Investigation on nano-based lubricants used in compressor of a vapour compression refrigeration system

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ABSTRACT: The refrigeration system is a process used to lower or maintain its temperature below the ambient temperature by cooling space, substance or system. It is done by adding copper nanoparticles and TWEEN oil in R600A refrigerant the coefficient of performance (COP) of the refrigeration system will increase due to more heat transfer rate.

Nano lubricants have a extensive variety of tenders in the fields of refrigeration systems. They are unique in the type of Nano-fluids with varieties of Nanoparticles. The copper nanoparticles and TWEEN oil are essential for the experimental procedure used to increase the heat transfer rate of VCR system (vapour refrigeration system). The combination of TWEEN oil and copper nanofluid is mostly effective in the compressor of the refrigeration system. The project work is focused on the nano additive refrigerants using vapour compression refrigeration systems, for this experiment we are using R600A refrigerant (isobutane) is a good replacement for other refrigerants and had a high positive impact on the environment has zero ozone depletion potential (ODP)

Copper nanoparticles are synthesized using the Sol-Gel process. The prepared copper nanoparticles by a sol-gel process are dispersed in PEG/ R600a refrigerant with an additive as TWEEN 80 oil with different varying proportions to study the characteristics. The VCR system performance were carried out by investigating in varying parameters. The blend (mixture) containing 0.5% vol of Cu nanoparticles in refrigerant shows increase transfer of heat rates. This nano refrigerant has additional decrease in work done consumed, which directed to a decrease in power utilization, where the time taken for 10 revolutions of the disc in energy meter differs positive. The COP of the refrigeration system is increased.

KEYWORDS: Nano lubricants, R600A(refrigerant), TWEEN oil, sol-gel process,

CU nanoparticles and VCR system

1.Introduction:

REFRIGERATION:

The Refrigeration process might be categorized as the way towards achieving and keeping up a temperature beneath that of the environment conditions, the point is to cool some item or space to the essential temperature. One of the utmost significant utilization of refrigeration process is the conservation of transitory sustenance items is by maintain them at low temperatures. For giving a warm solace to people by methods for cooling Refrigeration frameworks are likewise utilized broadly.

INDIA SCENARIO:

The process of refrigeration and air conditioning divisions have been in India for a long time. from the initial years of the past century. India is making mostly at present refrigerants are R22, R71, R134A, and hydrocarbon (HC) grounded on air conditioning process and refrigeration in huge quantity. In the year 2003 the usage of CFC type refrigerants was stopped in recently produced systems. The main factors that prescription and acceptance of a specific refrigerant different from its suitability, To the definite applications that is its high obtainability and price. The refrigerants mostly like R22, R133A, R12, and natural refrigerant (R717) are widely existing at less costs. Hydrocarbon (HC) and Hydro Fluro Carbon (HFC) combination mixtures (consists of R407, R410A and R404A) are not presently manufacture recently and hence, we have to import them at a high cost price. Due to this it can be probably to affect the gradually development in refrigeration systems and air conditioning divisions and also the complete adaptation to environmentally and approachable substitutions shortly.

AIR CONDITIONERS(A/C) IN AUTOMOBILES

In India, it is assessed that almost one million room forced air systems are being fabricated which runs on R22 as refrigerant reliably, which bargains of a window, split-type and bundled cooling units (Devotte elt al., 2006). The limit of the windows according to climate control systems ranges from 0.57 TR to 2.2TR. The decision of option to consider R22 in cooling tenders is R407 and R411 which are able to accessible in the India refrigeration market. Every year around 4500 focal cooling chillers were introduced, the greater part of these chillers depended on R11 and R2. Inadequate chillers were by and by introduced with R123 because of the absence of accessibility on this refrigerant. The long-standing requirement of the R11 and R22A for the cooling applications mostly is R123.

ENVIRONMENTAL IMPACTS

Green House gas (GHG) outflows from non-renewable energy source burning for power age and emanation of halogenated type of refrigerants reformed from the vapor pressure-based refrigeration, cooling and warmth siphon frameworks subsidize fundamentally to an Earth-wide temperature boost. A decrease in GHG outflows must be accomplished by utilizing condition benevolent and vitality proficient refrigerants. The high ecological effects cause the

halogenated type refrigerants discharges lead to recognizing a long-haul choice to encounter all the framework prerequisites with this framework execution, refrigerant – grease communication, vitality effectiveness, security, and administration. Halogenated type refrigerants are broadly utilized in the refrigeration process and cooling businesses over numerous decades due to their incredible thermo-physical properties and thermodynamic properties. According to the Montreal Protocol 1989, creating nations like India, with a for each capita utilization under 0.31 kg of ozone(O3) exhaustion substance had been arranged as Article 7 nations. Those nations are mandatory to eliminate all Chloro Fluro carbons (CFCs) by 2011 and all hydro Chloro Fluro carbons (HCFCs) by 2030. HFC refrigerants are considered as one between the seven focused on greenhouse gas under the Kyoto Convention of the United Nations of Frameworks Convention on Climate Change (UNFCCC) in 1998.

DEPLETION OF OZONE LAYER (O_3):

The foremost cause which effects mostly on the refrigeration manufacturing-based business is Ozone Depletion Potential (ODP) due to synthetic compounds into the environment. in the stratosphere somewhere in the range of 10 and 50 km and the ozone exist over the earth's surface 90%. Molina and Rowland (1975) are suggest the required details about the chlorine-based refrigerants to achieve the stratosphere are steady enough, where the chlorine iotas go about as an impetus to obliterate the ozone layer in stratosphere which shields from straight ultraviolet beams releases from sun.

GLOBAL WARMING POTENTIAL (GWP) :

GWP is the second most ecological effect, which is because of the ingestion of infrared rays discharges from the earth, initiating an expansion in worldwide across the temperature of earth surface. While sun-based radiation releases at 5900 K and 1361 W/m2 hits directly towards the earth, around 30% of radiation is reflected once more into space and the vast majority of the lasting radiation goes over the earth environment and achieves the ground. This sun-based radiation warms up the earth surface, which is around as a dark body transmitting vitality with an unearthly top in the infrared ray's wavelength go. This infrared ray radiation can't go over the environment due to retention by GHG adding the halogenated type refrigerants.

NANO FLUIDS

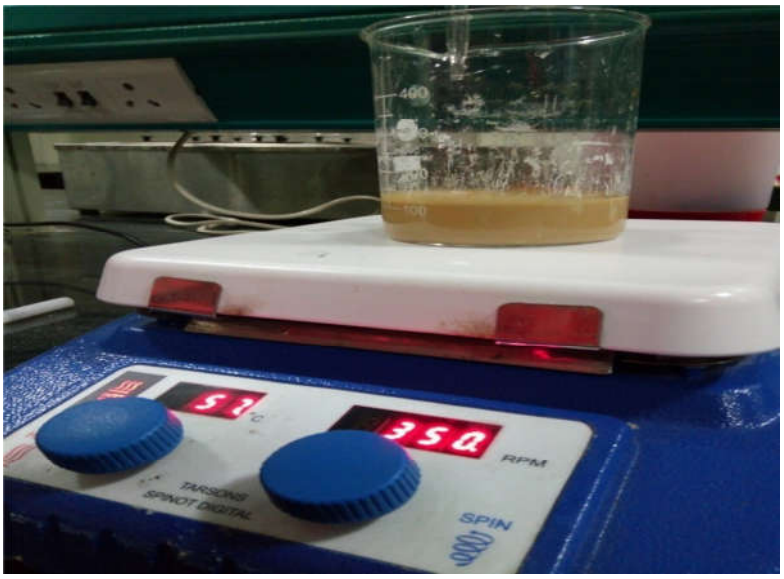
Nanofluids are designed colloids which comprise of a base type liquid with Nanoparticles estimated around (1-100 nm) are suspended inside them. Basic base type liquids incorporate water, bio-liquids, polymeric arrangements, natural fluids (for example tri-ethylene-glycols, ethylene, refrigerants, and others), normal oils and ointments, and other basic fluids. Materials mostly exploited as nanoparticles integrate results in temporary stable metals (e.g., gold(Au), copper(Cu)), metal oxides (alumina, zirconia, Titania, silica,), oxide pottery, metal carbides (for example SiC), metal nitrides (for example SiN ,AIN,), carbon in varies structures (e.g., precious stone, graphite, carbon nano cylinders, fullerene) and functionalized

nanoparticles. By dispersing of nanoparticles into the ordinary warmth move liquids, the warmth move execution of the liquids can be essentially enhanced. As a liquid type class, Nanofluids have an interesting element which is very not quite the same as those of traditional strong fluid blends in which millimetre or potentially micro meter-sized particles are included. Such particles settle quickly, stop upstream channels, disintegrate pipelines and cause serious weight drops. Every one of these weaknesses denies the use of customary strong fluid blends to miniaturized scale channels while nano liquids rather can be utilized in small scale warmth move. Warmth move execution of the nano liquid is better than that of the first unadulterated liquid in light of the fact that the suspended ultrafine particles amazingly increment the warm conductivity of the blend and improve its ability of vitality trade.

As indicated by the application, nano liquids are named warmth move nano liquids, tri-biological nano type liquids, surfactant and covering nano type liquids, synthetic nano liquids, extraction/process nano liquids, natural (contamination with cleaning) nano liquids, bio-and pharmaceutical nano liquids and therapeutic nano liquids (sedate conveyance, useful and tissue-cell connection)

NANOFLUIDS MIXTURE PREPARATION:

Nanofluids Preparation is the primary part step in obtaining the nano-phase type particles to altering the heat transferred for overall performance of the traditional fluids. This nanofluid do not truly refer to a solid-liquid mixture type.it needed some more extra necessities which are needed, such as steady suspension, even suspensions, normal durable suspensions, no chemical changes in the fluid. Mostly, these are fine strategies used for the guidance of suspensions to exchange the pH value cost of suspensions which are used in surface activators or dispersants which are used in ultrasonic vibration. All these strategies are considered in altering the properties of surface of liquid suspended with particles and suppressing the formation of nanoparticles secure suspensions obtain by cluster. It relies upon the utility required.



SURFACTANTS:

Surfactant is also called surface-active agent, substance together with a detergent that, when added to a liquid, decreases its surface tension, thereby growing its scattering and moistening properties. within the dyeing of textiles, surfactants help the dye to penetrate the cloth calmly. It can be used to disperse insoluble dyes and perfumes when aqueous suspensions occur.

2. Experimental Investigation:

Methodology

- Studying the properties of R600a (Isobutane) is a hydrocarbon-based refrigerant.
- Synthesis of copper nanoparticles.
- Characterization of Cu Nanoparticles
    - XRD
    - FESEM
    - Particle Size Analyzer
- Preparation of Cu- R600a nano-based refrigerant
- Studying the performance of VCRS
- Results and Discussions

SYNTHESIS OF NANOPARTICLES

- The precursor (Copper Acetate)
- Stabilizing agent (Benzaldehyde)
- The reducing agent (Sodium Borohydride)

Two similarly old (7 years) fridges RM and RC belongs to the equal brand and mostly have the identical form of a compressor in them and have been taken for this take a look at. fridge rm become used to behaviour of all the checks with the mixtures and RC that became walking with CFC12 all through the required test period to evaluate the performance of RM with the conventional machine at the diverse ambient situations. The representation of the experimental setup is proven in figure. five strain gauges with ±zero.25% accuracy was hooked up inside the outlet and inlet of every condenser and evaporator type pt100. RTD sensors of ±zero.1◦c degree accuracy had been mostly used to measure the temperature at numerous factors inside the inlet, and outlet of the compressor, evaporator, condenser and at numerous situations inside the meals/freezing compartment of the required system. Twenty-two such sensors are constant alongside to evaporator coil length. in that particular sensor became positioned on the outlet to the accumulator, two of them were located along with the accumulator duration and some other 1 sensor became positioned on to go out of the

accumulator. Since, the clinching plate type evaporator changed into the influence of plate warmness and transfer among adjoining pipes in computing the temperature changed into discovered. as a result, to avoid the have an impact on plates in measuring the temperature the pipe became adequately separated from the plate wherever the RTDS have been fixed. To approximation the cop_{Act} the identical form of evaporator coil was used within fridge was saved inside a subordinate refrigerant (poly ethylene glycol) calorimeter. wherein the heat in leak Turned into confirmed to be less than five% capacity of the evaporator. To keep the consistent temperature of a stirrer turned into furnished and 5 of temperature sensors were required to furnished into the calorimeter to trace the average temperature of the poly ethylene glycol. suitable ball valves for process were constant in the drift circuit among coils of evaporator. so, neither one of the required evaporators might be decided on to be covered in the following circuit for having a look at. Compressor load and heater load are measure by a wattmeter with ±0.2 w accuracy changed into were Used. right arrangement becomes also made to measure the consumption of energy, stress, temperature, flow and at various factors inside the refrigerator, RC. all the available temperature sensors have been related to a computer through a data logger. At the machine performance changes were used to look by measure values.

Materials Used for Synthesis:

1. sodium borohydride
2. cupric acetate
3. Tween oil (surfactant)





Setup of Experimentation:

This experimentation consists of a fan-cooling condenser, compressor, growth device, and evaporator segment. an expansion device which is recycled from capillary tube.

A. The water is loaded in a evaporator with a serpentine coil kind type. for charging the refrigerant the carrier ports were furnished at the inlet of growth device and compressor. The mass flows fee is measured with the assistance of a glide meter outfitted in the line among the drier unit and enlargement device.

B. The experimentation setup turned on which is located on a the platform with a steady temperature.



3.RESULTS:

1.calculations for before nano fluid additive used:

From R600A pressure-enthalpy chart (p-h) represents:

For P_1 = 2 bar, T_1 = 27.5ºC

P_2 = 25 bar, T_2 = 60.5ºC

h_1 = 428 kJ/kg

h_2 = 440 kJ/kg

$h_3 = h_4$ = 235 kJ/kg

COP_{th} = (h1 –h4) / (h2 – h1) = 16.05

Refrigeration effect (R.E) = ma (H1 –H2)

H1 = 64.5kJ/kg

H2 = 57.5 kJ/kg (obtained from psychometric chart)

ma = $(21 * 10^{-2}) * 3 * 1.183$ = 0.747 kg/s

R.E = .747 * 8 = 5.32 kW

Input value = no. of revolutions * (3600 / (time * 600))

Input value = 10 * 3600 / (107.2 * 600) = .559 kW

- COP_{act} = RE/input = 6.32

2.cop of the system with nano based lubricant/refrigerant (0.5%vol)

1. Compressor at suction pressure: 2 bar
2. Compressor at delivery pressure: 25 bar

1.Temperature at these junctions:

T1 = 32ºC

T2 = 55 ºC

T3 = 25 ^{o}C

T4 = -4.1 ^{o}C

2.Dry bulb Temperature of air at inlet and outlet:

Tin = 27 ºC Tout = 22.5 o C

3.Wet bulb Temperature of air at inlet and outlet:

Tin = 20 ºC Tout = 18.1 o C

4.Energy meter*:*

For 10 revolutions time taken by the disc = 115 s

Energy meter constant = 600

Velocity of air (V) = 3 m/s

From R600A pressure-enthalpy chart (p-h) represents:

For P1 = 2 bar, T1 = 31ºCà h1 = 427.9 kJ/kg

P2 = 25 bar, T2 = 54 ºC à h2 = 439.8 kJ/kg

- Enthalpy (h3) = h4 = 234.9 kJ/kg
- COP $_{th}$ = 18
- H1 = 52 kJ/kg H2 =45 kJ/kg (obtained from psychometric chart)

ma = (21 * 10^{-2})* 1.183 * 3 = 0.747 kg/s

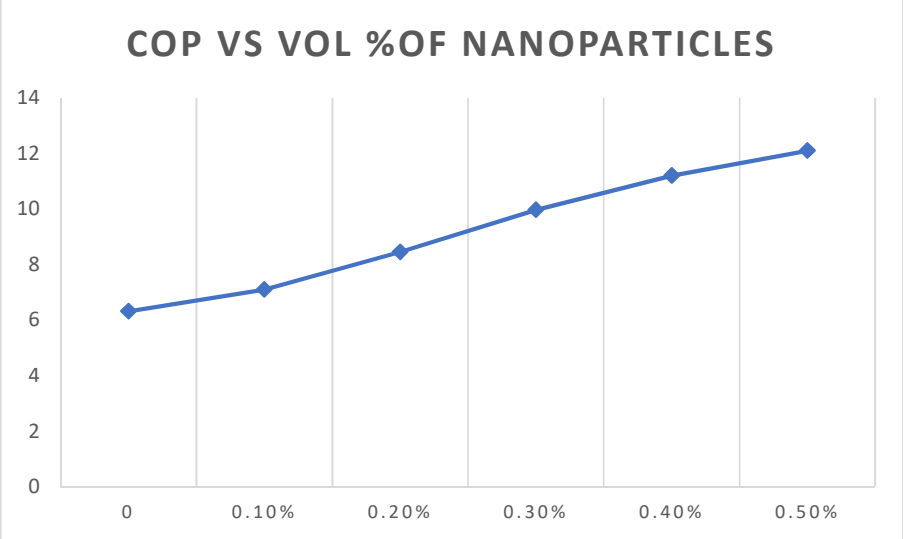
R.E = .747 * 7.4 = 5.52 kW

Input value= 3600*10 / (600*115) = .48 kW

COP $_{act}$ = Refrigeration effect (R.E)/input value= 12.1

GRAPH:

COP VS VOL %OF CU NANOPARTICLES



4.CONCLUSIONS:

- An experimental study was conducted on VCR system with a containing 0.5% vol of copper nanoparticles (Cu) of and the blend mixture PEG/R600a in refrigerant shows us increase in transfer of heat rates. The nano refrigerant can also reduce the consumer work is done, it causes reduction in the consumption of power, for 10 revolutions of a disc the time taken in energy meter differs positively from default conventional refrigerant used.
- With the dispersion of copper nanoparticles, the enhanced COP might be mainly because of improved of nanoparticles which were dispersed in refrigerant and also in oil of compressor improved thermal characteristics.
- With the nano inclusions, there were also issues pertaining to the settlement of nanoparticles, when refrigerant in steady condition.

TABLE: COP PERFORMANCE

SL NO	VOL% OF CU NANO PARTICLES	COP
1.	0	6.32
2.	0.1	7.1
3.	0.2	8.45
4.	0.3	9.97
5.	0.4	11.2
6.	0.5	12.1

5.REFERNCES

Rana JN and Pipwala H, A review on Thermodynamic Analysis of a Vapour Compression Refrigeration System using Hydrocarbon Refrigerants ,2017 Int. Res. J. Eng. Technol 1794–1797.

Subramani N and Mohan A, Performance Studies on a Vapour Compression Refrigeration System Using Nano-Lubricant, Int. J. Innov. Res. Sci. Eng. Technol., vol. 2, no. 1, pp. 522–530, 2013.

Saidur, R, A Review on the performance of nano-particles suspended with refrigerants and lubricating oils in refrigeration system, Int J of Renewable and Sustainable Energy Reviews, Vol. 15, 2011, 310-323. [8]

Joseph Sekher, S. , Improved energy efficiency for CFC domestic refrigerators retrofitted with ozone friendly HFC134a, Int J of Thermal Sciences, Vol. 43, 2004 ,307-314. [9]

Ching-Song Jwo, Efficiency analysis of home refrigerators by replacing hydrocarbon refrigerators, Int J of Measurment, Vol. 42, 2010, 697-701