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PERFORMANCE ANALYSIS OF VCR'S USING NANOREFRIGERANTS

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Abstract -*In accordance with Kyoto and Montreal protocol, it is highly indispensable to look for eco-friendly as well, energy efficient refrigerants thereby improving the refrigerating effect and co-efficient of performance. Nano fluids enticed many attentions around the world as a substantial alternative to increase the heat transfer performance. In present investigation, exergy analysis of VCRS is done with Nano refrigerants (R134a blended with ZnO) and (R134a blended with ZnO&SiO2) for the anomalous improvisation of thermo physical properties and heat transfer characteristics of refrigerants. The experiments used a 7 litre capacity domestic refrigerator as a test-ring which operates with Nano refrigerants. The coefficient of performance is evident to be higher rather than bare R134a refrigerant and the total consumed energy is saved significantly. Thus it demonstrates that nanoparticle and its dispersement in base fluid are the key contributors to the heat transfer & COP enhancements in refrigerators.*

Key Words: **Clustering, Exergy, Nano Refrigerants, R134a, Thermo Physical.**

1.INTRODUCTION

The industrial revolution that held after the second half of the twentieth century has enlarged the usage of new technical products in our daily life, in which the refrigerators and air conditioning systems play a very important role in the industrial, domestic and commercial sectors for cooling, heating, preserving foods and for cryogenic applications. There are innumerable significances of such systems which made it an inseparable part of the human life. These utilities are one of the major consumers of electricity around the globe. Energy consumption is directly proportional to the economic development of any nation i.e. lesser the consumption of energy, higher the development in their economy. Moreover the rate of energy consumption per capita has become one of the most important criterion of success in the development of the countries. However refrigerators and its areas are in a great interest now, because of the increase in the cost of conventional fuels, higher energy consumption and environmental concerns around the world. Hence a detailed study is required in this field so as to curtain the energy consumption as well as to increase the performance of the existing systems without polluting the environment.

1.1 Refrigeration Cycle

Refrigeration is a method of taking out heat from a low-temperature reservoir and transporting it to a high-temperature reservoir. It is also defined as the process of attaining and retaining a temperature below that of the surrounding, the aim of cooling some product or space to the required temperature. Perhaps the popular applications of rerigeration are storing perishable food, Refrigeration is used to deliquesce gases like oxygen, nitrogen, propane and methane, while transfering the food and dairy prodeucts, cryogenic applications as well as in many power plants, chemical processes with low temperature requirements. A refrigerant is a substance basically in the liquid or gaseous state which brings out the refrigeration effect. The selection of refrigerant is based upon two of the most important factors, Ozone Depletion Potential (ODP) and Global Warming Potential (GWP). The commonly used refrigerant in present day is R134a wich has very low ODP and GWP values (ODP-0 & GWP-1200). The normal refrigeration cycle is a closed cycle process. Nearly all the domestic refrigeration is Vapour Compression Refriggeration type. The main processes in this cycle are listed below.

- Process 1-2: Isentropic compression of saturated vapour in compressor
- Process 2-3: Isobaric heat rejection in condenser
- Process 3-4: Isenthalpic expansion of saturated liquid in expansion device
- Process 4-1: Isobaric heat extraction in the evaporator

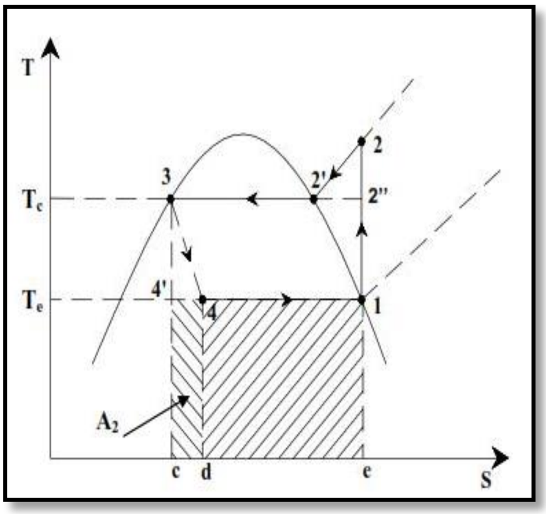

Fig. 1: Refrigeration Cycle

1.2 Nanoparticles and its application in Refrigeration

Nanoparticles as well as Nano fluids have grabbed attention of many in this present scenario. Nanoparticles are nanometer sized particles in the order of 10-9 m. Nano fluids are engineered colloids which consist of a base fluid with Nano sized particles (1-100 nm) suspended within them.Nano fluids have special advantage that these fluids possess enhanced properties than the base fluids. They possess many attractive features like enhances thermo physical properties, higher thermal conductivity and higher surface area. There are several classifications of Nano fluids in which the nanoparticles dispersed in the base fluids may be of metal oxides, carbides, nitrides, carbon nanotubes, diamond, graphite etc.

2. LITERATURE SURVEY

Many researches has been initiated in this field. Kumar, Sridhar, & Narasimha, (2013) [1] et al., Conducted experimental study on performance of VCR system with Al2O3 nanoparticles, mineral oil as lubricant and R600a as refrigerant in the domestic refrigerator. The experimental setup for this purpose was build based on the national standards of India. The nanoparticles are added in to refrigerant which results in increasing of thermal conductivity and heat transfer property of the refrigerant.

The mass fraction of nanoparticles in lubricant is 0.06%. The heat transfer characteristics were estimated numerically. This study indicates that when mineral oil and Al2O3 nanoparticles were used then the power consumption of compressor is decreases by 11.5% and the freezing capacity is also higher. The coefficient of performance of the system also increases by 19.6% when POE oil changed with mixture of nanoparticles mineral oil.

Hays, A [2]. et al has stated that the Nano fluid preparation plays a vital role in the thermal conductivity and thermo physical properties of them. Abbas, M., (2013) [3] et al., concluded that the COP of the refrigeration system increases about 4.1% if 0.1 % CNT is used. But CNT is very costly while comparing to other materials. Preparing CNT in normal conditions affect the properties of CNT and it is not as easy as preparing other Nano fluids. Kumar, D., Elansezhian, R. (2012) [4] et al., acknowledged the same that COP increases on mixing nanoparticles with refrigerant than using bare refrigerant.

He has also stated that upon using ZnO nanoparticles, the COP has been increased significantly and the power consumption has been reduced [5]. Similarly some other researches like Anoop, K., et al (2014) [6], Bartelt, K., et al (2008) [7] and Jiang, W., [8] et al (2009) says that parameters like thermo physical properties, nucleate pool boiling heat transfer co-efficient, friction in moving parts of refrigeration system and energy consumption has been affected positively by using the mixture of nanoparticle blended with the refrigerant.

3. METHODS AND MATERIALS

There are 3 important factors that has been taken into consideration during this research which mainly drives the whole process. They are

1. Refrigerant
2. Selection of nanoparticles
3. Method of preparation of Nano fluids

3.1 Refrigerants

As stated earlier in this paper, there are many types of refrigerants but they are selected on the basis of their ODP and GWP values. In this investigation R134a has been selected since it possess 0 ODP and low GDP (1200) value. More over this refrigerant is economical and is readily available in the market. They are barely toxic and has good heat transfer characteristics.

3.2. Selection of Nanoparticles:

They are characterized by their high thermal conductivity values. The following table shows the thermal conductivities of some of the commonly used nanoparticles for heat transfer applications.

Material	CNT	Diamond	Cu	Al	Ni	Ni	Si	CuO	ZnO	Al_2O_3	TiO_2	Oil
Thermal Conductivity (W/mK)	1800 to 6600	2200 to 2300	350 to 400	200 to 250	90 to 240	100 to 150	100 to 150	20 to 40	10 to 50	30 to 40	0.4 to 11.8	0.1 to 0.2

Table. 1: Thermal Conductivities

In this investigation ZnO and SiO2 has been selected since it has high thermal conductivities than other materials that are economically available in market. CNT's, Diamond and Copper nanoparticles are costlier and their methods of preparations are tedious rather than Zinc Oxide and Silicon dioxide nanoparticles.

3.3. Method of preparation of Nano fluids:

There are many important things to be noted down in this part. Method of preparation of Nano fluids involves many important points viz, the stability of nanoparticles in the base fluid after its dispersement and nanoparticle clustering. The selection of method for preparing the Nano fluids mainly depends on these factors. There are two main methods for preparing Nano fluids. They are one-step method and two-step method. One step method of preparing the Nano fluids is crucial and difficult. Hence two-step method is used for preparation in which the base fluid selected is taken separately and the nanoparticles are dispersed in the base fluid using intensive magnetic force agitation, ultrasonic agitation, high-shear mixing, homogenizing, ball milling.

4. METHODOLOGY

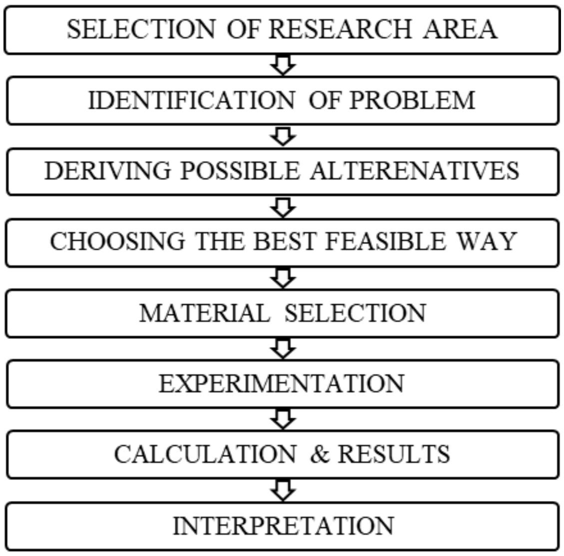

Fig.2: Flow chart – Methodology.

The below table shows the design of experiments carried out to complete the investigation. As per our convenience the design of experiments has been drafted with required proportions of nanoparticles mixed with base fluids.

PROPORTIONS	TEMPERATURE	
R134a	20°C	15°C
R134a with ZnO-1g and SiO_2-1g	20°C	15°C
R134a with ZnO-1.5g and SiO_2-0.5g	20°C	15°C
R134a with ZnO-0.5g and SiO_2-1.5g	20°C	15°C

Table.2: Design of Experiments.

Initially, using bare refrigerant R134a, experiments has been done followed by mixing the nanoparticles in the various above mentioned proportions and the experimentations has been conducted.

5. EXPERIMENTATION

The following has been followed during experimentation.

STEP 1: The experimental setups are cleaned and wiped.

STEP 2: The refrigerant that is inside the compressor is pumped out. Nitrogen gas is used to flush out the blockages and impurities in the experimental setup.

STEP 3: Before filling the refrigerant R134a inside the compressor it is vacuumed at about -30 psi.

STEP 4: Then using suitable hoses the refrigerant of about 0.5 kg is filled inside the compressor for every instance of testing in both the setups separately.

STEP 5: The following readings has been noted down.

- **W-** Quantity of water used in the setup in Litre (l)
- **Ei-** Initial Energy meter reading in Kilowatt (KW)
- **Eo-** Final Energy meter reading in Kilowatt (KW)
- **Tr-** Room Temperature in degree Celsius (°C)
- **Tf-** Final Temperature in degree Celsius (°C)
- **H1-** Enthalpy of refrigerant at compressor outlet taken from P-h chart of R134a for its corresponding pressure and temperature
- **H2-** Enthalpy of refrigerant at condenser inlet taken from P-h chart of R134a for its corresponding pressure and temperature
- **H3-** Enthalpy of refrigerant at expansion valve inlet taken from P-h chart of R134a for its corresponding pressure and temperature
- **H4-** Enthalpy of refrigerant at compressor inlet taken from P-h chart of R134a for its corresponding pressure and temperature

STEP 6: The stopwatch is switched on to note down the time taken for the experiment to complete

STEP 7: The atmospheric temperature is made to drop to 20°C and all the readings in the below tabular column are noted down.

STEP 8: Similarly the temperature is allowed to drop to 15°C again all the readings are noted down in the respective columns.

STEP 9: Accordingly results has been calculated

NOTE: For every proportion used in this research, the refrigerant that has been filled inside is pumped out and nitrogen flushing has been done to remove the agglomeration of nanoparticles in the channel if any.

Fig.3: Experimental Setup

6. RESULTS

The Actual COP, Theoretical COP and the power input & output has been calculated for the respective design of experiments. The following are the important results obtained.

- Actual COP of the system with bare refrigerant has been obtained around 1 to 1.25
- Upon using the blending of nanoparticles with refrigerant, the Actual COP of the system has been increased to around 26 %
- Different proportions yield different variations in the performance.
- Different nanoparticles has different effects in the COP.

7. CONCLUSION

This research has proved that the blend age of nanoparticles with refrigerant has positive influence on the performance as well as the power consumption of the refrigeration cycle.

REFERENCE

[1]. Kumar, R.R (2013), Heat transfer enhancement in domestic refrigerator using R600a/mineral oil/ nano-Al2O3 as working fluid. International Journal of Computational Engineering Research, 42-50

[2]. Hays, A., et al, 2006, The effect of nanoparticle agglomeration on enhanced Nano fluidic thermal conductivity, International Refrigeration and Air Conditioning Conference, Purdue University, paper R132

[3]. Abbas, M., et al, 2013, Efficient Air-condition unit by using Nano-refrigerant, EURECA 2013, p. 87-88

[4]. Kumar, D., Elansezhian, R., 2012, Experimental study on Al2O3 – R134a Nano refrigerant in refrigeration systems, International Journal of Modern Engineering Research, vol.2, iss. 5, p. 3927-3929.

[5]. Kumar, D., Elansezhian, R., 2014, ZnO Nano refrigerant in R152a refrigeration systems for energy conservation& green environment, Front. Mech. Eng., DOI 10.1007/s11465-014-0285-y

[6]. Anoop, K., et al, 2014, Rheology of mineral oil-SiO2 Nano fluids at high pressure and high temperatures, International Journal of thermal sciences, 77 p. 108–115.

[7]. Bartelt, K., et al, 2008, Flow-boiling of R134a/POE/CuO Nano fluids in horizontal tube, International Refrigeration and Air Conditioning Conference, Purdue University, paper 928.

[8]. Jiang, W., et al, 2009, Experimental and model research on Nano refrigerant thermal conductivity, ASHRAE HVAC&R Research, vol. 15 no. 3, p. 651-669.