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Experimental Analysis of the Effect of Nanoparticles on Performance of the Air Conditioning Compressor

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ABSTARCT:

It evaporating heat transfer is very important in refrigeration and air conditioning Systems. HFC 134a may be the alternative is often used in large scale Refrigerants in refrigeration equipment, such as domestic refrigerators And air conditioners. Despite the high temperatures of the global potential to Relatively high, HFC134a and stressed that it was a long time alternative refrigerants in many countries. By adding cooling nanoparticles to improve results in thermophysical properties and heat transfer characteristics of Cooling, thereby improving the cooling performance System. In these experiments the effect of using quotas using R134a system vapor pressure in the heat transfer coefficient of evaporation Research by heat transfer using CFD flow analysis Software. The experimental device constructed according National standards in India. Experimental studies suggest that nanorefrigerant system normal operation of cooling. Hot Transport coefficients assessed using fluid flow heat Ranged 10-40 kW / m2 And he was varied concentrations using nano CUO 0.05 to 1% and particle size of 10 to 70 nm. Results They suggest that increases the heat transfer coefficient with the evaporator Use nanoCuO.

INTRODUCTION: Rapid industrialization has led to unprecedented development and growth technological advances around the world. Global warming and today the ozone layer It has become a drain on the one hand and rising oil prices on the other hand, the main Challenges. Excessive use of fossil fuels leads to a decrease in its sharp, Nuclear power is not safe. In the face of an impending energy resources Crisis there is a need for the development of thermal systems that are efficient in energy use. Thermal systems such as refrigerators and air conditioners consume a lot of The electric energy. the development of energy efficiency and air cooling is required air conditioning systems with cooling nature of use. The rapid progress of Nanotechnology can lead to the emergence of heat transfer fluids called new generation nanofluids. Nanofluids is willing to suspend nanometer-sized particles (1-100nm) in Conventional fluid and has a higher thermal conductivity than the base fluid. Nanofluids have the following characteristics compared with ordinary solid-liquid Comment. I) a greater heat transfer between particles and fluids due to the high Surface of the particles b) improve the stability and dispersion with prevailing Brownian Movement c) reduces particles clogged d) reduce the pump capacity compared to the base Fluid heat transfer equivalent. Based on the applications, the nanoparticles are Currently she carried out by a very wide range of materials, the most common of the new Jill be ceramic nanoparticles, which are the divided metal oxide Ceramics, such as oxides of titanium, zinc, aluminum and iron, for example, but not limited to prominent And nanoparticles silicate, generally in the form of nano clay flakes. By In addition to cooling of nanoparticles to improve results in thermophysical properties and characteristics of the refrigerant heat transfer, and therefore Improve the performance of the cooling system. The vapor pressure Nanoparticles cooling system can be added to lubricants. HFC 134a may be an alternative cooling often used widely in refrigeration Equipment such as refrigerators and air conditioners. Despite the global Heat the potential for relatively high HFC134a, and stressed that the long-term alternative refrigerants in many countries. Experience vapor pressure It was carried out cooling pad test to calculate the cooling effect and laboratory apparatus performance testing to identify potential sites to promote cooling effect. Mathematical modeling to test section tube evaporator using partial differential equations. This has been done theoretical analysis Tests in the evaporator section. The use of a network program evaporator maneuver test section designed and use the program flow in the heat transfer analysis Make different concentrations of nanoparticles CUO.

LITERATURE REVIEW:

technologies. Renew Sustain Energy Rev 2001;5(4): 343–72[1] they given initialisation of work that Absorption refrigeration was discovered by Nairn in 1777, though the first commercial refrigerator was only built and developed in 1823 by Ferdinand Carré, who also got several patents between 1859 and 1862 from introduction of a machine operating on ammonia–water. By 19th century, systems operating on ammonia–water found wide application in residential and industrial refrigerators. Systems operating on lithium bromide–water were commercialized in the 1940's and 1950's as water chillers for large buildings air conditioning.

Horuz I. An alternative road transport refrigeration. Tr. J. Of Engineering and Environmental Science 1998;22:211-222. [2]conducted experimental investigation into the effect on the performance of the IC engine of introducing the VAR system into the exhaust system and also the provision of appropriate off-road/slow running cooling systems, in order to take account of the reduction in exhaust gas flow in slow running traffic or stationary situations or when the vehicle is parked and cooling is still required. Built-in eutectic plates could provide temporary cooling under such conditions. Such plates could be recharged by redirecting the cooling effect from the main body to the eutectic plate during off-load periods of continuous full-load travel.

Alam [3] Shah A. A proposed model for utilizing exhaust heat to run automobile air-conditioner. The 2nd Joint International Conference on Sustainable Energy and Environment 2006. studied the possibility of operating a triple fluid vapour absorption system using engine exhaust power. From the analysis it was concluded that there is a possibility of operating a triple fluid system using engine exhaust power.

[4]S.U.S. Choi, ASME, 99(1995) showed that the addition of a small amount of nanoparticles (less than 1% by volume) to base fluid would increase the thermal conductivity of the fluid up to approximately two times. But thermal conductivity having the most important property is not easy to determine accurately by a single formula, but there are some experimental relations that could be used to estimate it. With increase in temperature, there is increase in thermal conductivity but there is abnormal behavior of the thermal conductivity at high temperatures which is related to the solubility of the nanoparticles. In the nanometrical size range, kinetics of dissolution of particles is enhanced due to the small size according to the Kelvin equation.

Eastman JA, Choi US, Thompson LJ, Lee S. "Enhanced thermal conductivity through the development of nanofluids. Mater Res Soc Symp proc 1996;457:3-11[5] concluded that report that thermal conductivity of ethylene glycol of nanofluids containing 0.3% volume fraction of copper particles can enhance thermal properties by 40% compared to that of EG (Ethylene Glycol) base fluid.

Z. Zhang and Q. Que, Wear 209, 8 (1997).[6] In automobile lubrication nanoparticles dispersed in mineral oils were reported to be effective in reducing wear & enhancing load carrying capacity [41]. Recently lots of researchers show their interest to enhance the tri biological properties (such as load carrying capacity, wear resistance and friction reduction) of nanoparticle suspended lubricants. The vehicle life time as well as the performance will be increased by using the nanoparticle suspended lubricants. Osorio et al. investigated the tribological properties of CuO suspended lubricant.

[7] Wang X, Xu X, Choi SUS: Thermal conductivity of nanoparticle-fluid mixture. J Thermophys Heat trans 1999, 13:474-480 due to the low pressure operation compared with a 50/50 mixture of ethylene glycol and water, which is the universally used automotive coolant. The nanofluids has a high boiling point, and it can be used to increase the normal coolant operating temperature and then reject more heat through the existing coolant system and also contributed to a reduction in friction and wear. It is conceivable that greater improvement of savings could be obtained in the future but with time nanofluids degrade radiator material and Erosion of radiator material will be there. Choi studied on the development of energy efficient nanofluids and smaller and lighter radiators. A major goal of the nanofluids project is to reduce the size and weight of the HV cooling systems by >10% thereby increasing fuel efficiency by >5%. Nanofluids enable the potential to allow higher temperature coolants and higher heat rejection in HVs. A higher temperature radiator could reduce the radiator size by perhaps 30%.

[8] Interagency working group on nano science, national nano technology initiative: Leading to the next industrial revolution, Technology National Science and Technology Council, USA, February (2000). Due to depletion of natural resources like natural gas, oil and water at faster rate and due to trends toward faster speeds it is need to improve the efficiency and the performance of automobile by using different methods. If this rate is continued, then we are at verge of extinction. Many methods like reducing the vehicle weight, improving the engine performance have been used and also under investigation. In the recent research it has been found that we can use the nanoparticles as fuel additives to improve the fuel economy as well as to reduce the exhaust emissions and also combustion stability. The scientists in nano

science and technology council in USA have achieved to increase 10-25% combustion efficiency by adding 0.5% of aluminum nanoparticles to a rocket's solid fuel.

[9] Eastman JA, Choi SUS, Li S, Yu W, Thompson LJ. "Anomalously increased effective thermal conductivities of ethylene glycol-based nanofluids containing copper nanoparticles". Appl Phys Lett 2001;78(6):718–20. Eastman et al found [24] that a "nanofluid" consisting of copper nanometer-sized particles dispersed in ethylene glycol has a much higher effective thermal conductivity than either pure ethylene glycol or ethylene glycol containing the same volume fraction of dispersed oxide nanoparticles. Thermal conductivity of ethylene glycol can be increased by 40 % for a nanofluids consisting of ethylene glycol containing approximately 0.3 volume % Cu nanoparticles of mean diameter <10 nm.

[10] Xie H, Wang J, Xi T, Liu Y, Ai F: Thermal conductivity enhancement of suspensions containing nanosized alumna particles. J Appl Phys 2002, 91:4568-4572 Xie et al. used 60.4-nm-sized particles, observed higher thermal conductivity enhancement for larger nanoparticles in ethylene glycol-based nanofluids. In the case of Xie et al. , the researchers used 60.4-nm-sized Al2O3 dispersed in water and prepared stable solution by adjusting pH. The nanoparticles are de-agglomerated by using an ultrasonic disrupter after mixing with a base fluid and were homogenized by using magnetic force agitation. The enhancement observed was 21% for 5% volume fraction and 14% at 3.2% volume fraction.

METHODOLOGY:

Two-step method is the most widely used method for preparing Nano fluids. Nanoparticles used in this method are first produced as dry powders by chemical or physical methods. Then, the Nano sized powder will be dispersed into Mineral oil in the second processing step with the help of intensive magnetic force agitation and ultrasonic agitation. The schematics of magnetic stirrer and magnetic beads are shown in the figures:

Figure 3.1: Magnetic stirrer

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Lubricating oil with Nano particles is placed in a beaker on the stirrer with a magnetic bead in it.

Figure: 3.2 Different Magnetic Beads

Two-step method is the most economic method to produce Nano fluids in large scale, because Nano powder 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. Effects of Nano particles on air-conditioning cannot be isolated if surfactants are used.

Amount of lubricating oil used for the experiment is 650ml and the amount of TiO_2 Nano particles used is 0.2772 grams and the amount of Al_2O_3 Nano particles used is 0.1126 grams.

SPECTRAL ABSORBENCY ANALYSIS

Spectral absorbency analysis is an efficient way to evaluate the stability of Nano fluids. In general, there is a linear relationship between the absorbency intensity and the concentration of nanoparticles in fluid. Experiments evaluated the dispersion characteristics of TiO_2 and Al_2O_3 suspension using the conventional sedimentation method with the help of absorbency analysis by using a spectrophotometer after the suspension deposited for 24 h and 7 days. If the Nano materials dispersed in fluids have characteristic absorption bands in the wavelength 190–1100 nm, it is an easy and reliable method to evaluate the stability of Nano fluids using UV spectral analysis. The variation of particle concentration of Nano fluids with sediment time can be obtained by the measurement of absorption of Nano fluids, because there is a linear relation between the nanoparticle concentration and the absorbance of suspended particles. The outstanding advantage comparing to other methods is that UV spectral analysis can present the quantitative concentration of Nano fluids. It is believed that the stability of Nano fluids was strongly affected by the characteristics of the suspended particles and the base fluid such as particle morphology.

The intensity of transmitted radiation is measured using transducers. Intensity of incident radiation is known. Absorption is defined as the logarithm of ratio of intensities of incident and transmitted radiation.

$$Absorption=\log (I_0/I)$$

Where I_0 is the intensity of incident radiation and I is the intensity of transmitted radiation

RESULTS AND DISCUSSIONS

- Thermal conductivity of Nano particles mixed in lubricating oil is found to be greater than that of the base fluid. This result agrees with that of the results obtained in literature. This is to be expected as thermal conductivity of metals/ metal oxides nano particles is higher than the base low thermal conductivity mineral oil.
- Analysis of dispersion characteristics of nanoparticles in lubricating oil using spectrophotometer shows that the Nano fluid is not stable and nano particles form sediments on the 1st day and 7th day, this is perhaps the reason we got only slight improvement in EER as nanoparticles had settled in the crank casing of the compressor. In order to overcome the problem of sedimentation of nano particles, surfactants can be used in lubricating oil.
- Compressor performance tests indicate that increase in EER is 0.1% when TiO_2 Nano particles are mixed with Mineral oil and 1.5% decrease in EER, when Al_2O_3 Nano particles are mixed with Mineral oil which is not encouraging. So, further experimentation is required with higher concentrations of nanoparticles with smaller sizes of Nano particles; surfactants can also be added to the Nano Fluids and EER checked.

For Base Oil: Mineral oil

TECUMSEH

Tecumseh Products India Pvt.Ltd,Hyderabad

Calorimeter Test Results

Cal-2 Q.F:7.3- 01-15

TEST DOCUMENTATION			
TEST PURPOSE	DEV SAMPLE	REPORT NO.	C12081016 - L2
TEST DATE	8/11/2012	PROJECT NO.	
BILL OF MATERIAL	BS12081016	MODEL NO.	RNB5528BNA
COOLING METHOD	425 CFM	DISPLACEMENT CC/REV	28
SERIAL NUMBER	146417	MOTOR MANUFACTURER	TPIPL HYD
CODE DATE		MOTOR SPECS.	PSC
REFRIGERANT	R410A	PHASE	Single Phase
REQUESTING ENGINEER	M.P.REDDY	FREQUENCY Hz	50
TESTED BY	MD.GHOUSE	CUSTOMER NOTFN. NO.	
TEST NAME	ASHRAE-R410a	TEST NUMBER	5547

TEST MEASUREMENTS					DEV SAMPL TEST WITH
PRESSURES	ACTUAL VALUE		SET VALUE		(MINERAL OIL)
	BAR (A)	PSIA	BAR (A)	PSIA	
SUCTION PRESSURE	9.9336	144.07	9.954	144.37	O.C.R- 1.47%
DISCHARGE PRESSURE	33.846	490.90	33.85	490.95	
CAL. OUT PRESSURE	9.908	143.70			

TEMPERATURES	ºC	ºF	ºC	ºF
EVAPORATING TEMP.	7.1	44.8	7.2	45.0
CONDENSING TEMP.	54.5	130.1	54.5	130.1
DEGREE OF SUPERHEAT	27.9	50.3	27.8	50.0
DEGREE OF SUBCOOLING	8.4	15.1	8.4	15.2
RETURN GAS TEMP.	35.0	95.0	35.0	95.0
LIQUID TO EXPN. VALVE	46.1	115.0	46.1	115.0
CAL. OULET TEMP.	35.1	95.1	35.0	95.0
COMPR. CHAMBER AMB.	34.9	94.9	35.0	95.0
Top Shell	73.9	165.1		
Bottom Shell	58.1	136.6		
Middle at shell	70.5	159.0		
Discharge Line	87.1	188.7		

ELECTRICAL MEASUREMENTS				
PARAMTER	ACTUAL VALUE		SET VALUE	
FREQUENCY	49.99	Hz	50	Hz
COMPRESSOR VOLTAGE1	219.44	Volts	220	Volts
COMPR. CURRENT1	10.79	Amp.		
COMPR. POWER	2304	Watts		
COMPR. PF, MEASURED	0.97			
CAL. HEATER ENERGY	6663	Watts		
RUN CAPACITOR USED	45MFD			
ECR	316.32	Volts		
ECH	245.38	Volts		
START WDG. CURRENT	4.68	Amp.		
MAIN WINDING CURRENT	8.5	Amp.		
MOTOR SPEED	2882	RPM		

REFRIGERATION RESULTS				
MASS FLOW RATE, CALC.	2.291	Kg/min	303.06	Lbs/hr
MASS FLOW RATE, MEAS.	2.276	Kg/min	301.14	Lbs/hr
MASSFLOW AGREEMENT	0.63	%		
CORRECTED CAPACITY	6745.85	Watts	23037.08	Btuh
CORRECTED COMP. POWER	2304.46	Watts		
VOLUMETRIC EFFICENCY	88.30	%		
ISENTROPIC EFFICENCY	65.89	%	EER	10.00

DEVIATION ANALYSIS		NOMINAL	ACTUAL	DEVIATION
COMPR. POWER, Watts		2320	2304.46	-0.7
COMPR. CURRENT, Amp.		11.5	10.79	-6.2
CAPACITY, Btu/Hr		23400	23037.08	-1.6
EER (Btu/Wh)		10.10	10.00	-1.0

Winding Temperature 105.40℃ Checked By

For Nano Fluid: Mineral oil + 0.01(v/v)% Tio_2:

TECUMSEH

Tecumseh Products India Pvt.Ltd,Hyderabad

Calorimeter Test Results

Cal-2 Q.F:7.3- 01-15

TEST DOCUMENTATION			
TEST PURPOSE	DEV SAMPLE	REPORT NO.	C12081016- L3
TEST DATE	9/11/2012	PROJECT NO.	
BILL OF MATERIAL	BS12081016	MODEL NO.	RNB5528BXC
COOLING METHOD	425 CFM	DISPLACEMENT CC/REV	28
SERIAL NUMBER	146417	MOTOR MANUFACTURER	TPIPL HYD
CODE DATE		MOTOR SPECS.	PSC
REFRIGERANT	R410A	PHASE	Single Phase
REQUESTING ENGINEER	M.P.REDDY	FREQUENCY Hz	50
TESTED BY	MD.GHOUSE	CUSTOMER NOTFN. NO.	
TEST NAME	ASHRAE-R410a	TEST NUMBER	5548

TEST MEASUREMENTS					DEV SAMPLE(TEST WITH)
PRESSURES	ACTUAL VALUE		SET VALUE		MINERAL OIL + TITANIUM
	BAR (A)	PSIA	BAR (A)	PSIA	DI -OXIDE.
SUCTION PRESSURE	9.9382	144.14	9.954	144.37	
DISCHARGE PRESSURE	33.862	491.13	33.86	491.10	O.C.R - 2.4%
CAL. OUT PRESSURE	9.912	143.76			

TEMPERATURES	ºC	ºF	ºC	ºF
EVAPORATING TEMP.	7.1	44.9	7.2	45.0
CONDENSING TEMP.	54.5	130.2	54.5	130.2
DEGREE OF SUPERHEAT	27.9	50.2	27.8	50.0
DEGREE OF SUBCOOLING	8.4	15.2	8.4	15.2
RETURN GAS TEMP.	35.0	95.0	35.0	95.0
LIQUID TO EXPN. VALVE	46.1	115.0	46.1	115.0
CAL. OULET TEMP.	35.0	95.0	35.0	95.0
COMPR. CHAMBER AMB.	35.0	95.0	35.0	95.0
Top Shell	71.2	160.2		
Bottom Shell	54.5	130.2		
Middle at shell	78.9	174.0		
Discharge Line	87.6	189.6		

ELECTRICAL MEASUREMENTS				
PARAMTER	ACTUAL VALUE		SET VALUE	
FREQUENCY	49.996	Hz	50	Hz
COMPRESSOR VOLTAGE1	220.26	Volts	220	Volts
COMPR. CURRENT1	10.772	Amp.		
COMPR. POWER	2304	Watts		
COMPR. PF, MEASURED	0.97			
CAL. HEATER ENERGY	6676	Watts		
RUN CAPACITOR USED	45MFD			
ECR	316.62	Volts		
ECH	245.26	Volts		
START WDG. CURRENT	4.7	Amp.		
MAIN WINDING CURRENT	8.52	Amp.		
MOTOR SPEED	2880	RPM		

REFRIGERATION RESULTS				
MASS FLOW RATE, CALC.	2.296	Kg/min	303.76	Lbs/hr
MASS FLOW RATE, MEAS.	2.300	Kg/min	304.34	Lbs/hr
MASSFLOW AGREEMENT	-0.19	%		
CORRECTED CAPACITY	6756.29	Watts	23072.72	Btuh
CORRECTED COMP. POWER	2304.18	Watts		
VOLUMETRIC EFFICENCY	88.49	%		
ISENTROPIC EFFICENCY	66.04	%	EER	10.01
DEVIATION ANALYSIS		NOMINAL	ACTUAL	DEVIATION
COMPR. POWER, Watts		2320	2304.18	-0.7
COMPR. CURRENT, Amp.		11.5	10.772	-6.3
CAPACITY, Btu/Hr		23400	23072.72	-1.4
EER (Btu/Wh)		10.10	10.01	-0.9

Winding Temperature 102.76℃ Checked By

For Nano Fluid: Mineral oil + 0.01(v/v)% Al_2O_3:

Tecumseh Products India Pvt.Ltd,Hyderabad

Calorimeter Test Results

Cal-2 Q.F:7.3- 01-15

TEST DOCUMENTATION			
TEST PURPOSE	Dev sample	REPORT NO.	C12081016-L4
TEST DATE	9/11/2012	PROJECT NO.	
BILL OF MATERIAL	BS12081016	MODEL NO.	RNA5528BXC
COOLING METHOD	425 CFM	DISPLACEMENT CC/REV	28
SERIAL NUMBER	146417	MOTOR MANUFACTURER	TPIPL,HYD
CODE DATE		MOTOR SPECS.	PSC
REFRIGERANT	R410A	PHASE	Single Phase
REQUESTING ENGINEER	M.P.REDDY	FREQUENCY Hz	50
TESTED BY	R.CHANDRA	CUSTOMER NOTFN. NO.	
TEST NAME	ASHRAE-R410a	TEST NUMBER	5549

TEST MEASUREMENTS					
PRESSURES	ACTUAL VALUE		SET VALUE		Tested with Al2O3 oil
	BAR (A)	PSIA	BAR (A)	PSIA	Mineral oil+ Aluminium oxide.
SUCTION PRESSURE	9.9364	144.12	9.954	144.37	
DISCHARGE PRESSURE	33.854	491.01	33.86	491.10	O.C.R - 1.7%
CAL. OUT PRESSURE	9.912	143.76			

TEMPERATURES	ºC	ºF	ºC	ºF
EVAPORATING TEMP.	7.1	44.9	7.2	45.0
CONDENSING TEMP.	54.5	130.1	54.5	130.2
DEGREE OF SUPERHEAT	27.8	50.1	27.8	50.0
DEGREE OF SUBCOOLING	8.5	15.2	8.4	15.2
RETURN GAS TEMP.	35.0	95.0	35.0	95.0
LIQUID TO EXPN. VALVE	46.1	114.9	46.1	115.0
CAL. OULET TEMP.	35.0	95.0	35.0	95.0
COMPR. CHAMBER AMB.	34.9	94.9	35.0	95.0
Top Shell	71.3	160.3		
Bottom Shell	58.8	137.8		
Middle at shell	75.0	167.0		
Discharge Line	86.8	188.3		

ELECTRICAL MEASUREMENTS				
PARAMTER	ACTUAL VALUE		SET VALUE	
FREQUENCY	50.006	Hz	50	Hz
COMPRESSOR VOLTAGE1	219.5	Volts	220	Volts
COMPR. CURRENT1	10.916	Amp.		
COMPR. POWER	2330	Watts		
COMPR. PF, MEASURED	0.97			
CAL. HEATER ENERGY	6642	Watts		
RUN CAPACITOR USED	45MFD			
ECR	316.28	Volts		
ECH	244.4	Volts		
START WDG. CURRENT	4.7	Amp.		
MAIN WINDING CURRENT	8.56	Amp.		
MOTOR SPEED	2860	RPM		
REFRIGERATION RESULTS				
MASS FLOW RATE, CALC.	2.284	Kg/min	302.18	Lbs/hr
MASS FLOW RATE, MEAS.	2.297	Kg/min	303.92	Lbs/hr
MASSFLOW AGREEMENT	-0.58	%		
CORRECTED CAPACITY	**6721.90**	**Watts**	**22955.28**	**Btuh**
CORRECTED COMP. POWER	**2329.72**	**Watts**		
VOLUMETRIC EFFICENCY	88.69	%		
ISENTROPIC EFFICENCY	64.98	%	**EER**	**9.85**

DEVIATION ANALYSIS		NOMINAL	ACTUAL	DEVIATION
COMPR. POWER, Watts		2320	2329.7	*0.4*
COMPR. CURRENT, Amp.		11.5	10.91	-5.1
CAPACITY, Btu/Hr		23400	22955.3	*-1.9*
EER (Btu/Wh)		10.09	9.85	*-2.3*

WINDING TEMPERATURE 106.7 °C Checked By

CONCLUSIONS

- Spectroscopic analysis of nanoparticles added to lubricant oil shows that sediments start forming on the 7th day indicating that Nano particles are not fairly well dispersed in the base fluid. Surfactants may be added to enhance the dispersal level.
- Thermal conductivity of Nano fluids (TiO_2, Al_2O_3 Nano particles added to Mineral oil) is greater than that of the base fluid. This is to be expected as thermal conductivity of metals/metal oxides nano particles added is higher than that of the base mineral oil. This is consistent with literature which reports an increase in Thermal Conductivity when Nano particles are added to water/Ethylene Glycol.
- The reproducibility of the air conditioning test facility was checked by repeating one case twice. Results showed agreement of EER values within ± 0.1%. The Energy Efficiency Ratio for TiO_2 spiked lubricant increased by 0.1% and for Al_2O_3, spiked lubricant, EER decreased by 1.5%. It is concluded that significant results were not obtained. It is inferred that in order to get an increase in EER, the nano particles concentration has to be increased and size of nano particles has to be decreased and tests have to be conducted afresh.

Also, care should be taken that lubricating oil left over in the crank case of the compressor housing after a particular experiment should be removed totally and filled afresh for next experiment, to avoid contamination

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