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Effect of nano particles on air conditioning compressor performance

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ABSTRACT

Nano particles are found to attract the attention in the recent years due to their diverse uses. Addition of metal or non-metal oxides to a base fluid leads to a different working fluid called NANO FLUID. Addition of Nano particles lead to change in both transport and thermal properties for fluid. In a traditional air conditioning system, there will be certain amount of lubricating oil that is carried away by the refrigerant in the compressor. So certain amount of lubricating oil circulates along with the refrigerant in the air conditioning circuit. If the solubility of lubricating oil in the refrigerant is low, there is a danger of accumulation of lubricating oil in the condenser. If the solubility of lubricating oil in the refrigerant is high, refrigerant washes away all the lubricating oil in the compressor and there is a danger of abrasion in the compressor. There is a danger of sedimentation of Nano particles in compressor if it is not dispersed properly in the oil. If the Nano particles are not correctly dispensed, there is a danger of their interference with environment. Nano particles are found to hinder the growth of plants. They are carcinogenic and hence care should be taken to handle them judiciously. Economic issues regarding the usage of Nano particles have also to be considered as they are quite expensive.The refrigerant used in the air-conditioning setup that is used for testing is R-410a. The refrigerant R-410a is azeotropic suggesting that the phase change temperature does not remain constant as in the case of traditional refrigerants. Temperature of the refrigerant (R-410a) decreases during the phase change. The refrigerant used in the air-conditioning setup that is used for testing is R-410a. The refrigerant R-410a is azeotropic suggesting that the phase change temperature does not remain constant as in the case of traditional refrigerants. Temperature of the refrigerant (R-410a) decreases during the phase change.

Introduction

There is an increase in energy utilization in recent years. So there has been a desire to decrease the energy utilized by different appliances used in daily life. Nano particles are found to attract the attention in the recent years due to their diverse uses.

Addition of metal or non-metal oxides to a base fluid leads to a different working fluid called NANO FLUID. Addition of Nano particles lead to change in both transport and thermal properties for fluid. In a traditional air conditioning system, there will be certain amount of lubricating oil that is carried away by the refrigerant in the compressor. So certain amount of lubricating oil circulates along with the refrigerant in the air conditioning circuit. If the solubility of lubricating oil in the refrigerant is low, there is a danger of accumulation of lubricating oil in the condenser. If the solubility of lubricating oil in the refrigerant is high, refrigerant washes away all the lubricating oil in the compressor and there is a danger of abrasion in the compressor. Therefore, for the proper functioning of the appliance using the given refrigerant and lubricating oil, they must be compatible with each other. For the refrigerant and lubricating oil to be compatible, polarity of both refrigerant and lubricating oil must be same. This ensures optimal solubility of lubricating oil in the refrigerant. Nano particles added to the lubricating oil clog the surface asperities thus decrease the sliding friction between the surfaces. Clogging of the surface asperities also found to decrease the nucleate boiling heat transfer characteristics. Addition of Nano particles also found to enhance the critical heat flux of the refrigerant. Literature studies show that Thermal conductivity of Nano fluid is greater than that of base fluid. Also viscosity of Nano fluid is greater than that of the base fluid. These are the uses of Nano particles. Nano particles also have certain disadvantages. There is a danger of sedimentation of Nano particles in compressor if it is not dispersed properly in the oil. If the Nano particles are not correctly dispensed, there is a danger of their interference with environment. Nano particles are found to hinder the growth of plants. They are carcinogenic and hence care

should be taken to handle them judiciously. Economic issues regarding the usage of Nano particles have also to be considered as they are quite expensive.The refrigerant used in the air-conditioning setup that is used for testing is R-410a. The refrigerant R-410a is azeotropic suggesting that the phase change temperature does not remain constant as in the case of traditional refrigerants. Temperature of the refrigerant (R-410a) decreases during the phase change.

Refrigerant R410a is the blend of R32 50 %(w/w) and R125 50 %(w/w).

It can operate at higher pressures than traditional refrigerants. Also, the ozone depletion potential of R410a is zero which suggests that it is environmental friendly.

Properties of R410a:

R410A is a binary blend of HFC compounds 50% of R32 and 50% of R125

No chlorine content, no ozone depletion potential. *ODP = 0*. Global warming potential *GWP* = 1725.

Table1. Properties of Refrigerant R410A :

Properties	**Units**	**R410A**
Components	-	HFC-32 HFC-125
Composition	% weight	- 50/50
Molecular Weight	g/mol	72.6
Bubble Temperature (at	°C	-52.2
Temperature Glide (at 1.013 bar)	K	0.1
Liquid Density (at 25°c)	Kg/m³	1.0615
Density of Saturated	Kg/m³	4.12
Vapour Pressure at: 25°c 50°c	bar* bar*	16.4 30.5
Critical Temperature	°C	72.2
Critical Pressure	bar*	49.5
Critical Density	Kg/m³	0.491
Latent Heat of Vaporisation (at 1.013 bar)	KJ/kg	271.5

NANO FLUID PREPARATION USING TWO-STEP METHOD

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 1: Magnetic stirrer

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

Figure: 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.

Table2.**Mineral Oil – (Suniso 4gs Oil) Properties:**

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.

Figure 3. photo spectrometer

Results obtained from Photospectrometer:

TiO_2 Nano particles have peak absorption between the wavelengths 225nm and 410nm.

Absorption of spectrum on 1st Day for TiO_2

From the above Al_2O_3 nano particles have peak absorption between 375nm to 460 nm.

Results of Photo spectrometer absorption on day1 and day 7 from the start of testing indicate that some amount of TiO_2 and Al_2O_3 Nano particles form sediments in the lubricating oil , with TiO_2 nano particles having less sedimentation in the lubricating oil as compared with Al_2O_3 nano particles.

Methods to Enhance the Stability of Nano fluids:

Surfactants used in Nano fluids are also called dispersants. Adding dispersants in the two-phase systems is an easy and economic method to enhance the stability of Nano fluids. Dispersants can markedly affect the surface characteristics of a system in small quantity. Dispersants consists of a hydrophobic tail portion, usually a long-chain hydrocarbon, and a hydrophilic polar head group. Dispersants are employed to increase the contact of two materials, sometimes known as wettability. In a two-phase system, a dispersant

tends to locate at the interface of the two phases, where it introduces a degree of continuity between the Nanoparticles and base fluids.

When the base fluid of Nano fluids is polar solvent, water-soluble surfactants should be selected; otherwise, oil soluble ones are to be selected.

Surface Modification Techniques: Surfactant-Free Method:

Use of functionalized nanoparticles is a promising approach to achieve long-term stability of Nano fluid. It represents the surfactant-free technique. Yang and Liu presented a work on the synthesis of functionalized silica (SiO2) Nanoparticles by grafting Silanes directly to the surface of Silica Nanoparticles in original nanoparticle solutions. One of the unique characteristics of the Nano fluids was that no deposition layer formed on the heated surface after a pool boiling process. Hwang et al. introduced hydrophilic functional groups on the surface of the nanotubes by mechanochemical reaction. The prepared Nano fluids, with no contamination to medium, good fluidity, low viscosity, high stability, and high thermal conductivity, would have potential applications as coolants in advanced thermal systems.

THERMAL CONDUCTIVITY ANALYSIS

Thermal conductivity of Nano fluid is investigated by "THERMAL CONDUCTIVITY OF LIQUID AND GASSES APPARATUS". The apparatus looks as shown in the Fig. 6.1:

The device consists of a console, a plug/jacket assembly. Console consists of voltmeter, thermo couple output, electrical input. Plug/jacket assembly consistsof a heater, a water jacket, annular space between the heater and water jacket to accommodate the test fluid, thermo couples input, an 'O' ring seal. The annular space between the heater and water jacket is kept small to supress convection heat transfer between the surfaces.

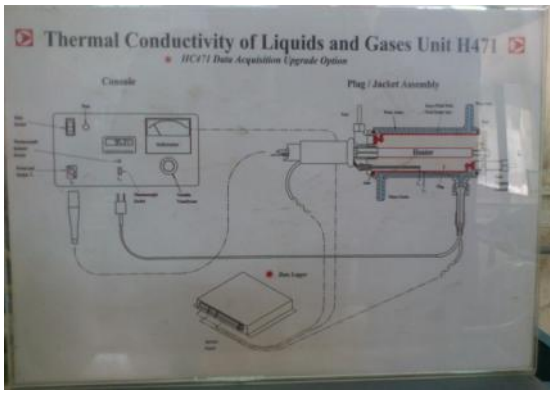

figure 3.: thermal conductivity of liquid and gasses apparatus

Experimental procedure:

- The apparatus is cleaned so as to remove any dust present in the annular space.
- Initially, apparatus is operated with dry air to find the heat transfer losses occurring due to radiation between the heater and water jacket, temperature difference between heater and atmosphere, conduction through 'O' seal rings.
- Heat loss through any of the above reasons is plotted versus temperature.
- Heat conducted through the fluid is the difference between heat supplied and the heat lost.
- Now the apparatus is operated with the given working fluid (lubricating oil without CuO Nano particles) and its thermal conductivity is calculated at different voltage inputs.
- The apparatus is then operated using the

given Nano fluid anh its thermal conductivity is calculated.

Results:

- The obtained values of thermal conductivity are as follows:

Where the temperatures denote the average of heater and jacket temperatures. Obtained values of Thermal conductivities are plotted versus temperature on a graph.

Graphs:

Thermal conductivity graph:

Where the values on X-axis denote the temperatures in degrees Celsius and the values on Y-axis denote Thermal conductivities in Watt per meter per Kelvin.

From the above graphs, it ias observed that there is increase in Thermal conductivity of Nano fluids as compared with the base fluid. Literature studies have shown an increase in Thermal conductivity by the addition of Nano particles to Ethylene Glycol/water.

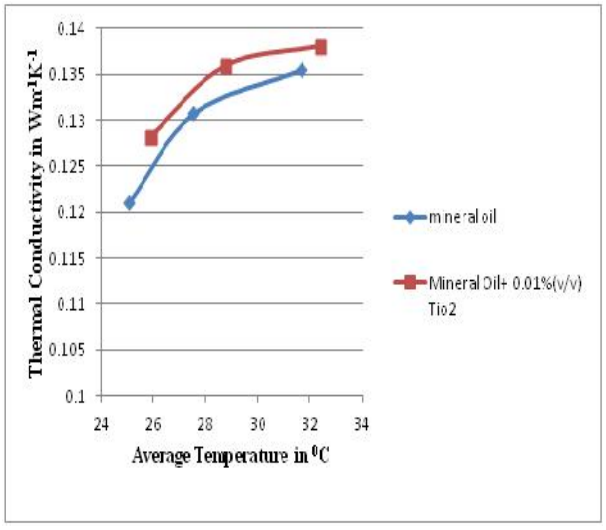

Figure 5.2: Thermal Conductivity of Mineral Oil (vs) Nano Fluid (Mineral Oil + 0.01 % (v/v) TiO_2 Nano particles)

PERFORMANCE TESTS ON AIR-CONDITIONER COMPRESSOR SETUP

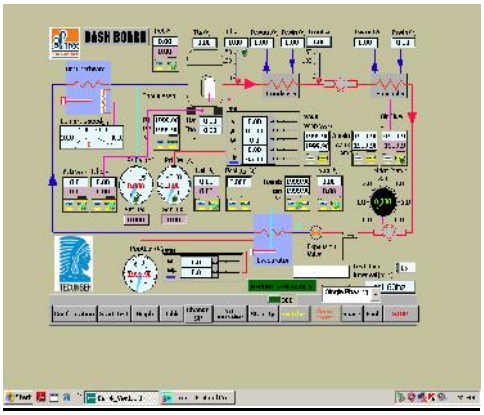

Figure 6.: Line diagram of experimental setup

Figure 7: Experimental Air-conditioning compressor equipment

The Nano lubricant prepared above is tested in the compressor of air-conditioning test facility in M/S TECUMSEH. The equipment is run till the time steady state is reached or heat balance is attained. The refrigerant used is R-410a. Apparatus are available to maintain the same temperature all over the room. Thermocouples are provided to ensure the required conditions are maintained in the test setup.

Apparatus is provided to measure the power input to the compressor and temperatures at different places in the conditioned space.

Figure 8: Compressor test cabin

Test Procedure:

LABORATORY AND TEST UNIT PREPERATION

1. Machine to be tested is selected and inspected according to the sampling, receiving check list.
2. If the machine is in satisfactory condition (i.e., without damage and improper functioning) machine is installed in the facility and installation check list is followed.
3. Power supplies of test room, 2 TR chiller and computer software are switched ON.
4. Lab view software is initialised on the computer.

5. For the test conditions to be followed, TEST REQUEST is to be referred.

Following procedure should be followed for conducting **cooling capacity** test.

The purpose of the test is to determine the magnitude of following functions:

a) Net Cooling capacity,

b) Net power input to compressor,

1. Calorimetric test condition is selected (27°C/ 19°C, 35°C / 24°C) for the unitary air conditioner (IS – 1391 Part 1) and (27°C/ 19°C, 35°C / ----) for split air conditioner (IS – 1391 Part 2).
2. UUT (Unit Under Test) is switched ON.

3. Fan speed is set for the highest and ensuring the unit is in cooling mode, temperature is set to minimum set point.
4. System is allowed to be stabilized for the above mentioned test conditions.
5. Test unit is run for 4 hours under the stabilized condition and the values obtained are recorded.
6. Test data is compared with the declared values.

7. For the test unit to qualify the cooling capacity test, cooling capacity of the unit should not be less than that of the 90% of the declared value and power consumption of the unit should not be more than 110% of the declared value.

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 1stday 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.

Conclusions And Scope Of Future Work

- 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.

SCOPE OF FUTURE WORK:

- Examine other Nano particles at higher concentrations and smaller sizes.
- Try out with surfactants added to the lubricating oil, to overcome sedimentation.

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