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PREDICT THE PERFORMANCE OF AIR CONDITIONING SYSTEM BY USING NANOREFRIGERANT

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ABSTRACT

R134a is most widely adopted alternate refrigerant in refrigeration equipment, such as domestic refrigerators and air conditioners. This refrigerant heat transfer capacity is not so good and increase power consumption. Due to these limitation nanofluids are enhanced with the normal lubricant and increases the heat transfer capacity and reduces the power consumption. The experimental studies indicate that the air conditioning system with nanorefrigerant works normally. It is found that the coefficient of performance is increased by 13 % and the power consumption reduces by 20 % when POE oil is replaced by a mixture of POE oil and Al_2O_3 nanoparticles.

Keywords: Aluminium Oxide nanoparticles, Nanorefrigerant, Refrigeration effect, Power consumption, COP.

1 INTRODUCTION

It is true that rapid industrialization has led to unprecedented growth, development and technological advancement across the globe. It has also given rise to several new concerns. Today global warming and ozone layer depletion on the one hand and spiraling oil prices on the other hand have become main challenges. Excessive use of fossil fuels is leading to their sharp diminution and nuclear energy is not out of harm's way. In the face of imminent energy resource crunch there is need for developing thermal systems which are energy efficient. Thermal systems like refrigerators and air conditioners consume large amount of electric power. So it is necessary to develop energy efficient refrigeration and air conditioning systems.

The rapid advances in nanotechnology have led to emerging of new generation heat transfer fluids called nanofluids. Nanofluids are prepared by suspending nano sized particles (1-100nm) in conventional fluids and have higher thermal conductivity than the base fluids. Nanofluids have the following characteristics compared to the normal solid liquid suspensions. i) higher heat transfer between the particles and fluids due to the high surface area of the particles ii) better dispersion stability with predominant Brownian motion iii)reduces particle clogging iv) reduced pumping power as compared to base fluid to obtain equivalent heat transfer. Based on the applications, nanoparticles are currently made out of a very wide variety of materials, the most common of the new generation of nanoparticles being ceramics, which are best split into metal oxide ceramics, such as titanium, zinc, aluminium and iron oxides, to name a prominent few and silicate nanoparticles, generally in the form of nanoscale flakes of clay.

Addition of nanoparticles changes the boiling characteristics of the base fluids. Nanoparticles can be used in air conditioning systems because of its remarkable improvement in thermo-physical and heat transfer capabilities to enhance the performance of air conditioning systems. In air conditioning system the nanoparticles can be added to the lubricant (compressor oil). When the refrigerant is circulated through the compressor it carries traces of lubricant + nanoparticles mixture (nano-lubricants) so that the other parts of the system will have nanolubricant -refrigerant mixture.

The purpose of this article is to report the results obtained from the experimental studies on air conditioning system. In the present study the refrigerant selected is R134a and the nanoparticle is alumina.

2 EXPERIMENTAL SET-UP

For the studies an air conditioner trainer is used. The system consists of a compressor, air-cooled condenser, thermostatic expansion valve and an evaporator. The compressor used is a hermetically sealed reciprocating compressor. The evaporator is in the form of a finned tube and it is made of copper. A finned tube heat exchanger is used as the condenser and it is also made of copper. The condenser is cooled using a fan.

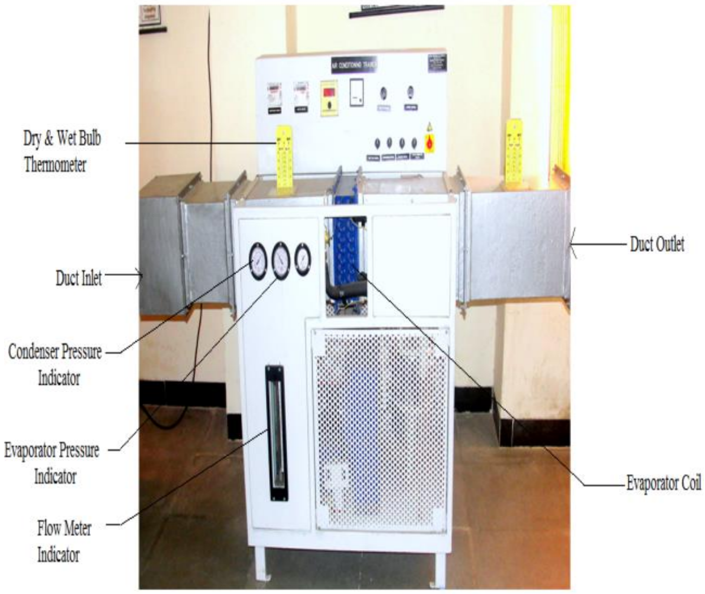

Fig1. Photograph of the experimental set up

The Bourdon tube pressure gauges are used to measure the pressures at the salient points of the air conditioning system, one each at the outlets of compressor, condenser, expansion device and evaporator. T- type thermocouples were used to measure the temperature at the various locations. The experimental setup used for the present study is shown in Figure 1 Before charging the system with the refrigerant; the system was checked thoroughly for leaks. Leak testing was carried out by charging the system with nitrogen at a pressure of 200 Psi. After the leak test the system was properly evacuated using a vacuum pump. The compressor was filled with nanolubricant and the system was charged with the refrigerant, in this case R134a.

3 METHODOLOGY

For controlling the temperature of air within a set of limits in the required season at various loads the methodology used in the experimentation can be done with this set-up. The operating procedure of experimental set-up is given below:

3.1 Cooling and Dehumidification

Switch ON the power supply unit and start the duct fan and Start condenser fan and wait for 2 – 3 minute. Check the water in bottle of wet bulb thermometer after that Start the compressor, flow of liquid will be observed in rotameter. Observe temperature of air and refrigerant on dry and wet bulb thermometer and temperature indicator respectively. Wait for 45 minute for achieving steady state condition and then note down the readings.

3.2 Heating of Air

Switch ON the power supply unit and start the duct fan and Check the water in bottle of wet bulb thermometer. Switch on the heater. Adjust the heater input with the help of dimmer stat provided on panel. Wait for 5 – 10 minutes to reach steady state and then note down the readings.

3.3 Preparation of nanofluid

Preparation of nanolubricant is the first step in the experimental studies on nanorefrigerants. Nanofluids can be prepared using single step or two step methods. In the present study two step procedure is used. Commercially available nanoparticles of aluminium oxide (manufactured by Sigma Aldrich) with average size <50nm were used for the preparation of nanolubricant. The experimentation is done with mass fraction of nanoparticles in the nanoparticle–lubricant mixtures for 1% and 2% by mass. An ultrasonic vibrator is used for the uniform dispersion of the nanoparticles and it took about 24 hours of agitation to achieve the same.

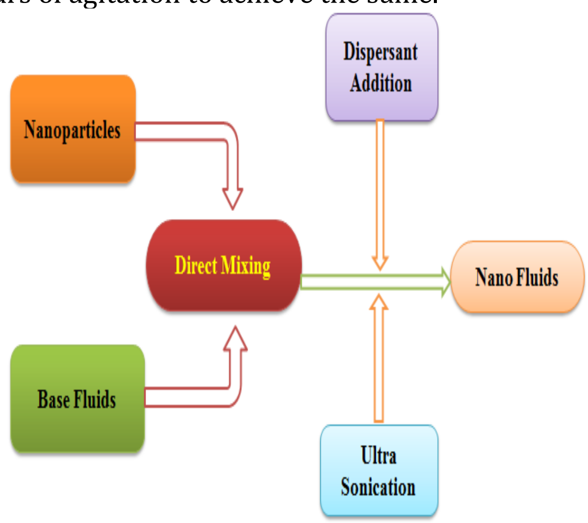

Fig 2 Two-step method

4 RESULTS AND DISCUSSION

In the present experimental study, two cases have been considered. The hermetic compressor filled with i) pure POE oil (poly-ester oil) ii) POE oil + alumina nanoparticles as lubricant. The mass fraction of the nanoparticles in the nanolubricant is 1% & 2% were considered.

4.1 Ambient temperature vs theoretical COP

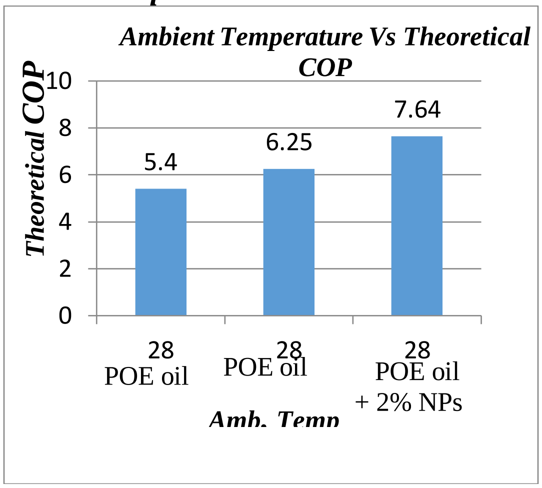

Fig 3 Ambient temperature Vs Theoretical COP

The ambient temperature vs theoretical COP chart is shown in fig 3. In all the cases ambient temperature is same i.e. 28°C. From figure it is clear that the theoretical COP of the system is increases if we use the nanolubricant instead of pure POE oil. At 28°C the COP of system for pure POE oil is 5.4, for mixture of POE oil and 1% Al_2O_3 the COP is 6.25 & for mixture of POE oil and 2% Al_2O_3 the COP is 7.64. For the calculations of theoretical COP the enthalpies values at salient points are taken from P-h chart of R134a.

4.2 Ambient temperature vs Carnot COP

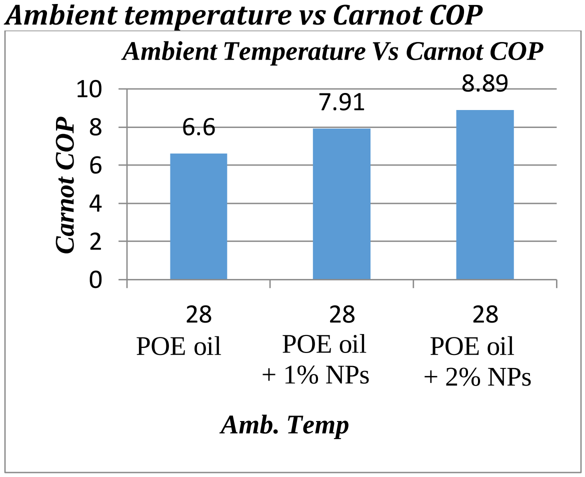

Fig 4 Ambient temperature Vs Carnot COP

Figure 4 shows the variation of Carnot COP with respect to ambient temperature. In all the cases the ambient temperature is same i.e. 28°C. From figure it is clear that the Carnot COP of the system is increases if we use the nanolubricant instead of pure POE oil. At 28°C the COP of system for pure POE oil is 6.6, for mixture of POE oil and 1% Al_2O_3 the COP is 7.91 & for mixture of POE oil and 2% Al_2O_3 the COP is 8.89.

4.3 Ambient temperature vs actual COP

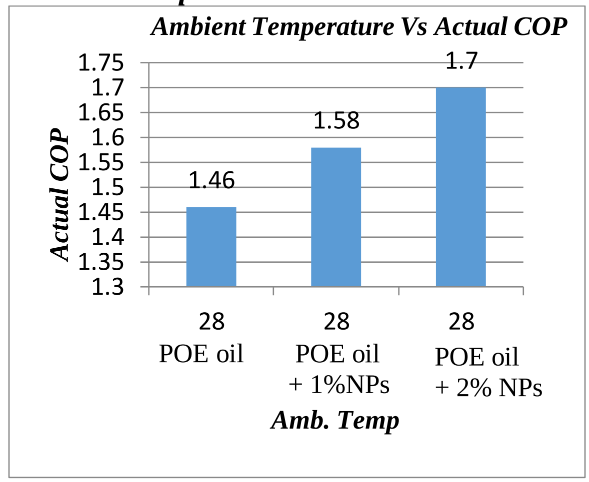

Fig 5 Ambient temperature Vs Actual COP

Figure 5 shows the variation of actual COP with respect to ambient temperature. In all the cases the ambient temperature is same i.e. 28°C. From figure it is clear that the actual COP of the system is increases if we use the nanolubricant instead of pure POE oil. At 28°C the COP of system for pure POE oil is 1.46, for mixture of POE oil and 1% Al_2O_3 the COP is 1.58 & for mixture of POE oil and 2% Al_2O_3 the COP is 1.70.

4.4 Ambient temperature vs Power consumption

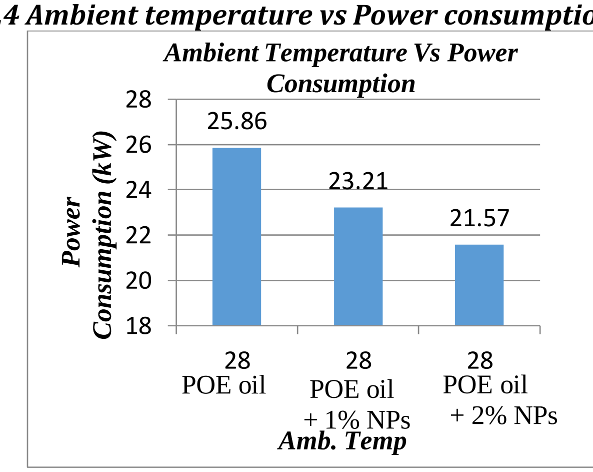

Fig 6 Ambient temperature Vs Power consumption

Figure 6 shows the comparison of power consumption of the compressor. The reduction in power consumption is 20 % if mixture of Al_2O_3 nanoparticles & POE oil is used instead of POE oil. At 28°C the power consumption of system for pure POE oil is 25.86 kW, for mixture of POE oil and 1% Al_2O_3 the power consumption is 23.21kW & for mixture of POE oil and 2% Al_2O_3 the power consumption is 21.57 kW.

5 CONCLUSION

Extensive experimental studies have been conducted to evaluate the performance parameters of an air conditioner system with nanolubricant. The conclusions derived out of the present study are

(ii) The R134a refrigerant and POE oil mixture with nanoparticles worked normally.

(ii) The coefficient of performance of the air conditioning system increases by 13 % when the conventional POE oil is replaced with nanorefrigerant.

(iii) Also the power consumption of the compressor reduces by 20% when the nanolubricant is used instead of conventional POE oil.

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