Australian Journal of Basic and Applied Sciences, 9(7) April 2015, Pages: 1-10

ISSN:1991-8178

Australian Journal of Basic and Applied Sciences

Journal home page: www.ajbasweb.com

Performance Evaluation of Air Conditioning System Using Nanofluids

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ARTICLE INFO

Article history:
Received 12 October 2014
Received in revised form 26 December 2014
Accepted 25 January 2015
Available online 25 February 2015

Keywords:
Air Conditioning, Compressor, Compressor, Condenser, Evaporator, Nanofluids

ABSTRACT

This paper describes thermal modeling of air conditioning system using various nanofluids. The performance of the heat pipe greatly depends on the filling ratio of the working fluids. The model uses information of the fluid input conditions, geometric characteristics of the system, size of nanoparticles and the compressor speed to forecast the fluids output temperatures, the operating pressures, the compressor power consumption and the system overall energy performance. Such an analysis can be conveniently useful to compare the thermal performance of different nano particles. The use of nanofluids as a fluid in air conditioning system was studied and the computer simulation program was developed to solve the nonlinear equations of the system model. The advantages of nanofluids are: (1) higher thermal conductivity than that predicted by currently available macroscopic models (2) excellent stability and (3) little penalty due to an enhancement in pressure drop and pipe wall erosion experienced by suspensions of micrometer or millimeter particles. Simulation results have shown that for the same geometric characteristics of the system performance increased from 12% to 18% by application of nanofluid as a fluid in VCS. In this paper the performance of refrigeration system with R22 and 0.1%v of three types of nanofluids namely (CuO, ZnO, Al_2O_3) has been analysed, compared and the results have been discussed.

To Cite This Article: S. Vandaarkuzhali and Dr.R.Elansezhian., Performance Evaluation of Air Conditioning System Using Nanofluids. ***Aust. J. Basic & Appl. Sci.***, *9(7): 1-10, 2015*

INTRODUCTION

Nanofluids are a new class of fluids engineered by dispersing nanometer-sized materials (nanoparticles, nanofibers, nanotubes, nanowires, nanorods, nanosheet, or droplets) in base fluids. In other words, nanofluids are nanoscale colloidal suspensions containing condensed nanomaterials. Nanofluids have been found to possess enhanced thermophysical properties such as thermal conductivity, thermal diffusivity, viscosity, and convective heat transfer coefficients compared to those of base fluids like oil or water. It has demonstrated great potential applications in many fields. For a two-phase system, there are some important issues we have to face. One of the most important issues is the stability of nanofluids, and it remains a big challenge to achieve the desired stability of nanofluids. Here, review the new progress in the methods for preparing stable nanofluids and summarize the stability mechanisms. In recent years, nanofluids have attracted more and more attention. The main driving force for nanofluids research lies in a wide range of applications. Although some review articles involving the progress of nanofluid investigation were published in the past several years, most of the reviews are concerned of the experimental and theoretical studies of the thermophysical properties or the convective heat transfer of nanofluids. The purpose of this paper will focuses on the new preparation methods and stability mechanisms, especially the new application trends for nanofluids in addition to the heat transfer properties of nanofluids. We will try to find some challenging issues that need to be solved for future research based on the review on these aspects of nanofluids.

II. Preparation Methods for Nanofluids:

1.1. Two-Step Method:

Two-step method is the most widely used method for preparing nanofluids. Nanoparticles, nanofibers, nanotubes, or other nanomaterials used in this method are first produced as dry powders by chemical or physical methods. Then, the nanosized powder will be dispersed into a fluid in the second processing step with the help of intensive magnetic force agitation, ultrasonic agitation, high-shear mixing, homogenizing, and ball milling. Two-step method is the most economic method to produce

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nanofluids in large scale, because nanopowder synthesis techniques have already been scaled up to industrial production levels. Due to the high surface area and surface activity, nanoparticles have the tendency to aggregate. The important technique to enhance the stability of nanoparticles in fluids is the use of surfactants. However, the functionality of the surfactants under high temperature is also a big concern, especially for high-temperature applications.

Due to the difficulty in preparing stable nanofluids by two-step method, several advanced techniques are developed to yield nanofluids, including one-step method. In the following part, we will introduce one-step method in detail.

*1.2. **One-Step Method:***

To reduce the agglomeration of nanoparticles, Eastman *et al*. developed a one-step physical vapor condensation method to prepare Cu/ethylene glycol nanofluids. The one-step process consists of simultaneously making and dispersing the particles in the fluid. In this method, the processes of drying, storage, transportation, and dispersion of nanoparticles are avoided, so the agglomeration of nanoparticles is minimized, and the stability of fluids is increased. The one-step processes can prepare uniformly dispersed nanoparticles, and the particles can be stably suspended in the base fluid. The vacuum-SANSS (Submerged Arc Nanoparticle Synthesis System) is another efficient method to prepare nanofluids using different dielectric liquids. The different morphologies are mainly influenced and determined by various thermal conductivity properties of the dielectric liquids. The nanoparticles prepared exhibit needle-like, polygonal, square, and circular morphological shapes. The method avoids the undesired particle aggregation fairly well. One-step physical method cannot synthesize nanofluids in large scale, and the cost is also high, so the one-step chemical method is developing rapidly. Zhu *et al*. presented a novel one-step chemical method for preparing copper nanofluids by reducing CuSO4·5H2O with NaH2PO2·H2O in ethylene glycol under microwave irradiation. Well-dispersed and stably suspended copper nanofluids were obtained. Mineral oil-based nanofluids containing silver nanoparticles with a narrow-size distribution were also prepared by this method. The particles could be stabilized by Korantin, which coordinated to the silver particle surfaces via two oxygen atoms forming a dense layer around the particles. The silver nanoparticle suspensions were stable for about 1 month. Stable ethanol-based nanofluids containing silver nanoparticles could be prepared by microwave-assisted one-step method. In the method, polyvinylpyrrolidone (PVP) was employed as the stabilizer of colloidal silver and reducing agent for silver in solution. The cationic surfactant octadecylamine (ODA) is also an efficient phase-transfer agent to synthesize silver colloids. The phase transfer of the silver nanoparticles arises due to coupling of the silver nanoparticles with the ODA molecules present in organic phase via either coordination bond formation or weak covalent interaction. Phase transfer method has been developed for preparing homogeneous and stable grapheme oxide colloids. Graphene oxide nanosheets (GONs) were successfully transferred from water to n-octane after modification by oleylamine, and the schematic illustration of the phase transfer process is shown in Figure 1. However, there are some disadvantages for one-step method. The most important one is that the residual reactants are left in the nanofluids due to incomplete reaction or stabilization. It is difficult to elucidate the nanoparticle effect without eliminating this impurity effect.

1.3. Other Novel Methods:

Wei *et al*. developed a continuous flow microfluidic microreactor to synthesize copper nanofluids. By this method, copper nanofluids can be continuously synthesized, and their microstructure and properties can be varied by adjusting parameters such as reactant concentration, flow rate, and additive. CuO nanofluids with high solid volume fraction (up to 10 vol%) can be synthesized through a novel precursor transformation method with the help of ultrasonic and microwave irradiation. The precursor Cu(OH)2 is completely transformed to CuO nanoparticle in water under microwave irradiation. The ammonium citrate prevents the growth and aggregation of nanoparticles, resulting in a stable CuO aqueous nanofluid with higher thermal conductivity than those prepared by other dispersing methods. Phase-transfer method is also a facile way to obtain monodisperse noble metal colloids. In a water cyclohexane two-phase system, aqueous formaldehyde is transferred to cyclohexane phase via reaction with dodecylamine to form reductive intermediates in cyclohexane. The intermediates are capable of reducing silver or gold ions in aqueous solution to form dodecylamine-protected silver and gold nanoparticles in cyclohexane solution at room temperature. Feng *et al*. used the aqueous organic phase transfer method for preparing gold, silver, and platinum nanoparticles on the basis of the decrease of the PVP’s solubility in water with the temperature increase. Phase transfer method is also applied for preparing stable kerosene based Fe3O4 nanofluids. Oleic acid is successfully grafted onto the surface of Fe3O4 nanoparticles by chemisorbed mode, which lets Fe3O4 nanoparticles have good compatibility with kerosene. The Fe3O4 nanofluids prepared by phase-transfer method do not show the previously reported “time dependence of the thermal conductivity characteristic”. The preparation of nanofluids with controllable microstructure is one of the key issues. It is well known that the properties of nanofluids strongly depend on the structure and shape of nano materials. The recent research shows that nanofluids synthesized by chemical solution method have both higher conductivity enhancement and better stability than those produced by the other methods. This method is distinguished from the others by its controllability. The nanofluid microstructure can be varied and manipulated by adjusting synthesis parameters such as temperature, acidity, ultrasonic and microwave irradiation, types and concentrations of reactants and additives, and the order in which the additives are added to the solution.

1.4 Methods For Performance Improvements:

To improve thermal performance of vapour compression air conditioning systems by improving:

First law efficiency-According to first law of thermodynamic energetic efficiency /COP is defined as the ratio of net air conditioning effect to the per unit power consumed. First law analysis restricted to calculate only coefficient of performance of the systems and

Second law efficiency- The concept of exergy was given by second law of thermodynamics. Second law efficiency is the exergy of the heat abstracted in to the evaporators from the space to be cooled and exergy of fuel is actual compressor work input.

III. ***Literature Review:***

Jiang *et al*. (2009) observed that thermal conductivity of nanofluids also depend on the nanoparticles size and temperature.

Trisaksri and Wongwises (2009) investigated TiO2 in HCFC 1416 in a cylindrical copper tube and found that the nucleate pool boiling heat transfer deteriorated with increasing nanoparticle concentrations especially at higher heat fluxes.

Hao *et al*. (2009) investigated the heat transfer characteristics of refrigerant-based nanofluids flow boiling inside a smooth tube at different nanoparticles concentration, mass fluxes, heat fluxes, and inlet vapor qualities to analyze the influence of nanoparticles on the heat transfer characteristics of refrigerant-based nanofluid flow boiling inside the smooth tube and developed correlation for predicting the heat transfer coefficient of refrigerant-based nanofluid and the predicted heat transfer coefficients agree with 93% of the experimental data and found that the heat transfer coefficient of refrigerant-based nanofluid in flow boiling is larger than that of pure refrigerant and the maximum enhancement is about 29.7% when observed with a mass fraction of nanoparticles 0–0.5 wt%. and the reduction of the boundary layer height due to the disturbance of nanoparticles enhances the heat transfer.

Mohanraj *et al*. (2009) conducted experiment on domestic refrigerator and observed that under different environmental temperatures COP of system using mixture of R290 and R600a in the ratio of 45.2: 54.8 by weight showing up to 3.6% greater than same system using R134a, also discharge temperature of compressor with mixture of R290 and R600a is lower in the range of 8.5-13.4K than same compressor with R134a.

Hindawi (2009) carried out an experiment on the boiling heat transfer characteristics of R22 refrigerant with Al2O3 nanoparticles and observed that the nano particles enhanced the refrigerant heat transfer characteristics with reduced bubble sizes.

Padilla *et al*. (2010) studied exergy analysis of domestic vapour compression Air Conditioning system with R12 and R413A and concluded that performance in terms of power consumption, irreversibility and exergy efficiency of R413A is better than R12, so R12 can be replaced with R413A in domestic vapour compression Air Conditioning system.

Bolaji *et al*. (2011) had done comparative analysis of R32, R152a and R134a refrigerants in vapour compression refrigerator through experimental investigation and found that R32 refrigerant gives lowest performance and R134a and R152a showing nearly same performance but best performance was obtained of system using R152a.

Ahamed *et al*. (2011) emphasized on use of hydrocarbons and mixture of hydrocarbons and R134a in vapour compression Air Conditioning system and observed that compressor shows much higher exergy destruction as compared to rest of components of vapour compression Air Conditioning system and this exergy destruction can be minimized by using of nanofluid and nanolubricants in compressor.

Stanciu *et al*. (2011) conducted the numerical and graphical investigation on one stage vapour compression Air Conditioning system for studied refrigerants (R22, R134a, R717, R507a, R404a) in terms of COP, compressor work, exergy efficiency and Air Conditioning effect. They also studied the effect of subcooling, superheating and compression ratio on the same system using considered refrigerants and present system optimization when working with specific refrigerant.

Reddy *et al*. (2012) did numerical analysis of vapour compression Air Conditioning system using R134a, R143a, R152a, R404A, R410A, R502 and R507A and discussed the effect of evaporator temperature, degree of subcooling at condenser outlet, superheating of evaporator outlet, vapour liquid heat exchanger effectiveness and degree of condenser temperature on COP and exergetic efficiency. They reported that evaporator and condenser temperature have significant effect on both COP and exergetic efficiency and also found that R134a has the better performance while R407C has poor performance in all respect.

Anand and Tyagi (2012) did detailed exergy analysis of 2TR window air conditioning test rig with

R22 as working fluid and reached to the conclusions that irreversibility in system components will be highest when the system is 100% charged and lowest when 25% charged and irreversibility in compressor is highest among system components.

Ahamed *et al.* (2012) had performed experimental investigation of domestic refrigerator with hydrocarbons (isobutene and butane) by energy and exergy analysis. They reached to the results that energy efficiency ratio of hydrocarbons comparable with R134a but exergy efficiency and sustainability index of hydrocarbons much higher than that of R134a at considered evaporator temperature. It was also found that compressors shows highest system defect (69%) among components of considered system.

Selladurai and Saravanakumar (2013) compared the performance between R134a and R290/R600a mixture on a domestic refrigerator, which is originally designed to work with R134a and found that R290/R600a hydrocarbon mixture showed higher COP and exergetic efficiency than R134a. In their analysis highest irreversibility obtained in the compressor compare to condenser, expansion valve and evaporator.

Mastani Joybari *et al.* (2013) performed experimental investigation on a domestic refrigerator originally manufactured to use of 145g of R134a.They concluded that exergetic defect occurred in compressor was highest as compare to other components and through their analysis it has been found that instead of 145g of R134a if 60g of R600a is used in the considered system gave same performance which ultimately result into economical advantages and reduce the risk of flammability of hydrocarbon refrigerants.

Jiang *et al.* (2009) observed experimentally the thermal conductivities of carbon nanotube (CNT) nanorefrigerants are much higher than those of CNT–water nanofluids or sphericalnanoparticle–R113 nanorefrigerant and found that the smaller the diameter of CNT larger the thermal conductivity enhancement of CNT nanorefrigerant.

Hwang *et al.* (2006) found the thermal conductivity enhancement of nanofluids is greatly influenced by thermal conductivity of nanoparticles and basefluid. They observed the thermal conductivity of water based nanofluid with multiwall carbon nano tube has noticeably higher thermal conductivity compared to SiO2 nanoparticles in the same base fluid.

Hao *et al.* (2010) observed experimentally the nucleate pool boiling heat transfer characteristics of refrigerant/oil mixture with diamond nanoparticles. The refrigerant was R113 and the oil was VG68. The results indicate that the nucleate pool boiling heat transfer coefficient of R113/oil mixture with diamond nanoparticles is larger than that of R113/oil mixture by maximum of 63.4% and the enhancement increases with the increase of nanoparticles concentration in the nanoparticles/oil suspension and decreases with the increase of lubricating oil concentration. Authors developed a correlation for predicting the nucleate pool boiling heat transfer coefficient of refrigerant/oil mixture with nanoparticles and it agrees well with the experimental data of refrigerant/oil mixture with nanoparticles.

Peng *et al.* (2009) studied the influence of nanoparticles on the heat transfer characteristics of refrigerant-based nanofluids flow boiling inside a horizontal smooth tube, and developed a correlation for predicting heat transfer performance of refrigerant based nanofluids by preparing refrigerant based nanofluids, In the experiment, R113 refrigerant and CuO nanoparticles were used and found that the heat transfer coefficient of refrigerant-based nanofluids is higher than that of pure refrigerant, and the maximum enhancement of heat transfer coefficient found to be about 29.7%.

Kumar and Elansezhian (2014) experimentally investigated the effect of concentration of nano Zno ranges in the order of 0.1%,0.3% and 0.5% v with particle size of 50 nm on various thermodynamic parameters (i.e. COP, suction temperature ,input power and pressure raio with 152a as working fluid. In simple vapour compression Air Conditioning system .They found that maximum COP of 3.56 and 21% reduction of power input was obtained with 0.5% v of ZnO. Pressure ratio decreases with increase in nano ZnO concentration.

Mahbubul *et al.* (2013) Thermo-physical properties, pressure drop and heat transfer performance of Al2O3 nanoparticles suspended in the ecofriendly R-134a refrigerant was investigated .To determine the thermal conductivity and viscosity of the nano refrigerants for the nanoparticle concentrations of 1 to 5 vol.% existing model was studied .Thermal conductivity of Al2O3/R-134a nanorefrigerant increased with the augmentation of particle concentration and temperature however, decreased with particle size intensification. In addition, the results of viscosity, pressure drop, and heat transfer coefficients of the nanorefrigerant show a significant increment with the increase of volume fractions. The frictional pressure drop shows rapid increment of more than 3 vol. % with particle volume fraction, and the pumping power increases with particle concentration similar to pressure drop increment. The pumping power is proportional to the pressure drop of nano-air conditioner.

Nanofluid always is treated as a homogenous fluid. [8] Velagapudi *et al.* (2008) proposed the following correlation for the thermal conductivity of nanofluids: Constant c depends on the particle-base fluid combination (Velagapudi *et al*., 2008). For water-based nanofluids with nanoparticles of Al2O3, CuO, Cu and TiO2, the value of c is 1, 1.298, 0.74 and 1.5, respectively. Concerning viscosity, specific correlations for each nanofluid were employed.

IV *Experimental Setup:*

A. Components:

The experimental consists of compressor, fan cooled condenser, expansion device and an evaporator section. Capillary tube is used as an expansion device. The evaporator is of coil type which is loaded with water. Service ports are provided at the inlet of expansion device and compressor for charging the air conditioner. The mass flow rate is measured with the help of flow meter fitted in the line between expansion device and dryer unit. The experimental setup was placed on a platform in a constant room temperature. The ambient temperature was 30°C. The air flow velocity was found to be less than 0.35m/s.

B. Measurement:

The temperatures at different parts of the experimental setup are measured using resistance thermocouples. For experimentation, 12 resistance thermocouples were used. The pressure at compressor suction, discharge, condenser outlet and at evaporator outlet is measured with the help of pressure gauges. The power consumption of the system was measures by a digital Watt-hr meter. A digital wattmeter is also connected with the experimental setup. Table1. Summarized the characteristics of the instrumentation.

Table 1: Summarized the characteristics of the instrumentation.

Variable	Device	Range
Temperature	Pt100 PID Controller	-500C to 1990C
Power	digital Watt-hr meter	6-20A
Pressure	Pressure Gauge Meter	0 bar -10 bar

C. Leak Proof testing and charging of experimental setup:

The fabricated experimental setup was filled with N2 gas at a pressure of 5 to 7 bar and this pressure was maintained for 5 hrs. 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. The air conditioner R22 was charged through the charging line to the compressor. Precision electronic balance with accuracy ±1% was used to charge into the system. Every time the system was allowed to stabilize for 10 min.

D. Preparation of Nanofluid:

The preparation of nanofluid includes the production of nano sized particles and then dispersed into the base fluid. The two techniques used to produce nanofluids are single-step method and two-step method. For the preparation of aluminum oxide, Copper Oxide and Zinc Oxide particles, two-step method is more suitable. In the current study, aluminium oxide , Copper Oxide and Zinc Oxide of 0.1% mass concentration is used and the reason for choosing alumina, CuO and ZnO is due to it’s widely known thermal properties and easy dispersion. The aluminium oxide, CuO and ZnO nano particles are purchased from a commercial trader. The properties of the nanofluid are average particle size=50 nm, density=3800 kg/m3, thermal conductivity=40 W/mK, specific heat=773 J/kgK. The required volume fraction of 0.1% was prepared by dispersing the specified quantity in de-ionized water using an ultrasonic bath and sonication was done for 6 hours. This ultrasonic vibrator generates ultrasonic pulses in the power 180 W at 40 KHz. The stability of dispersion is determined by measuring its pH value and it is found around 5.5, which is far from ISO-Electrical point. Thus the Al2O3 nanoparticle in water is more stable. The visual inspection after 10 days showed that Al2O3, ZnO and CuO nanoparticles maintained good dispersion with water.

The nanofluid is treated as a homogeneous fluid. Based on experimental data of several authors, Velagapudi *et al.*

$$\frac{k_{nf}}{k_m} = c\,\mathrm{Re}_m^{\;0.175}\,\phi_p^{\;0.05}\left(\frac{k_p}{k_m}\right)^{0.2324} \tag{1}$$

where the Reynolds number is given by:

$$\mathrm{Re}_m = \left(\frac{1}{V_m}\right)\left(\frac{18k_pT}{\pi\rho_p\,d_p}\right)^{1/2} \tag{2}$$

Constant c depends on the particle-base fluid combination (Velagapudi *et al.*, 2008). For water-based nanofluids with nanoparticles of Al2O3, CuO, and ZnO the value of c is 1, 1.298, 0.74 and 1.5, respectively. Concerning viscosity, specific correlations for each nanofluid were employed. For example, for water-Al2O3 nanofluid, the viscosity is given by Pak and Cho (1998), as follows:

$$\mu_{nf} = \mu_m\left(533.9\phi^2{}_p + 39.11\phi_p + 1\right) \tag{3}$$

$$\rho_{nf} = \rho_p\,\phi_p + \rho_m\left(1-\phi_p\right) \tag{4}$$

$$c_{p,nf} = \frac{\phi_p\,\rho_p\,c_{p,p} + \left(1-\phi_p\right)\rho_f\,c_{p,f}}{\rho_{nf}} \tag{5}$$

Finally, density and specific heat are determined based on mass and energy balances, respectively.

Specific correlations for the Nusselt number of nanofluids have been available in the literature, as it is felt that the direct use of traditional correlations, such as from Dittus-Boelter (1930) or Gnielinski

(1976), tend to under predict the heat transfer (Yu *et al*., 2008). Pressure drop on the nanofluid side was calculated in the same way as for any other fluid (Xuan and Roetzel, 2000).

V. ***Experimental Procedure:***

The procedure for the conduction of experiments is as follow

(a) A performance test is made with the system loaded with pure R22. The data is treated as the basis for the comparison with the nano air conditioner mixtures.

(b) The air conditioner R22 by mass in the proportion with the concentration 0.1%v of nanofluids namely (CuO, ZnO, Al2O3) was charged in the compressor and the performance tests were conducted.

Fig. 1: Photograph of the experimental setup.

RESULTS AND DISCUSSION

The results presented here are based on the experimental measurements which performed under different operating conditions and parameters that affect the evaporating heat transfer coefficient. The measurements are performed for CuO, Al2O3 and ZnO nanoparticles concentrations of 0.1v.

The result of the Air Conditioning capacity obtained at different evaporating temperatures is shown in Figure 2. Evaporating temperature was varied in between the air conditioners like CuO 0.1%v, Al2O3 0.1%v, R22 and ZnO 0.1%v nano air conditioner as a result of the variation of the indoor temperatures from 16oC to 31oC using the system temperature control. It was observed that for all the investigated air conditioners, the Air Conditioning capacity increased with the increase in evaporating temperature. At the same, evaporating temperature, Air Conditioning capacity obtained with the R22 system is higher than the Alumina.

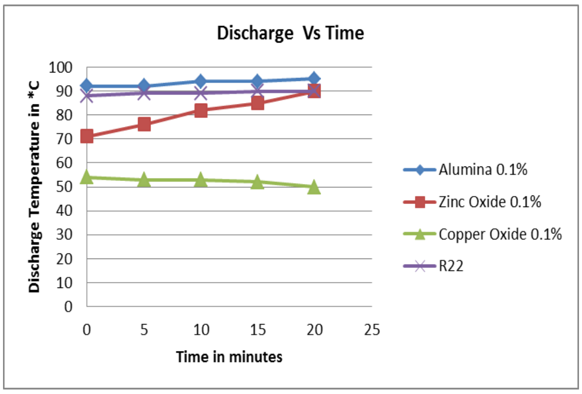

Fig. 2: Variation of Discharge Temperature of Compressor with Time.

The discharge temperature is found to increase with the air conditioners and higher discharge temperature was recorded for nano Alumina and nano Zinc Oxide as shown in figure 2. But the lowest temperature is found to decrease with the air conditioner and lower temperature was recorded for nano Copper Oxide. The discharge temperature is increased from 700C to 900C by the time increased for nano Zinc Oxide air conditioner. The system performance decreased as temperature increased. The decrease is due to a need for higher discharge temperature to achieve maximum cooling-COP.

The discharge pressure is found to increase with the air conditioners and higher discharge pressure was recorded for nano Zinc Oxide as shown in figure 3. But the lowest pressure is found to decrease with the air conditioning and lower pressure was recorded for R22. The discharge pressure is decreased from 17 to 15 and then slightly increased from 15 to 17 for nano Zinc Oxide air conditioning. As can be seen, compressor power consumption increases linearly from 7.1 kW to 9.5 kW with increasing pressure while cooling capacity increases from a lower pressures and then become more or less constant at

24.2 kW as discharge pressure increases. The cooling-COP first increases with increasing pressure from 5 to 20 minutes for Alumina, Copper Oxide and Zinc Oxide. But in the case of Zinc Oxide , the discharge pressure is decreases for first 5 minutes then discharge pressure is also gradually increased. Here Zinc Oxide nanofluids is better than other nano fluids. The high side pressure at 18 in bar here is the optimum condition where cooling-COP reaches the highest value for using of Zinc Oxide nanofluids. But discharge pressure is increased, the compressor efficiency is decreased. As the discharge pressure is reduced the capacity of the compressor increases.

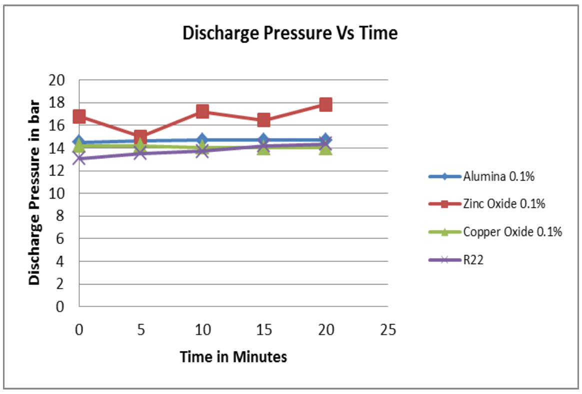

Fig. 3: Variation of Discharge Pressure of Compressor with Time.

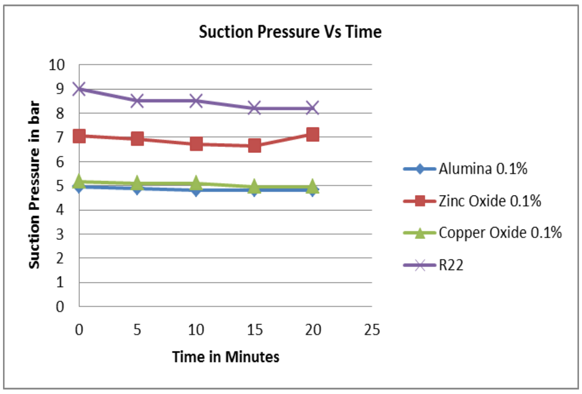

Fig. 4: Variation of Suction Pressure of Compressor with Time.

The figure 4 shows the relationship between the suction pressure and the time of R22, CuO 0.1%v, Al2O3 0.1%v and ZnO 0.1%v nano air conditioners. As shown in the figure, the changes of suction pressure with the time for the four air conditioners; the suction pressure is also nearly same except R22. But R22 slightly decreases the pressure with the increasing the time.

The actual coefficient of performance (COP) for the system is computed at the steady-state when the minimum temperature is achieved in the conditioned room and it is obtained as the ratio between the Air Conditioning capacity (Qevap) and the total power consumption (Wt). The total power consumption was used in equation (3) not just the compressor power in order to obtain the actual overall COP of the system.

COP=Qevap /Wt ------------(3)

The compressor pressure ratio is the ratio between the compressor discharge pressure (Pdis)
and suction pressure (Psuc):

PR= Pdis/Psuc --------------(4)

The COP value increases and the maximum COP was obtained for CuO of R22. Highest value of COP found experimentally is 4.52. The COP was higher than those with CuO 0.1%v and Al2O3 0.1%v at all evaporating temperatures. The lowest COP was obtained in the R22 System.

VII. *Conclusion:*

The performances of Air Conditioning have been studies in details and following conclusions were made.

- Highest value of COP found experimentally is 5.26.
- The COP increases with the usage of nano CuO 0.1%v air conditioner.
- The pressure ratio decreases with the increase in nano CuO concentration. The pressure ratio was lowest for CuO nano air conditioner.
- The results showed that after adding nano CuO 0.1%v air conditioner the performance of Air Conditioning system was significantly improved.

- The results also reveals that ZnO 0.1%v , Al2O3 0.1%v and CuO 0.1%v nano air conditioner works normally and safely in the system.
- The increasing condenser temperature the First law and Second law performance decreases.
- Out of three nanofluids, the CuO is better than other, because the COP is higher than other.
- The uses of nanofluids is to achieve for heat transfer, the suspensions of larger nanoparticles with the higher thermal conductivity and lower viscosity should be used.

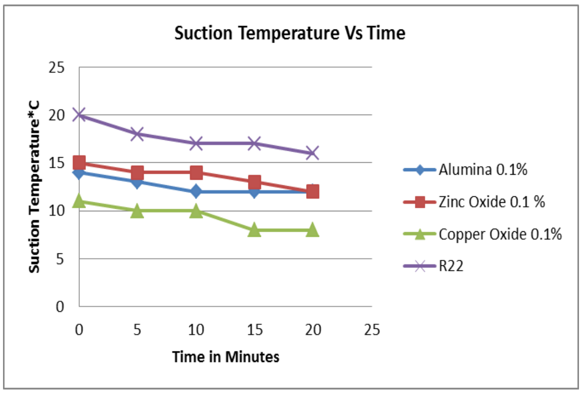

Fig. 5: Variation of Suction temperature of Compressor with Time.

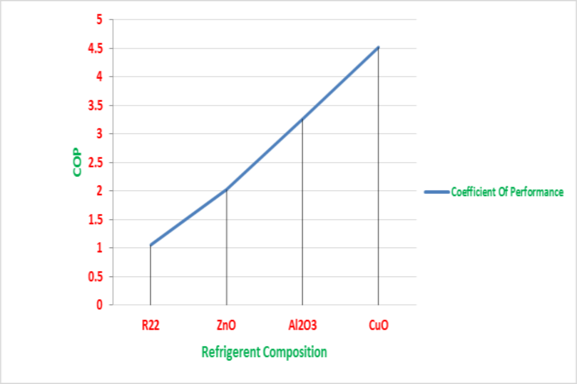

Fig. 6: Variation of Coefficient of Performance with Air conditioners.

Recommendations For Future Work:

Future research is required to investigate the influence of the nanofluids with different composition(i.e., 30:70,50:50 and 70:30).There are potentials to explore research to determine these properties experimentally.

ACKNOWLEDGMENT

I submit my sincere thanks at the feet of my respectful guide Dr.R.Elansezhian, Associate Professor, Pondicherry Engineering College for encouraging and providing moral support and courage without which my research work could not be a successful one.

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