EXPERIMENTAL INVESTIGATION ON FREE CONVECTION HEAT TRANSFER AUGMENTATION USING TRANSFORMER OIL – Cuo NANO FLUID

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Abstract - *Conventional fluids such as water, engine oil, kerosene, ethanol, and ethylene glycol have lower thermal conductivity compared to solids. Lower thermal conductivity of fluid became an obstacle to use in different applications. To overcome this obstacle, a new method such as dispersing nano sized solid particles in fluids which enhance the thermal conductivity of base fluids significantly and it is named as nano fluids. These nano fluids are succeeded in many applications whereas coming to natural convection it faces debacle. Nano fluids used to enhance the convection heat transfer but conversely by using the nano fluids deterioration occurred. Some of the researchers got enhancement but they got enhancement in lower volume fractions. The reason behind the deterioration is aggregation of nano particles leads to clogging and then to sedimentation and to find out the heat transfer enhancement using ultra sonication, magnetic stirring and surfactant addition is used to modify. But these modifiers affect the properties such as thermal conductivity, viscosity, specific heat etc.*

Particle size, shape, structure strongly influences the properties of nano fluids. The parameters thermal conductivity, viscosity, specific heat, thermal expansion coefficient, density all are related to volume fraction. It is extremely sensitive to deal everything related to volume fraction. To minimize the complexities Cuo of 30nm with spherical shape are procured. Volume fractions are 0.05%, 0.1%, 0.15%, 0.2% are preferred to conduct experiment ultra-sonication, magnetic stirring is preferred. Enhancement is obtained up to 0.15% volume fraction and further deterioration occurs. In the natural convection heat transfer enhancement through nano fluids is explained Correlations between Nusselt number and Rayleigh are drawn and presented.

Key Words: Nano fluid, Volume fraction, Cuo

1. INTRODUCTION

Fluids are frequently used as heat carries in heat transfer equipment. Examples of important use of heat transfer fluids include vehicular and avionics cooling systems in the transportation industry, hydraulic heating and cooling systems in buildings, industrial process heating as well as cooling systems in petrochemical, textile, pulp and paper, chemical, food and other processing plants. In all these applications, the thermal conductivity of heat transfer fluids plays a vital role in the development of energy-efficient heat transfer equipment.

1.1 Obstacles encountered to enhancement of heat transfer:

It has to be admitted that despite considerable previous research and development efforts put on heat transfer enhancement, few important improvements in cooling capabilities have been constrained because of the low thermal conductivity of conventional heat transfer fluids. However, it is well known that metals in solid form have orders of magnitude larger thermal conductivity of copper at room temperature is 700 times greater than that of water and is 3000 times greater than that of engine oil. And, the thermal conductivity of metallic liquids is much greater than that of non-metallic liquids. Therefore, thermal conductivities of fluids that contain suspended solid metallic particles are expected to be significantly more enhanced when compared with conventional heat transfer fluids.

1.2 Role of Nano fluids: decade ago, a new kind of heat transfer fluid called nano fluid was introduced which was derived from stably suspending nano particles in conventional heat transfer fluids, usually liquids resulted from the pioneering work of choi and Eastman (1). Commonly used 2 oxide nano particles are Aluminum (Al), Silicon (Si), Titanium (Ti), Copper (Cu), Zinc (Zn), Iron (Fe), Magnesium (Mg) and Silver (Ag) and base fluids are water, engine oil, kerosene, ethanol, methanol, ethylene glycol and mono ethylene glycol. Nano fluids consisting of such nano particles suspended in liquids have been shown to enhance the thermal conductivity as well as convective heat transfer Performance of the base fluids. It has been reported that the enhancement of nano fluids depends not only on nanoparticle parameters but also on their suspension stability in base fluid

2. LITERATURE REVUEW

In 1883 maxwell et.al [1] predicted that dispersion of solid particles may alter the properties of the fluids. However, he did not mention the size of solid particles. In 1993, Masuda et.al [2] used to disperse the submicron particles of Al2O3, Sio2, Tio2 and he observed enhancement in the properties of the fluid. From the inspiration choi and Eastman [3] develop a new kind of fluids and named them as nano fluids. In their pioneering work they observed enhancement up to 40 % in the thermal conductivity. The work of choi and Eastman attracted most of the researchers to concentrate on nano fluids. In the earlier stages of development of nano fluids all the researchers concentrated on the thermal conductivity

Putra et.al [4] experimentally investigated natural convection heat transfer by dispersing Al_2O_3 and CuO and observed systematic heat transfer deterioration and he stated that nature of this deterioration and its dependence on parameters such as particle concentration, material of the particles and geometry of the containing cavity. Koulolias et.al [5] found the deterioration of convective heat transfer coefficient and Nu by increasing of Rayleigh number with nano particle concentration. mohmmad ali et.al [6], Ho et.al [7], sudhakar subhudi et.al [8] observed increase in heat transfer coefficient. This is increment is restricted to low concentrations such as < 1%. Mohammed ali et.al [9] observed heat transfer coefficient increment up to 0.5% and for 0.75% observes the deterioration. Ho et.al [10] observed heat transfer increment of 18% at 0.1% but for $c_v > 2\%$ observes deterioration. Subhudi et.al [11] got enhancement in heat transfer for c_v in 0.01- 0.1%. Necessity arises to find out the reasons for the decrement at these higher volume fractions. At higher volume fractions nano particles tend to aggregate faster that directly effects the performance. Aggregations made to form fouling at the heating section which directly stating that lack of stability would degrade the performance. So the study is based on the stability and heat transfer enhancement was studied and possible agreements were concluded. Ravi Babu and Sambasiva Rao [12] conducted the experiments to find the natural convective heat transfer performance along a vertical cylinder immersed in water as well as water+EG blend. Ravi Babu and Sambasiva Rao [13] All things considered, whatever the heat input is given to the metallic cylinder will be carried away by the cooling water circulation and thereby steady -state condition is achieved. When steady -state condition is occurred, the readings of vertical brass cylinder surface temperatures at different positions and bulk fluid temperatures were noted down

3. METHODOLOGY:

3.1 Overview: In order to get enhancement in convection heat transfer through nano fluids, nano fluids because all properties of nano fluids are assumed to be constant throughout experiment. Experimentation should be performed on flawless setup which gives proper reading in evaluation of heat transfer enhancement. Construction of experimental setup is described in the section

3.2 Steps involved:

- Selection of nano material on basis of properties and its size.
- Measure the size of nano particles XRD analysis, SEM, TEM images.
- To prepare the nano fluids with base fluid for different volume concentrations such as 0.05, 0.1, 0.15, 0.2%.
- Utilization of Stabilization modifiers such as magnetic stirring and ultra- sonication in terms of time period.
- Construction of flawless setup which consist of ammeter, voltmeter, temperature indicator, regulator, heating coil, nano fluid container, constant cooling water supply in adequate place.
- To conduct the experiments with transformer oil and Nano fluids at different heat inputs 30, 40, 45,50W and determination of heat transfer performance of transformer oil based - titanium oxide nano fluid for different volume concentrations.
- To calculate and compare the heat transfer coefficients for both transformer oil and Nano fluids.

3.3 selections of nano particles:

Based on properties and availability, Copper oxide is selected as nano material. Aluminum oxide generally has higher thermal conductivity than Copper Oxide but it settles faster. Due to higher density, copper molecules tend to agglomerate early which leads to sedimentation at faster rate. Copper has outstanding properties and show less tendency to agglomerate compared to Aluminum oxide. Nano particles are available at range of 0-100nm, but higher sized nano particles will tend to form clusters at every stage. 30 nm size, $6.31 g/cm^3$ of bulk density.

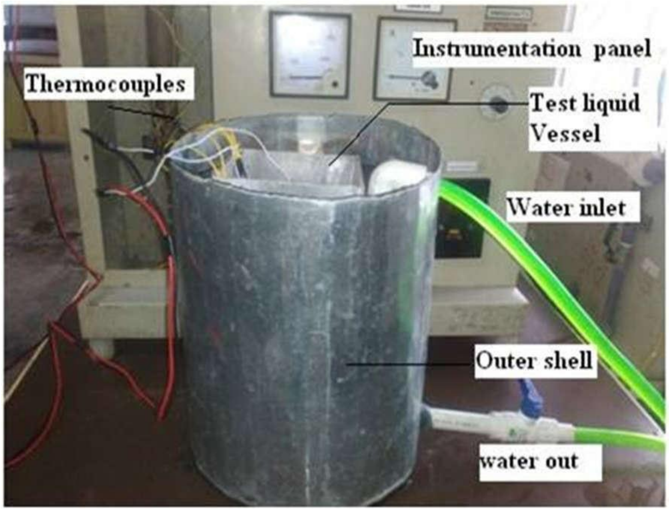
3.4 Selection of Volume fractions:

From the literature review, it can be stated that enhancement in natural convection heat transfer would be possible for low volume fractions. Sudhakar subudhi et.al observed enhancement up to 0.1% and deterioration at 0.12%. It is already known that enhancement would be possible at low volume fractions, so selected volume fractions should be low and one volume fraction should be high to make a comparative study. 0.05, 0.1, 0.15, 0.2% volume fractions are preferred. Transformer oil is selected as base fluid due its nature to soluble with both polar and non-polar solvents.

3. 5Construction of experimental setup and mode of experimentation:

A typical experimental setup consists of various elements like power supply, ammeter, voltmeter, dimmer stat, heating element, nano fluid container, cooling water supply, temperature indicator, thermocouples and digital thermo meter. Heat input is selected at 30, 40, 45,50W

4. EXPERIMENTAL SETUP AND EXPERIMENTATION



4.1. Components:

- External cylindrical GI container
- Heater
- Thermocouples
- Vertical Brass cylindrical surface
- Aluminum square enclosure
- Pipes (0.5 inch)

5. RESULTS & DISCUSSIONS

In this section, transformer oil and nano fluid data are compared for the nanoparticle volumetric concentrations, Ø = 0.05%, 0.1%, 0.15%, 0.2% for all power inputs, Q of 30, 40,45 and 50 W. The purpose is to identify any changes in the absolute value of the heat transfer coefficient trend line as the imposed heat flux increases for pure transformer oil and nano fluid. In fig5.2, the heat transfer coefficient of pure transformer oil and nano fluid in terms of the power input level is presented. It can be seen that as the power input increases, the heat transfer coefficient increases for all the cases. However, for the maximum nanoparticle concentration the rate of enhancement is notably less. In most of the cases, as Ra increases, Nu increases. However, for the maximum nanoparticle concentration, Nu becomes reduced. For the nano fluid with maximum nanoparticle concentration.

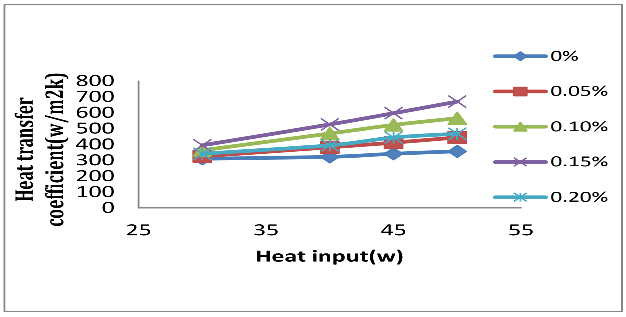


Fig1:Variation of heat transfer coefficient with different heat inputs for various volume fractions

Nusselt number is the function of Rayleigh number so the nusselt number behavior is depends on Rayleigh number behavior if Rayleigh number increase nusselt number increase where the nusselt number is increase heat transfer coefficient is increase. The heat transfer coefficient is increasing up to 0.15% volume fraction of Nanoparticles for all heat inputs. Beyond 0.15vol% of nanoparticles the heat transfer coefficient is decreasing due to agglomeration of nano particles.

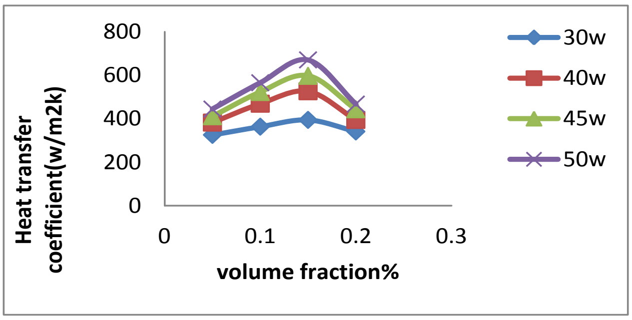


Fig 2: Variation of heat transfer coefficient with Cuo nanoparticle concentration for different heat input

6. CONCLUSIONS

- The free convection steady-state heat transfer of a vertical cylinder heated uniformly has been explored in this study and presented for various heat fluxes. Surface temperatures of the cylinder along the axial directions in case of transformer oil– Cuo nanofluid as mediums are examined and presented
- It is identified that in case of transformer oil –Cuo nanofluid the surface temperatures were recorded 9 to 12% lower than the temperatures when base fluid transformer oil as medium

- Natural convective heat transfer performance is augmented up to 0.15 vol % concentration of TiO_2 nanoparticles and then it is decreased after 0.15 vol % even it worse than the carrier fluid at higher concentrations.
- The natural convective heat transfer is enhanced by 17.8% at 0.15 vol % concentration compared to transformer oil at 50 W heat input as heat transfer coefficient is increased from 356.172w/m^{2}k to 670.465w/m^{2}k
- 0.05, 0.1,0.15,0.2% volume fractions require 1 hour of magnetic stirring to get stable suspension during the experiment.
- 0.05, 0.1,0.15,0.2% volume fractions require 30 min of ultra-sonication to get stable suspension during the experiment

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