Improvement of Cop of Vapor Compression Refrigeration System by using Nano-Refrigerants

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Abstract— In this paper, an experimental work was investigated on Nano refrigerant .Nano-refrigerants Al2O3-Ethylene glycol oil and TiO2-Ethylene glycol oil were used as Nano- refrigerant in R134a vapor compression refrigeration system. The fabrication of experimental setup was in the lab. The cooling capacity test was performed on the system. The results indicate that Al2O3 and TiO2 Nano refrigerant works normally and safely in the refrigeration system. The refrigeration system performance was better when Nano-refrigerants with R134a as working fluid. The COP of vapor compression refrigeration system improved 12.08% with addition of Al2O3 and COP improved 21.18% with the addition of TiO2 compare with R-134a. The results indicate that heat transfer coefficient increases with the usage of Nano Al2O3 and TiO2. Thus using Al2O3 and TiO2 Nano refrigerants in refrigeration system is found to be feasible.

Key words: Nano refrigerant, Al2O3 and TiO2 nanoparticle, COP, performance

I. INTRODUCTION

Nano fluids are a new class of advanced heat-transfer fluids engineered by dispersing nanoparticles smaller in diameter than 100 nano meter (nm) in conventional heat transfer fluids. Conventional heat transfer fluids have inherently poor thermal conductivity compared to solids. The nanoparticle materials are usually of metal, non-metal and their oxides, which enhance the heat transfer performance of base fluids. Hence, there is huge scope of its application in heat transfer area. Recently, some investigations revealed the application of nanoparticles in refrigeration systems and significant improvement in performance has been observed. Globally, 1, 1, 1, 2-Tetrafluoroethane (HFC134a) is the most used alternative refrigerant in refrigeration equipment such as domestic refrigerators, and automobile air conditioners. Despite the relatively high greenhouse warming potential (GWP) of HFC134a, HFC134a has been accepted as a long term alternative refrigerant in many countries. In recent times, Nano fluids have been noted as invaluable alternatives to conventional working fluids such as HFC134a, used in refrigeration system. Nano-particles suspended in refrigerant of the compressor is found to be increasing the system coefficient of performance. Nano Al2O3 and TiO2 give better performance in refrigerator. Sheng et al. studied the reliability and performance of a domestic refrigerator w i t h T i O 2 and mineral oil refrigerant w i t h R134a. The results obtained reduction in 26.1% energy consumption. Ching-Song Jwo et al. studied the usage of alumina in R134a refrigeration system. The thermal conductivity was found to increase upto 4.5%, when the sample temperatures were 20°C to 40°C. Xuan, et al., (2003) explained that due to their Nano structural features, nanoparticles exhibit enhanced properties (mechanical, thermal, physical, chemical), phenomenon and processes than conventional materials. Furthermore, the surface area per unit volume of nanoparticles is much larger (million times) than that of micro particles. These properties can be utilized to develop stable suspensions with enhanced flow, heat-transfer, and other characteristics.

II. EXPERIMENTAL SETUP AND METHODOLOGY

The setup consists of compressor, condenser, expansion device and an evaporator. Capillary tube is used as an expansion device. The coil type evaporator is loaded with water. To charge the refrigerant into refrigerator service port is provided to compressor. The total experimental setup placed on a platform at constant room temperature with fewer variations in temperatures. The adequate insulation has been provided in order to minimize the heat losses to environment. Refrigerant R134a is used as base refrigerant and Al2O3 used as nanoparticles with 20 nm diameter. The flow rate of refrigerant is maintained as 6.5 LPH through the evaporator. Evaporator is installed in water container and two constant heat fluxes at temperature 16ºC and 30.5ºC are supplied for different experiments. Experiments are first carried out by using pure R134a and then by using Nano refrigerant having 0.5% and 1% (wt %) Al2O3 nanoparticles in base refrigerant R134a. Investigation includes study of COP and temperature at all salient points at two different heat fluxes and ambient temperatures (21ºC and 28ºC). External compressor is used for system evacuation before charging in order to remove moisture from system. Refrigerant mass to be charged into the system is taken as 150 gm. All readings are taken after achieving steady state at 15 minutes time interval and average of all readings has been calculated at the end. The air flow velocity was found to be less than 0.35m/s. The following are the some specifications. Refrigerant used is R-134a, charged masses of refrigerants 150gm, 200gm and gross capacity of refrigerator is 80 Liters. The temperatures at different parts of the experimental setup are measured using thermocouples. And pressure gauges to find pressure at compressor inlet, outlet, condenser outlet and at evaporator outlet. The outlook of vapor compression refrigeration system is shown in below figure.

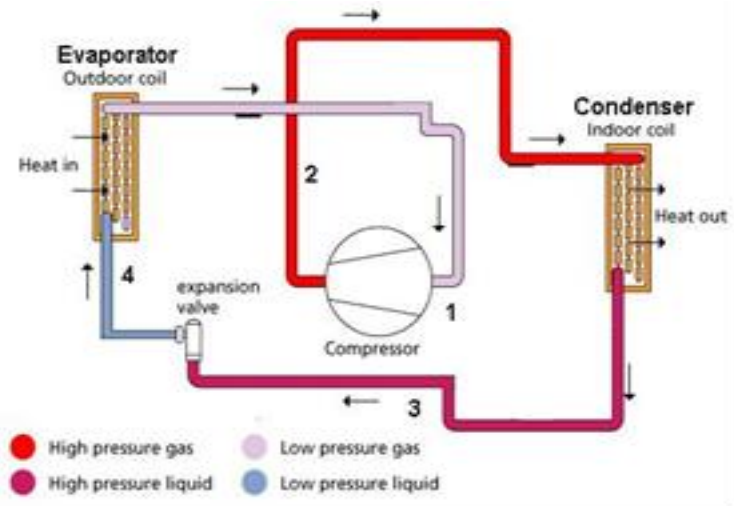

Fig. 1: Vapor Compression Refrigeration System

III. EXPERIMENTAL PROCEDURE

A. Preparation Of Nano- Refrigerant

Nanoparticles of Al2O3 are added to the refrigeration system by adding them to the refrigerant in the compressor of the system. The preparation and stability of this Nano refrigerant mixture is very important. The nanoparticles of Al2O3 in the range 40-50 nm were mixed with ethylene glycol to synthesize Nano refrigerant in a recommended method for Nano fluid. Ethylene glycol was used and supplied without further purification. The Nano particles of Al2O3 and ethylene glycol mixture were prepared with the aid of stirrer for 2 hrs. The mixture is then further kept vibrated with an ultrasonic homogenizer for half an hour to fully separate the nanoparticles and to prevent any clustering of particles in the mixture to obtain proper homogenization. No surfactant is added in this work as there may be any influence in reduction of thermal conductivity and performance.

Fig. 2: Preparation of Al2O3 Nano-Refrigerant

The same procedure done above was used to TiO2 Nano particles.

The nanoparticles of TiO2 in the range 40-50 nm were mixed with ethylene glycol to synthesize Nano refrigerant in a recommended method for Nano fluid. Ethylene glycol was used and supplied without further purification. The Nano particles of TiO2 and ethylene glycol mixture were prepared with the aid of stirrer for 2 hrs. The mixture is then further kept vibrated with an ultrasonic homogenizer for half an hour to fully separate the nanoparticles and to prevent any clustering of particles in the mixture to obtain proper homogenization. No surfactant is added in this work as there may be any influence in reduction of thermal conductivity and performance.

B. Concentrations Of Nano-Refrigerants

Nano-Refrigerant with 0.15% to 0.2% concentration of Al2O3 in the refrigerant R-134a is prepared and tested in the setup.
As same Nano-refrigerant with 0.15% to 0.2% concentration of TiO2 in the refrigerant R-134a is prepared and tested in the setup

C. Charging Of the Set Up

The fabricated experimental setup was filled withN2 gasata pressure of 3.5barto7bar and this pressure is maintained for 45minutes. Thus the system was ensured for no leakages. The system was evacuated by removing N2 gas. A vacuum pump was connected to the port provided in the compressor and the system was completely evacuated for the removal of any impurities. This process was carried out for all the trials. Through the service ports Nano refrigerant was carefully added to the system. Precision electronic balance with accuracy ±1% was used to charge a mass of 150 gm. into the system. Every time the system was allowed to stabilize for 20 min.

Fig. 3:

IV. PERFORMANCE TEST

A performance test is made for 150 gm. of pure R134a system which is treated as the basis for comparison with other results. Nano Al2O3 – R134a with 0.15% concentration was fed to the experimental setup and the tests were conducted under the same conditions. In order to obtain repeatability each test was run for 4 to 5 times. Performance tests were also conducted with charge mass of the order of 150gm., and 200gm.

A. Factors Affecting Refrigeration System

The factors that affect the performance of vapor compression refrigeration system are Refrigeration effect, Coefficient of Performance (COP).

1) Refrigeration Effect

Q= Heat removal / mass flow rate or refrigerant

Q= h1-hf3

2) Coefficient Of Performance

COP = Heat Removal / Work Input W= h2-h1

V. CONCLUSIONS

The study showed how R134a refrigerant in combination with Al2O 3 and TiO 2 Nano fluids were used as a working fluid of domestic vapor compression refrigerators. The results indicated that The R134a refrigerant and Nano fluid mixture worked normally and efficiently in the domestic refrigerator. Other major conclusions are listed below;

- The mixture of R-134a and Al2O 3 Nano - refrigerant improves the COP vapor compression refrigeration system by 12. 0 8% .
- And the mixture of R-134a and TiO2
- Nano -refrigerant improves the Copvap or compression refrigeration system by 21. 18 %.

Recommendations Based on the analysis performed, the following are recommended;

1) The Nano refrigerants R134a –Al2O3 and TiO2 are more eco-friendly working fluid with less power consumption than the pure R134a refrigerant, relatively higher COP, and better pull- down time and is therefore more suitable and highly preferable for modern day refrigerators than the pure R134a and other conventional refrigerants.
2) Based on the property characterization of the Nano fluid, there may be need for the development of a new compressor that takes cognizance of low viscosity and low pH nature of the Nano fluid.
3) There is a need for corrosion tests to be carried out on the compressor material to evaluate the aggressiveness of the Nano fluid.
4) The results show that the Nano fluid can enhance the performance of vapor compression systems. Therefore it is yet to be known if it will do the same for vapor absorption system.

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