EFFECT OF ZNO NANO LUBRICANT ON VAPOUR COMPRESSION REFRIGERATION SYSTEM

TALLAM Sitaram, Masters Student at Kumamoto University, Department of Mechanical Systems Engineering

TORII Shuichi, Professor at Kumamoto University, Department of Mechanical Systems Engineering.

ABSTRACT:

The principle point of this work is to investigate the impact of ZnO nanoparticles on the thermo actual properties of base POE oil and execution of the climate control system dealing with vapour compression cycle. In this work nanolubricant of 0.2%, 0.6% and 0.8% fixations were set up by blending ZnO nanoparticles of 30 to 60 nm size in the POE oil. The test information uncovers that the warm conductivity and thickness of nanolubricant is high at 0.8% by weight fixation and henceforth 0.8% by weight focus is chosen for exploratory execution assessment. Along these lines, nanolubricant in fume pressure framework is the latent way to deal with improve execution of the framework. An investigational result reasons that the framework works regularly and securely with the expansion of nano lubricant. COP of the climate control system alongside nanolubricant has been improved by 38% at 0.4Kw warmth load because of decrease in the blower force and expansion in the refrigeration impact. Trial results show that the blower power has been diminished by 33% and refrigeration impact has expanded by 7.8% with the enhancement of ZnO nanoparticles to the base POE oil for 0.4Kw warmth load. Results demonstrate that the time taken to arrive at 20°C from 38°C in the adapted space is decreased by 33% for ZnO nanolubricant. Subsequently, the ZnO nanolubricant can be utilized in the refrigeration and cooling framework to improve the exhibition.

Index Terms **- vapour compression refrigeration system, COP, Nanoparticles, Nanolubricant.**

INTRODUCTION:

In refrigeration and Air molding nano lubricant is the combination of blower oil and nanoparticles. Nanoparticles have a capacity to expand the warmth move properties of the base liquid. Different specialists have directed examinations to discover the exhibition of fume pressure refrigeration framework by adding nanoparticles to blower greasing up oil and found that it is the cutting-edge procedure to improve the presentation of the refrigeration and cooling framework. Coming up next are the significant qualities revealed for nanofluids. They are [3] found that adding TiO_2 nanoparticles to the mineral oil improves the dissolvability and furthermore tracked down that the framework performing better by repeating more ointment oil back to the blower. Expansion of nanoparticles to the base oil can improve warm conductivity of the base liquid [1, 3, 4, 8, 11-13, 22, 24, 25]. Warm conductivity of the base liquid can be improved either by blending nanoparticles to the base liquid in enormous extents or by utilizing nanoparticles of having higher warm conductivity. The subsequent methodology has been affirmed by the different analysts. [18] Conducted examination to discover the effect of nanoparticle size on warm conductivity and reasons that nanofluid having more modest size nanoparticles can improve the warm conductivity of the base liquid. The test results uncovered that the warm conductivity increments by 6.6%, 12.5% and 22.2% relating to 0.1%, 0.2% and 0.3% volume centralization of nanoparticles. This improvement is seen because of the Brownian movement of the particles [21]. By blending of ZnO nanoparticles to the base POE oil the warm conductivity of the nanolubricant has been expanded up to 12% for round shape nanoparticles and 18% for rectangular shape nanoparticles at 5.0 vol. % fixation [10]. Thickness of nanolubricant is more than that of the unadulterated oil. Additionally, the thickness variety with the temperature concurs with the pattern of the unadulterated oil. The outcomes from wear tests show that expansion of CuO nanoparticles even up to 0.10% by mass of POE oil diminishes the erosion coefficient of the test example, note commendably [17]. Investigation esteems presumes that the consistency and thickness of the mineral oil nanolubricant is lesser by 25.78% and 8.65% contrast with the POE oil nanolubricant separately and henceforth the mineral oil nanolubricant can give better execution [17]. The consistency of Al_2O_3 nanolubricant of fixation 10 % by wt. of POE oil was 30 to 40 percent higher than that of unadulterated POE oil [15]. The ZnO nanolubricant displays the upgraded thickness by 7.7% for rectangular shape nanoparticles contrast with circular shape nanoparticles suspended in the POE oil up to 69% volume focus [10]. The convective warmth move coefficient increments apparently with the blending of MWCNT to the base POE oil [18]. The most extreme expansion in heat move co-effective of 23.8% is seen by diminishing the nanoparticles size from 80nm to 20nm [8]. [2] led a trial examination on stream bubbling of R-134a/POE combinations and R-134a/POE/CuO nanofluid in a level cylinder and found that for a nanolubricant mass part of 0.5%, no impact on the warmth move coefficient and for nanolubricant mass parts of 1% and 2%, the warmth move coefficient was expanded by 82% and 101% in contrast with R-134a/POE blends. Utilization of nanolubricant in the refrigeration and cooling can improve the presentation because of the above critical properties. Diminishes power utilization by 13.89% at 0.5% vol fixation and C.O.P. is expanded by 12.16% by utilizing R134a/POE oil/nano-SiO_2 as working liquid [18]. [23] explored the impact of ZnO - R152a in the exhibition improvement of Air-molding framework and tracked down that the pressing factor drop happens because of the presence of nano particles in the grease and this expands the COP. Test results uncover that the coefficient of execution (COP) of the refrigeration framework is improved by 16.67% when 0.2 gm/lt of Mineral Oil-Carbon nano powder is utilized [19]. [9] Found that the energy utilization of the homegrown cooled decreased by 15.22% at a mass fraction of 0.1% with the addition of graphite nanolubricant. Application of SiO_2 nanoparticles as lubricant additive in VCRS can enhances the energy saving from a minimum value of 7.03% to a maximum value of 12.30% [20]. With 0.2 gms/lit of TiO_2 nanolubricant along with R134a refrigerant enhanced the refrigeration effect by 10.3% and reduces the power consumption by 9.65% and hence the overall COP has been improved by 20.2% [17]. [7] Investigated the working of window type air-conditioner by the addition of TiO_2 nanoparticles to lubricant and found enhancement in the COP by 7.93% to 11.99 % and the average compressor input power for R22 with nanoparticles was (2.1 to 13.3) % lower than that of R22 without nanoparticles. [20] It is found that the addition of Al_2O_3 nanoparticles to the POE oil reduces the power consumption of the compressor by 11.5 % and the freezing capacity is higher. The results show that replacing R-134a refrigerant with hydrocarbon refrigerant and adding Al_2O_3 nanoparticles to the lubricant effectively reduces the power consumption by 2.4%, and the coefficient of performance was increased by 4.4% [16].

Thus, the use of nanoparticles in an air conditioning system as a nanolubricant is the new innovative way to improve the performance. This paper studies the influence of nanoparticles in split air conditioner by calculating the performance.

EXPERIMENTAL STUDY:

Nano Particles Characterization:

In this work ZnO nanoparticles is considered for the performance evaluation of a home air conditioner working on VCR system. SEM and XRD test were conducted to find the size and shape of the nanoparticles. From the SEM image of ZnO nanoparticles as shown in the fig 1 the shape of the nanoparticles is spherical or analogously spherical. Maximum intensity peaks in the XRD image are in between 30 – 60 nm and hence it is clear that the size of the nanoparticles is in between 30 – 60 nm as shown in fig 2

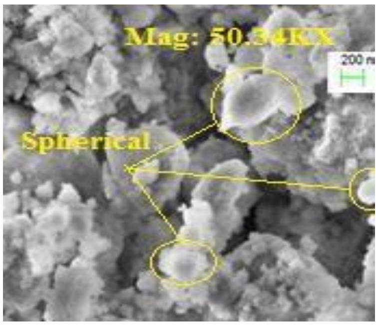


Fig.1 SEM image of ZnO nanoparticle

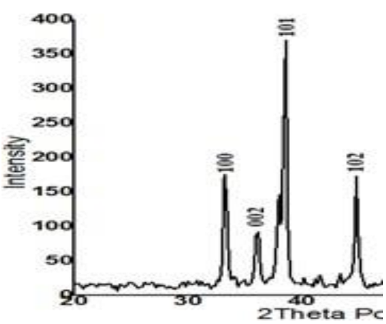


Fig.2 XRD image of AIN nanoparticle

PREPARATION OF NANOLUBRICANT:

In this paper, three samples of 0.2 wt.%, o.6 wt.% and 0.4 wt.% were prepared to evaluate the thermo- physical properties of the nanolubricant. The following is the procedure employed for the preparation of the nanolubricant. Measure the weight of 25ml of POE oil.

Calculate the mass of nanoparticles required for 0.2 wt.% concentration by using the following relation.

$$Wt.\% = \frac{W_{np}}{W_{np} + W_{POE}} \times 100 - -(1)$$

Mix the obtained mass of nanoparticles to POE oil and stir in magnetic stirrer for 1 hour. Nan particles are completely dispersed in the fluid by 3 hrs of sonication.

Again, stir the mixture using magnetic stirrer.

Repeat the same procedure for 0.6 wt.% and 0.8 wt.% concentrations.

Thermo-physical properties of the nanolubricant:

Thermal Conductivity:

Fig 5 shows the straight expansion in warm conductivity of nanolubricant with mass fixation at room temperature. It is shown that the warm conductivity of nanolubricant has been expanded up to multiple times more than the unadulterated POE oil at 0.8% fixation. As the warm conductivity of ZnO nanoparticles is higher than the base oil consequently the warm conductivity of nanolubricant is higher than unadulterated POE oil. As we realize that the warmth move coefficient is straightforwardly corresponding to warm conductivity, with higher warm conductivity nanolubricant can improve the pace of warmth move in condenser and evaporator. During working of the climate control system, little amount of the nanolubricant escapes alongside the refrigerant from the blower. The presence of the nanoparticles in the refrigerant and ointment blend can improve the warmth move in the condenser and evaporator. This upgraded heat move property of the blend liquid in the evaporator can improve the cooling impact in the adapted space and diminishes the time needed for arriving at the ideal temperature.

Viscosity measurement:

The coefficient of execution of the forced air system chipping away at VCR cycle was contrasted and POE oil as grease and with ZnO nanolubricant of 0.8% fixation. Fig 6(d) shows the improvement in the COP was seen with the expansion ZnO nanolubricant to the forced air system. The COP of the framework is determined utilizing the refrigeration impact and force needed to the blower. The increment in COP is 60% at 0.4Kw warmth load when POE oil is supplanted with POE oil + ZnO nanoparticle. This expansion in COP is because of expansion in refrigeration impact by 7.8% as demonstrated in the fig 6(b) and decline in the force utilization of the blower by 33% as demonstrated in the figure 6(a). The upgrade in the refrigeration impact is because of the presence of nanoparticles in the refrigerant and nanolubricant blend which improves the pace of warmth move in the evaporator and condenser. The decrease in the force utilization is because of the accompanying reasons. a) Addition of nanoparticles in the blower oil decreases the pressing factor proportion as found in the fig 6(g). b) Presence of nanoparticles in the POE oil will expands the

warmth moves from the blower which is the purpose behind the drop of release temperature as show in the fig 6(f). The low release temperature and low pressing factor proportion can improve the existence of the blower and diminishes the force needed for the pressure.

I. EXPERIMENTAL SYSTEM:

The experimental setup was fabricated according to the standards. The indoor unit of the split type of air conditioner is placed in a cabin made of wooden planks of 8’ × 4’ × 8’ (lxbxh). The heat load in the conditioned space is calculated from load calculation by assuming 2 persons working with laptop and one light in the conditioned space. The heat thus obtained from the load calculation is given by four bulbs of each 100 watts is placed in the conditioned space to provide sensible heat. The outdoor unit includes the condenser, expansion valve and a rotameter. Four thermocouples and two pressure gauges were placed at the required locations to collect the data for calculating the performance. The power consumed by the entire unit is measured from digital watt meter. The block diagram of the experimental set up was shown in the fig 3.

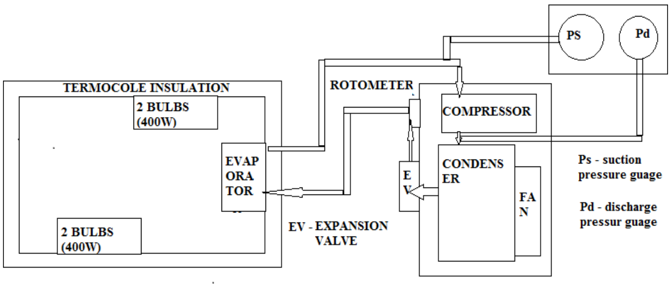


Fig: 3 Block experimental setup diagram

1) Heat gain by the occupants:

$Q_o = K ´ q_g ´ CLF$

= 140 W. (CLF = 1.0)

3) Heat gain by the walls:

$Q_w = U ´ A´ (T_0 - T_{i)}$

= 2.208 w

For four sides there is same material so

Qw = 4*2.208 = 8.8 W

2) Heat gain by the infiltration:

$Q_{\text{inf}} = m_0 ´ C_{pm} ´ (T_0 - T_{i)}$

= 142W

4) Heat gain by the electric appliance:

$Q_l = W_i ´UF ´ BF ´ CLF$

= 100 w.

5) Heat gain from laptop (Qlt) = 30w.

$Qtotal = Qo + Q\text{inf} + Qw + Ql + Qlt$

= 390.4w

3.1 Experimental Procedure:

The performance of air conditioner was initially measured by using refrigerant R410a and POE oil in the compressor as the lubricant for the base data. Then, R410a and POE oil with 0.8% concentration of ZnO nanoparticles was used as working fluid for the same test. Experimental readings were taken when the conditioned space reaches the desired temperature of 20ºC.The performance of the unit is measured from the standard equations.

4. Results and discussions

In this work performance evaluation has been done with POE oil alone and POE + ZnO nanolubricant of 0.8% mass fraction.

4.1 Viscosity:

Fig 4 shows the comparison of the viscosity of nanolubricant at room temperature for different percentage concentration of nanoparticles in the base oil. It is evident from the results that the viscosity of nanolubricant has been increased by the increase of wt.% concentration. The results indicate that the viscosity of nanolubricant has been increased by 10%, 32% and 37% corresponding to 0.2%, 0.6% and 0.8% weight concentration which is advantageous in terms of load capacity but not in terms of friction. The enhanced viscosity will increase the friction power. The enhanced viscosity of the nanolubricant can improve the fluid layer resistance which retains the more oil back to the compressor. However, it is absolutely essential to optimize the percentage weight concentration of nanoparticle in the POE oil so as to complete the desired merit without affecting the other properties.

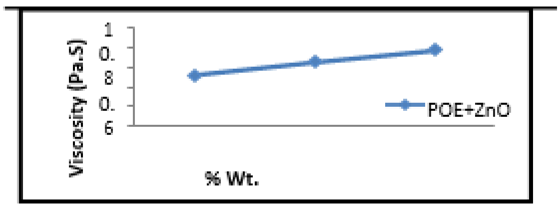


Fig 4: Viscosity Vs Wt. % Concentration

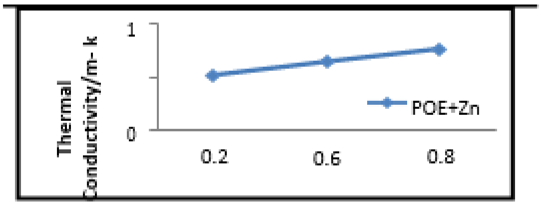


Fig 5: Thermal Conductivity Vs Wt.% Concentration

4.2 Thermal Conductivity:

Fig 5 shows the linear increase in thermal conductivity of nanolubricant with mass concentration at room temperature. It is shown that the thermal conductivity of nanolubricant has been increased up to 5 times more than the pure POE oil at 0.8% concentration. As the thermal conductivity of ZnO nanoparticles is higher than the base oil therefore the thermal conductivity of nanolubricant is higher than pure POE oil. As we know that the heat transfer coefficient is directly proportional to thermal conductivity, with higher thermal conductivity nanolubricant can improve the rate of heat transfer in condenser and evaporator. During working of the air conditioner, small quantity of the nanolubricant escapes along with the refrigerant from the compressor. The presence of the nanoparticles in the refrigerant and lubricant mixture can improve the heat transfer in the condenser and evaporator. This enhanced heat transfer property of the mixture fluid in the evaporator can improve the cooling effect in the conditioned space and reduces the time required for reaching the desired temperature.

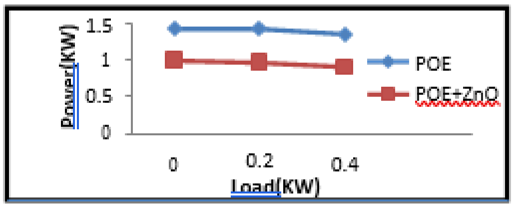
4.3 Coefficient of Performance:

The coefficient of performance of the air conditioner working on VCR cycle was compared with POE oil as lubricant and with ZnO nanolubricant of 0.8% concentration. Fig 6(d) shows the enhancement in the COP was observed with the addition ZnO nanolubricant to the air conditioner. The COP of the system is calculated using the refrigeration effect and power required to the compressor. The increase in COP is 60% at 0.4Kw heat load when POE oil is replaced with POE oil + ZnO nanoparticle. This increase in COP is due to increase in refrigeration effect by 7.8% as shown in the fig 6(b) and decrease in the power consumption of the compressor by 33% as shown in the figure 6(a). The enhancement in the refrigeration effect is due to the presence of nanoparticles in the refrigerant and nanolubricant mixture which improves the rate of heat transfer in the evaporator and condenser. The reduction in the power consumption is due to the following reasons.

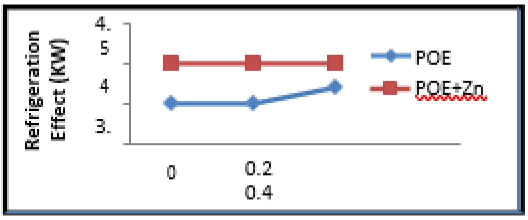
Addition of nanoparticles in the compressor oil reduces the pressure ratio as seen in the fig 6(g).

Presence of nanoparticles in the POE oil will increases the heat transfer from the compressor which is the reason for the drop of discharge temperature as show in the fig 6(f). The low discharge temperature and low pressure ratio can improve the life of the compressor and reduces the power required for the compression.

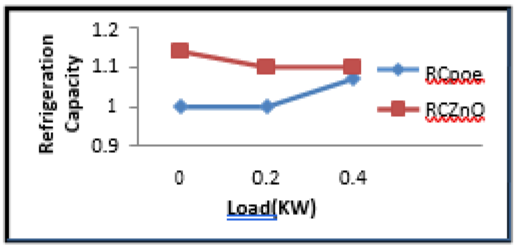
As the density and thermal conductivity of the nanolubricant is more than the POE oil and therefore the presence of nanoparticles in the refrigerant and POE oil mixture can improve the heat transfer in the evaporator and therefore the time taken to reach the desired temperature in the conditioned space has been reduced by 25% at 0.4kw heat load as shown in the fig 6(h)



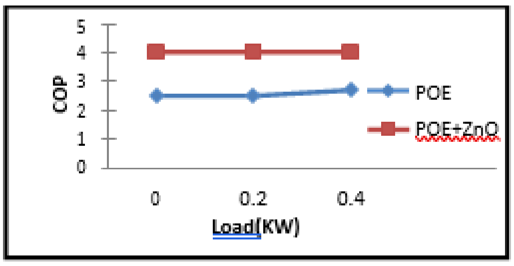
(a)



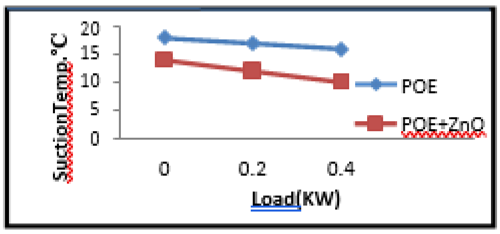
(b)



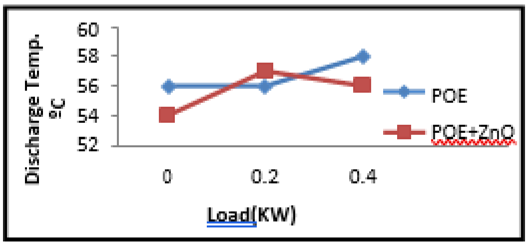
(c)



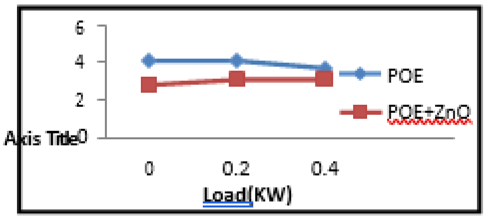
(d)



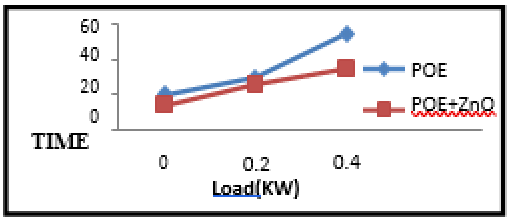
(e)



(f)



(g)



(h)

Fig: 4(a)Load Vs Power

(b) Load Vs RE

(c) Load Vs RC

(d) Load Vs COP

(e)Load Vs Suction Temperature

(f)Load Vs Discharge Temperature

(g) Load Vs PR

(h)Load Vs Time

CONCLUSION:

Test was led to decide the thermo-actual properties of ZnO-POE oil nanolubricant and execution of the forced air system chipping away at the fume pressure refrigeration framework was explored by adding ZnO nanolubricant to the blower. A few ends were drawn from the exploratory examinations. Appropriately, adding ZnO nanoparticles to the base POE can improve the warm conductivity, consistency and the framework working securely and ordinarily. The improved COP of the framework was seen when nanolubricant was utilized by 38% at 0.4Kw warmth load. In addition, the force utilization of the responding blower was diminished by 33% with the use of nanolubricant rather than unadulterated grease. The presence of nanoparticles in the oil + refrigerant blend upgraded the warmth move rate in the condenser and evaporator which improves the cooling limit by 10.7% and refrigeration impact by 10.2% at 0.4 kw heat heap of the forced air system. Test results recommend that the nanoparticles, when utilized as added substances to blower oil, are compelling when planning energy proficient refrigeration frameworks.

Nomenclature

To	Outside Temperature	A	Surface area
Ti	Inside Temperature	mr	Mass of refrigerant
Cpm	Humid specific heat	T3	Temperature inlet to condenser
Pd	Discharge Pressure	T4	Temperature outlet to condenser
Mo	mass of air infiltered	Ps	Suction Pressure
U	overall heat transfer coefficient	Wi	Installed wattage
Subscripts			
f	base fluid	np	nanoparticles
nf	nanofluid		

REFERENCES

[1] A. Eastman, S.U.S. choi, S. Li, L.J. Thompson, S. Lee, Enhancement thermal conductivity through the development of nano fluids, in: 1996 Fall meeting of the Metals Research Society (MRS), Boston, USA.

[2] Bartelt, Kristen; Park, Younggil; Liu, Liping; and Jacobi, Anthony, "Flow-Boiling of R-134a/POE/CuO Nanofluids in a Horizontal Tube" (2008). International Refrigeration and Air Conditioning Conference. Paper 928. http://docs.lib.purdue.edu/iracc/928

[3] Bi S., Guo K., Liu Z., Performance of a domestic refrigerator using Tio2-R600a nanorefrigerant as working fluid. Energy Conversion and management, 2011, Vol. 52, No. 1, pp. 733-737.

[1] Ching-song jwo, Lung-yue Jeng, Ho Chang and Tun-Ping Teng, Experimental study on thermal Conductivity of Lubricant containing nanoparticles, Advanced Material Science, 18 (2008) 660-666.

[2] Ching-Song Jwo, Lung-Yue Jeng, Tun-Ping Teng, and Ho Chang, Effects of nanolubricant on performance of hydrocarbon refrigerant system,2009, Journal of Vacuum Science & Technology B 27, 1473 (2009); doi: 10.1116/1.3089373

[3] H.Q. Xie, M. Fuji, X. Hang, Effect of interfacial nanolayer on the effective thermal conductivity of nanoparticles fluid mixture, int. J.

[4] Haider ali hussen, Experimental Investigation for TiO2 nanoparticles as a Lubricant-Additive for a Compressor of window Type Air-Conditioner System,2014, Journal of Engineering,

[5] Hwang Y, Par HSK, Lee JK, Jung WH, Thermal conductivity, and lubrication characteristics of nanofluids. Curr Appl P- Hys; 2006, 6S1:e67–71.

[6] Jiang-feng Lou, Hua Zhang and Ruixiang wang, Experimental investigation of graphite Nanolubricant used in a domestic refrigerator, 2015, Advances in Mechanical Engineering 1– 9.

[7] Jisun Jeong a, Chengguo Li b, Younghwan Kwon b, Jaekeun Lee b, Soo Hyung Kim c, Rin Yun, Particle shape effect on the viscosity and thermal conductivity of zno nanofluids, 2013, international journal of refrigeration 36, 2233-2241.

[8] Liu M-S, Lin MC-C, Huang I-Te, Wang C-C. Enhancement of thermal conductivity with cuo for nanofluids. Chem Eng Technol; 2006, 29(1):72–7

[9] Lorenzo Cremaschi, Thiam Wong, Andea A.M.Bigi, Thermodynamics heat transfer properties of Al2O3 nano lubricant, International Refrigeration & Airconditioning Conference, 2014, Purdue University.

[10] M Mahabul, A.Saadah, R.Saidur, MA.Khairul, A.Kamyar. Thermal performance analysis of Al2O3 / R134a refrigerant, International journal of heat and mass transfer 85(2015) 1034- 1040.

[11] M Shivashankar and K.Parashivamurthy, Thermal Conductivity Augmentation Of Zno Nanofluids For Coolant Applications, 2012, Issn 2278 – 0149 Int. J. Mech. Eng. & Rob. Res. Vol. 1, No. 2,

[12] M. S. Bandgar, Dr. K. P. Kolhe, Dr. S. S. Ragit, An experimental investigation of VCRS using R134a/ POE oil /mineral oil/nano-SiO2 as working fluid, 2016, Journal of Emerging

Technologies and Innovative Research (JETIR), Volume 3, Issue 7 .

[13] Manoj Babu, S. Nallusamy, K. Rajan, Experimental Analysis On Vapour Compression Refrigeration System Using Nanolubricant With Hfc-134a Refrigerant, 2015,Nano Hybrids Issn: 2234-9871, Vol. 9, Pp 33-43 Doi:10.4028/Www.Scientific.Net/Nh.9.33

[14] Mohammed Ajmal A, sunirmajilya, Bharath Kumar H, N. Gobinath, Investigation of tribological characteristics of Polyol Ester – Copper Oxide nanolubricant, International Journal of chemtech Research,2017, ISSN: 0974-4290, ISSN(Online):2455- 9555 Vol.10 No.5, pp 93- 97.

[15] N. Kamaraj, A.Manoj babu, Experimental analysis of Vapour compression refrigeration System using the refrigerant with nano particles, 2016, International Conference on Engineering Innovations and Solutions (ICEIS—2016) E-ISSN: 2348 – 8360 16-25

[16] Nilesh S. Desai and P.R.Patil, Application of SiO2 Nanoparticles as Lubricant Additive in VCRS: An Experimental Investigation, 2015, Asian Review of Mechanical Engineering ISSN: 2249 - 6289 Vol. 4 No. 1, 2015, pp. 1-6.

[17] R. Reji Kumar, K. Sridhar, M.Narasimha, Heat transfer enhancement in domestic refrigerator using r600a/mineral oil/nano- Al2O3 as working fluid,2013, International Journal of Computational Engineering Research, Vol 03, Issue 4, 42-50.

[18] R.Santhanakrishnan, V.Shanmugam, Preparation and property analysis of nano-lubricant for vapour compression refrigeration system, 2016, Journal of Chemical and Pharmaceutical Sciences, ISSN: 0974-2115, 2895-2899

[19] S.U.S choi, Z.G Zhang, W. Yu, F. E Lockwood, EA. Grulke, Anomalously thermal Conductivity enhancement in nano tube suspensions, Appl. P- Hys. Lett. 79 (2001) 2252 – 2254.

[20] R. Reji Kumar, K. Sridhar, M.Narasimha, Heat transfer enhancement in domestic refrigerator using r600a/mineral oil/nano- Al2O3 as working fluid,2013, International Journal of Computational Engineering Research, Vol 03, Issue 4, 42-50.

[21] R.Santhanakrishnan, V.Shanmugam, Preparation and property analysis of nano-lubricant for vapour compression refrigeration system, 2016, Journal of Chemical and Pharmaceutical Sciences, ISSN: 0974-2115, 2895-2899

[22] S.U.S choi, Z.G Zhang, W. Yu, F. E Lockwood, EA. Grulke, Anomalously thermal Conductivity enhancement in nano tube suspensions, Appl. P- Hys. Lett. 79 (2001) 2252 – 2254.

[23] S.Vandaarkuzhali, Dr.R.Elansezhian, Study on the influence of ZNO - R152a in the performance enhancement of Air- conditioning system,2016, international open ACCESS journal of Modern Engineering Research (IJMER, Vol. 6, Iss. 12 Dec. 2016, 67-72

[24] Wang RX, Xie HB, A refrigeration system using HFC134a and mineral lubricant appended with N-tio2(R) as working fluid, 2003, in proceedings of the 4th international

symposium of HVAC, Tsinghua University
[25] Weiting Jiang, Guoliang Ding, Hao Peng, Measurement and model on thermal conductivities of carbon nano tube nanorefrigerants, International Journal Of thermal science, 48 (2009) 1108-1115