heat rejection per TR = (210/NRE) x (h_2-h_3) = $\frac{210}{162}$ x (210) = 274.8 kJ/min
9. Heat rejection Ratio = $\frac{274.8}{210}$ =1.308
10. Compressor pressure Ratio = $\frac{\text{Discharge pressure}}{\text{Suction pressure}}$ = P_d/P_s = $\frac{165}{7}$ = 22.857

Table: No 3: Experimental data observed for R600a refrigerant under full load condition with mineral oil and Al_2O_3 at different time intervals after running for 2 hours.

S.NO	PRESSURE (Psi)		TEMPERATURE (^OC)				TIME (min)
	Suction	Discharge	Evaporator (min) Outlet	Compressor Outlet	Condenser Outlet	Evaporator inlet	
1	16	200	21.5	37.7	32.2	6.5	5
2	15	190	18.1	39.3	33.7	4.2	10
3	14	180	16.3	47.6	34.4	2.7	15
4	13	170	13.7	54.2	35.1	-0.4	20
5	12	160	11.3	61.4	36.4	-2.8	25
6	11	150	10.6	63.1	37.3	-4.8	30
7	10	145	9.4	65.0	38.2	-6.6	35
8	9	140	7.5	68.3	39.7	-8.8	40
9	8	135	6.7	69.4	41.0	-11.0	45
10	7	130	4.3	74.8	41.1	-11.5	50

Experimental setup with R600a:

Compressor Suction Pressure Ps = 8 Psi
Compressor Discharge Pressure Pd = 135 Psi
Compressor Outlet Temperature T2 = 69.4^{O}C
Condenser Outlet Temperature T3 = 41^{O}C
Evaporator Outlet Temperature T1 = 6.7^{O}C

From p-h chart of R134a Enthalpy values are:

h_1=418 kJ/kg
h_2=461 kJ/kg
h_3=258 kJ/kg
h_4=258 kJ/kg

Calculation Performance Parameters:

1. Net Refrigeration Effect (NRE) = h_1-h_4 = 418 - 258 = 160 kJ/kg
2. Mass flow rate to obtain one TR, kg/min. $m_r = \frac{210}{NRE} = \frac{210}{160}$ = 1.3125 kg/min
3. Work of Compressor = h_2-h_1= 461 – 418 = 43 kJ/kg
4. Heat Equivalent work of compression per TR =m_r x (h_2 -h_1) = 1.3125 x (43) = 56.44 kJ/min
5. Theoretical power of compressor =$\frac{56.44}{60}$ = 0.9406 kW
6. Coefficient of performance (COP) = $\frac{h_1-h_4}{h_2-h_1}$– = $\frac{418-258}{461-418}$= 3.72
7. Heat to be rejected in condenser = h_2-h_3= 461– 258 = 203 kJ/kg
8. Heat rejection per TR = (210/NRE) x (h_2-h_3) = $\frac{210}{160}$ x (203) = 266.4375 kJ/min
9. Heat rejection Ratio = $\frac{266.4375}{210}$ =1.268
10. Compressor pressure Ratio = $\frac{\text{Discharge pressure}}{\text{Suction pressure}}$ = P_d/P_s = $\frac{135}{8}$ = 16.875

Table: No 4: EXPERIMENTAL OBSERVED DATA FOR Al_2O_3 NANOPARTICLES WITH MINERAL OIL

S.NO	PARAMETERS	EXISTING SYSTEM AT NO LOAD CONDITION	IMPROVED SYSTEM WITH MINERAL OIL AND Al_2O_3 NANO PARTICLES AT NO LOAD CONDITION	IMPROVED SYSTEM WITH MINERAL OIL AND Al_2O_3 NANO PARTICLES AT PART LOAD CONDITION
1	Net refrigeration effect, kJ/kg	126	162	160
2	Coefficient of performance (COP)	1.5	3.24	3.72
3	Mass flow rate to obtain one TR, KJ/min	1.666	1.296	1.3125
4	Work of compression, kJ/kg	84	50	43
5	Heat equivalent of work of compression per TR, kJ/min	139.94	64.8	56.437
6	Compressor power, kW	2.3324	1.08	0.9406
7	Heat to be rejected in the condenser, kJ/kg	210	212	203
8	Heat rejection per TR, kJ/min	350	274.8	266.437
9	Heat rejection ratio	1.6667	1.308	1.268
10	Compressor pressure ratio	16.5	22.857	16.875

10. RESULTS AND DISCUSSION

a) COMPARISON OF COMPRESSOR WORK:

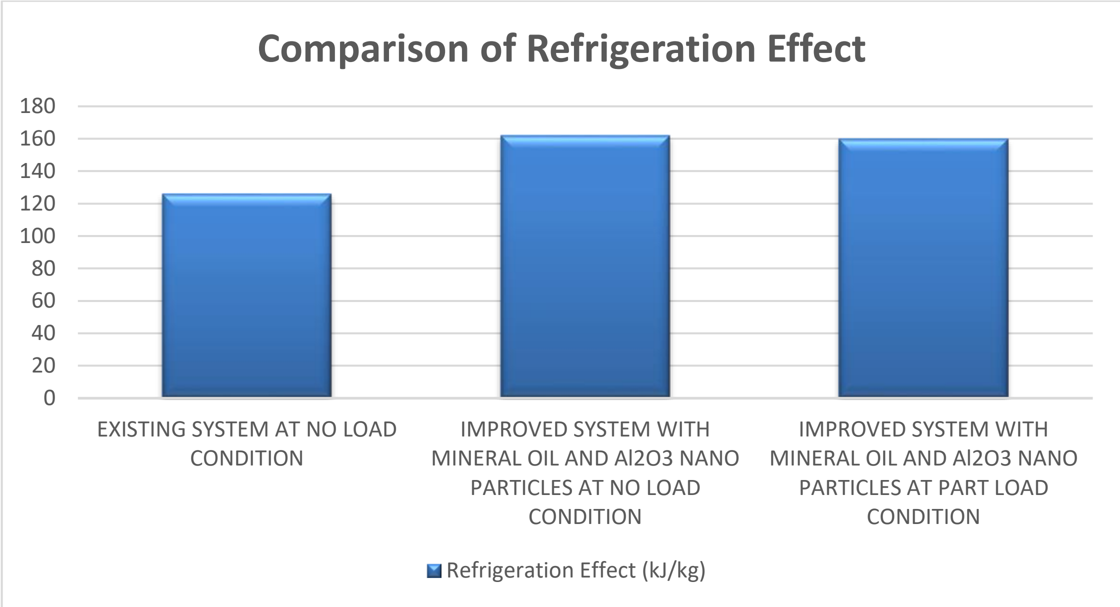

Fig 2: Variation of Refrigeration Effect

The above chart shows the refrigeration effect of the refrigerant R600a for the existing system and the improved system.

The refrigeration effect for the existing system using refrigerant R600a is 126 kJ/kg. The refrigeration effect for the improved system with mineral oil and Al_2O_3 nano lubricant at no load condition using refrigerant R600a is 162 kJ/kg. The refrigeration effect of the modified system with the added mineral oil and Al_2O_3 nano lubricants in the compressor is increased as compared to R600a existing system.

b) COMPARISON OF COMPRESSOR WORK:

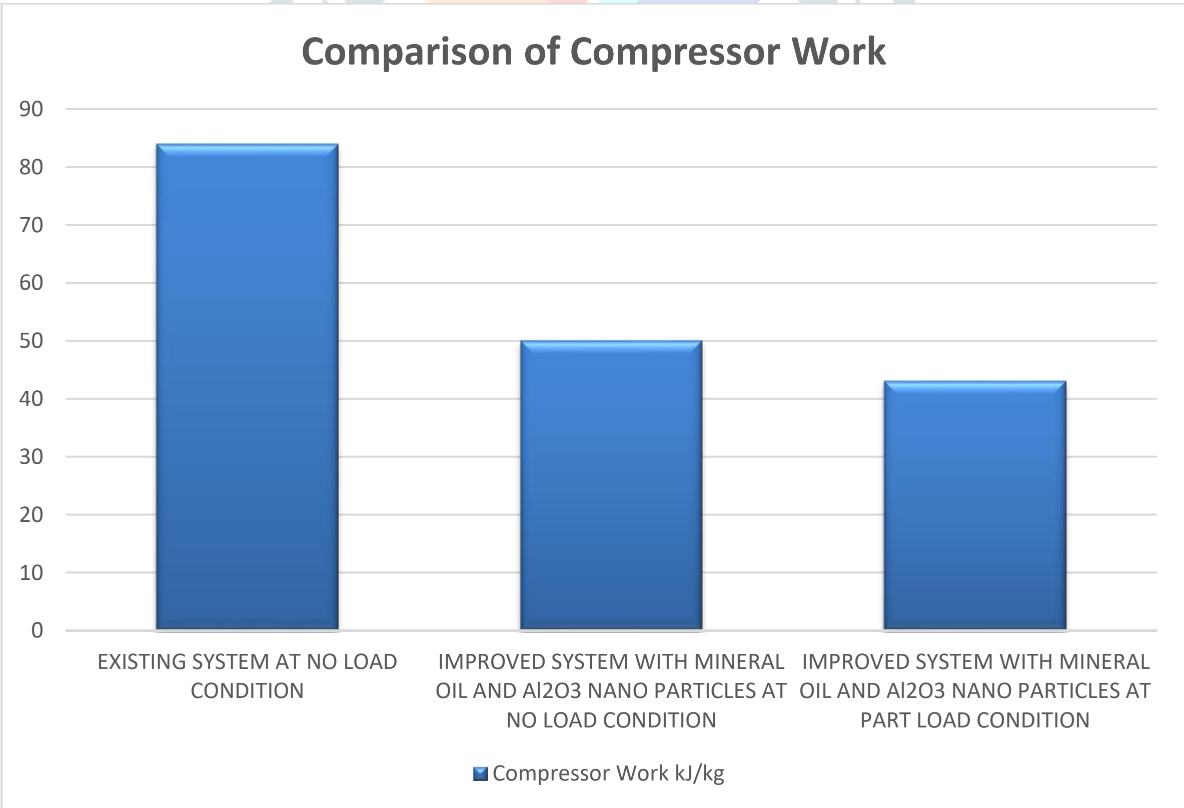

Fig 3: Variation of Compressor Work

c) COMPARISON OF COP:

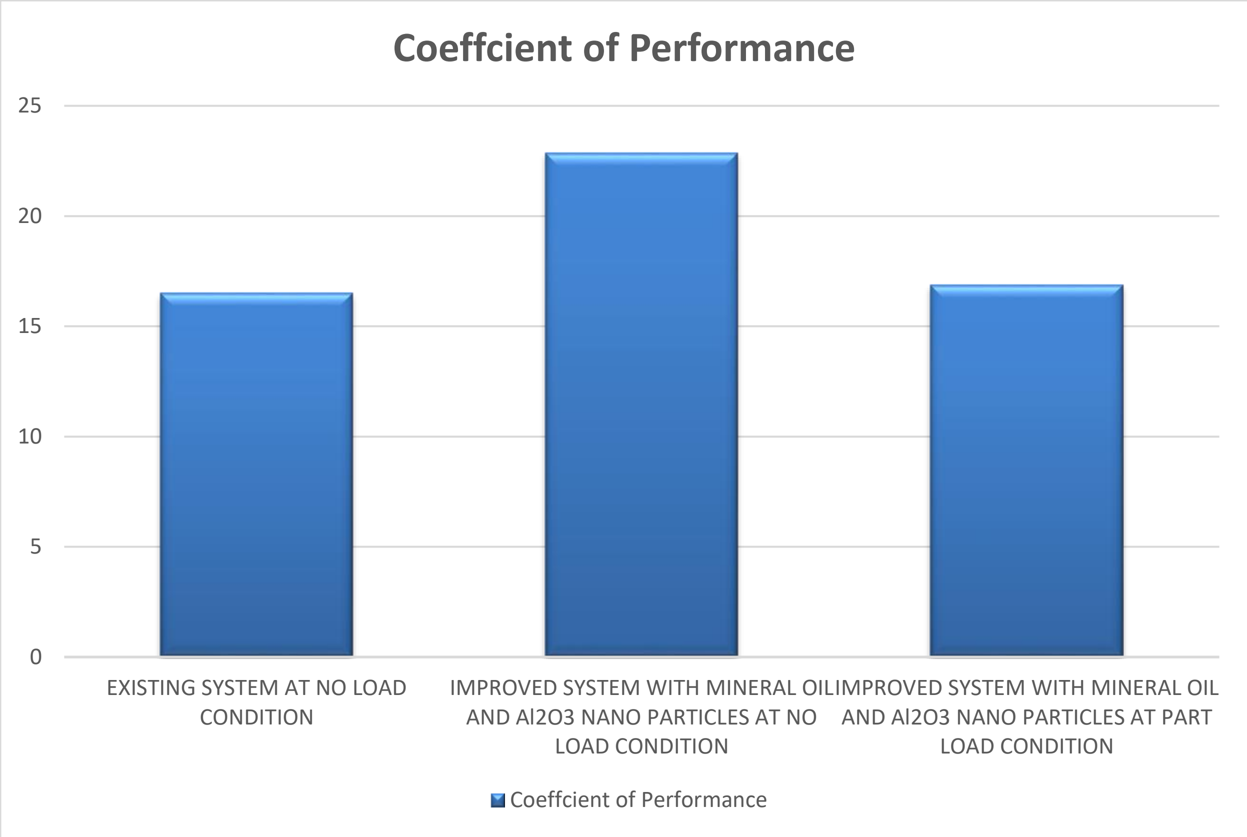

Fig 4. Comparison of COP

11. CONCLUSION: An experiment has been performed to study the refrigeration effect and COP in a domestic refrigerator running on a Vapor compression refrigeration system with the refrigerants R600a, mineral oil, and addition of nano lubricants (Al2O3) in the compressor. The results have been obtained as follows. R600a: For the existing system, the COP is 1.5, work done by the compressor in the normal VCR system is 84 kJ/kg and the power consumption by the VCR system is 2.33 kW, net refrigeration effect 126 kJ/kg, heat rejected in the condenser 210 kJ/kg. For the modified VCR system on no load condition with refrigerant R600a, mineral oil, and Al2O3 nanoparticles in compressor lubricant the COP is 3.24, work done by the compressor in the modified system is 50 kJ/Kg and the power consumption by the VCR system is 1.08 kW, net refrigeration effect is 162 kJ/kg, heat rejected in the condense is 212 kJ/kg. For the modified VCR system on partial load with refrigerant R600a, mineral oil, and Al2O3 nanoparticles in compressor lubricant the COP is 3.72, work done by the compressor in the modified system is 43 kJ/Kg and the power consumption by the VCR system is 0.9406 kW, net refrigeration effect is 160 kJ/kg, heat rejected in the condense is 203 kJ/kg

13. REFERENCES:

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