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An Experimental Study of Nanorefrigerant (HC +CuO) Based Refrigeration System

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ABSTRACT

In the present work, an experimental study is made on the performance of refrigeration system based on (R600a|R290) nanorefrigerant. Here cupric oxide (CuO) nanoparticles of size (20-30) nm has been taken. Three different volumetric concentrations (0.15, 0.25, 0.35) gm of CuO were being used in this refrigeration system. An advancement in COP and reduction in power consumption is seen during the observation . It is also found that cooling capacity of the system is increases with different volumetric concentrations of nanoparticles. The experimental studies indicate that the refrigeration system with nanorefrigerant works normally. Thus, cupric oxide (CuO) nanoparticles can be used to improve the performance of a hydrocarbon based refrigeration system under analyzed conditions.

Keywords : COP, CuO Nanoparticles, Hydrocarbon Refrigerent, Energy Consumption, Nanorefrigerant

I. INTRODUCTION

Refrigeration and Air-conditioning is the need of today's world. . For this purpose the Vapor compression refrigeration system is one of mostly used cyclic device. In this system, refrigerant which is employed as a working fluid is the main part of the system. Its working consists of four main processes which are as following:- evaporation, compression, condensation and throttling. The vapour refrigerant at low temperature and low pressure goes to compressor via inlet valve and discharges as high temperature and high pressure refrigerant. After that it enters to the condenser in which at constant pressure and temperature rejects its latent heat to surroundings. Now saturated liquid refrigerant is throttle by throttle valve. The temperature of the refrigerant becomes low below the temperature the refrigerated space during this process. Now refrigerant enters to the evaporated through which it absorb heat and reenters the compressors, thus completing the cycle.

II. METHODS AND MATERIAL

1. Refrigerants

Refrigerants are used as working substances in a Refrigeration systems for heat transfer purposes.
There are various type of refrigerant are available in market like HFC, HCFC, CFC, FC, HC, azeotropes etc. Due to high performance characteristics HCF refrigerant are mostly used. But nowadays the usage of HCF refrigerant is limited due to environmental and ozone layer depletion concern.

OZONE LAYER DEPLETION

$CCL_2F_2 = CCLF_2 + CL$

$O_3 + CL = CLO + O_2$

Now attention given usage of eco-friendly refrigerant in refrigeration and air-conditioning system. The hydrocarbon refrigerant are the best substitute due to its low GWP and low ODP. Here hydrocarbon refrigerant R600a|R290 were being used in this research work.

2. Nano Fluids

Nano fluids are a new class of advanced heat-transfer fluids which is combination of base fluid with suspended nano-sized particles (diameter < 100nm). In other words suspension of nano particle in a base fluid is called nano fluids.

Nano particles may be metal or metal oxides (like Cu, Ag, Al_2O_3, CuO, SiO_2) which helps in more heat transfer by increasing heat transfer characteristics.

By experimental studies it is observed that behaviour of nano fluid depends on various factors like size of particle, materials of particles, viscosity, volume fraction, shape of particles, thermal conductivity and base fluid.

3. Methodology

In this experiment, the performance of the pure hydrocarbon refrigerant is compared with the nanorefrigerant in which different volumetric concentrations of CuO nanoparticles are mixed with hydrocarbon refrigerant in vapor compression refrigeration system.

The refrigerant temperature at inlet and outlet of each component of the system be measured correctly. It is done with the help of thermometer.

In the same way, pressure across each component of system should be measured with the help of pressure gauge. These pressure gauges fitted at the inlet and outlet of the compressor and evaporator.

These measurements are important to evaluate the performance of the system. To find the power consumed and energy consumed by the system readings of wattmeter and energy meter are noted carefully.
First of all the performance is investigated with the pure hydrocarbon refrigerant. After that the weighted CuO nanoparticles are injected into the system and performance is evaluated.

The very important factor which varied during experiment is the volumetric concentration of nanoparticles in the system.

4. Procedure

The experimental setup is placed in a constant room temperature where proper insulation is maintained. The test rig is made in the reference to domestic refrigerator. The variation in ambient temperature is found to be ±2%. An evaporator of the system is dipped in 10 litres of water and maintained at constant evaporator temperatures (25-26 ^{0}C) and (35-36 ^{0}C).

All readings were noted at constant volume flow rate i.e. 3.5 LPH. First of all data is collected for pure hydrocarbon refrigerant and then nanoparticles are introduced having three different weights 0.15gm, 0.25gm and 0.35gm.

The charged mass of the gas is 45gm. Experiments were carried out with nanoparticles of size 20-30 nm.

Tests are performed to study C.O.P., power consumption, time taken for temperature fall from 40^{0}C to 25 ^{0}C, temperature drop in condenser, temperature gain in evaporator and temperature at all respective points.

The temperature at inlet and outlet of each component is measured with the mercury thermometer which was already calibrated with standard fluid.

First of all system is evacuated to remove moisture as moisture may combine with refrigerant and affect the thermo physical properties.

After that evacuated system is charged with hydrocarbon refrigerant (45 gm) through the charging line. Now the system is switched on until it reach in steady state condition. It almost achieved after 1:25 hrs.
When system achieved steady state condition, temperature and pressure reading at compressor inlet and outlet, condenser outlet and after expansion were taken within interval of 15 minutes.

The atmospheric temperature is also noted down. At the start and at the end of experiment readings of energy-meter and heater are also noted.

Similar procedure is applied for nano refrigerant HC+CuO (20-30 nm) for 0.15 gm, 0.25 gm and 0.35 gm mass of CuO.

Now all these noted readings are used to find COP, temperature drop in condenser, temperature gain in evaporator and time taken to achieve from 40 ^{0}C to 25^{0}C.

Now in this way performance of the vapour compression refrigeration system is evaluated.

III. RESULTS AND DISCUSSION

The addition of nanoparticles (CuO) in the refrigerant R600a|R290 increases the COP, Cooling capacity and reduction in power consumption of the refrigeration system. Following observations are made regarding this experiment.

An improvement in coefficient of performance was also observed during the investigation (3.18% – 11.57%). This was achieved under constant evaporator load at 25-26^{0}C. A reduction in power consumption (13.5%to19.7%) along with temperature drop (from 40^{0}C – 25^{0}C) is also achieved when nanorefrigerants are used.

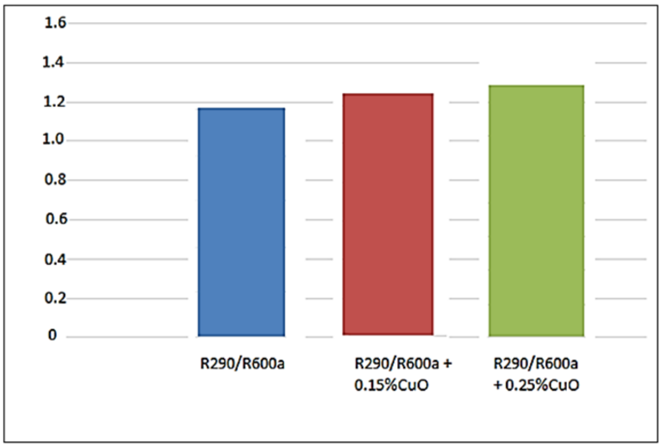

Figure 1. COP Variations for Refrigerants

The above plotted graph is COP comparison for pure refrigerant R600a|R290 and different volumetric concentrations of nanoparticles. The result shows that by adding nanoparticles COP of the refrigeration system increases.

Now graph is drawn for cooling load temperature time curve for different volume concentrations of nanoparticles.

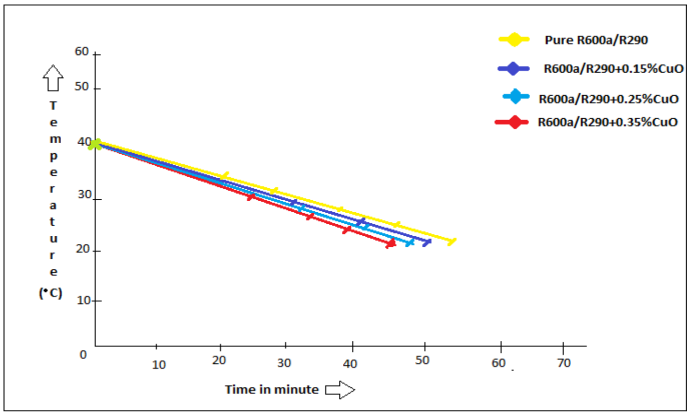

Figure 2. Cooling load curve for different concentrations

The result shows that as concentration of nanoparticles increases the time of cooling speed decreases. That is lesser time taken by system more efficient and effective the system.

IV. CONCLUSION

On the basis of present research work following results could be concluded:-

[1] There is improvement in COP of the system by 3.18%to 11.57 % due to usage of nanorafrigerant.

[2] It was observed that energy consumption reduces by 13.5% to 19.7% by using nanorafrigerant of different concentration taken under consideration.

[3] The system works normally and safely with nanorafrigerant without modifications in existing system. That is major advantages of using hydrocarbon-CuO nanorafrigerant along with green environment (negligible harmful effect on surroundings).

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