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RESEARCH ARTICLE

AN EXPERIMENTAL METHOD TO DETERMINE THE AUGMENTATION OF HEAT TRANSFER COEFFICIENT BY CuO - WATER NANOFLUID

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ABSTRACT

Nanofluid is colloidal suspension of nanosized solid particles in a liquid. Generally nanoparticles are made of metals, oxides, carbides, while base liquids may be water, ethylene glycol or oil. Having suspended tiny particles in the base liquid improves the thermal conductivity and thus the increase in heat transfer performance is expected. A test study has been completed to examine the heat transfer performance of water and CuO nanoparticles. This current experiment demonstrates the increases in convective heat transfer in nanofluid. The nanofluid developed by adding CuO nano sized particles of 10-20 nm in base liquid. Demineralized water is used as base liquid. Nanofluid with different volume fraction of CuO nano sized matter between 0.025-0.5 percent used in this current work. The test setup consists of a test section that includes copper pipe of 1000 mm length, inner diameter 10mm and a heater. To minimize the heat loss in test section, insulation layer is covered. Thermocouples are utilized in test section to measure the temperatures. The effect of solid volume fraction, nanofluid flow rate and the inlet temperature on heat transfer performance of the nanofluid is examined in this current work. The results show an increment in heat transfer with raising volume fraction of CuO nanoparticles and increase in temperature.

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INTRODUCTION

Nanofluid is a fluid in which it contains nanometer-sized particles is suspended in base fluid. The base fluids are the conventional heat transfer basic fluids. The conventional heat transfer fluids, including oil, water, and ethylene glycol mixture. The conventional fluids are poor heat transfer rate, since the thermal conductivity of these fluids play important role on the heat transfer coefficient between the heat transfer medium and the heat transfer surface. Therefore numerous methods have been taken to improve the thermal conductivity of these fluids by suspending nano/micro or larger-sized particle materials in fluids. Since the solid nanoparticles with typical length scales of 1–100 nm with high thermal conductivity are suspended in the base fluid, have been shown to enhance effective thermal conductivity and the convective heat transfer coefficient of the base fluid. Nanofluids have the potential to reduce such thermal resistances, and the industrial groups that would benefit from such improved heat transfer fluids are quite varied. They include transportation, electronics, medical, food, and manufacturing of many types.

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The purpose of this work is to obtain a deeper understanding into the convective heat transfer behavior of nanofluid. The overall heat transfer enhancement due to nanofluid has been investigated, and specialized tests have also been performed to observe the convective heat transfer enhancement in the test section. Aqueous based nanofluid containing CuO of different volume fractions will be analyzed under constant heat flux boundary condition.

Preparation of Nanofluid

The preparation of nanofluid is that the first key step in experimental studies with nanofluid. One step technique and two step technique are generally used for preparing the nanofluid.

Single Step Technique

In the single step method, the nanoparticles synthesis and nanofluid preparation are done at the same time. The nanoparticles are straightforwardly prepared by a physical vapor deposition technique or a liquid chemical method. In single step technique, agglomeration of nanoparticles is reduced and the stability of the nanofluid is increased as storage, transportation, drying and dispersion of nanoparticles are avoided. However, this method only applicable for small scale production and, at current stage, it is almost impossible to scale up to industrial scale.

Two Step Technique

In the two step technique, the nanoparticles synthesis and nanofluid preparation is separated. Firstly, dry nanoparticles are produced; after which, they are dispersed in a appropriate base fluid. This is simpler then single step method as it can easily buy readily obtainable nanoparticles in market and then disperse them in the base fluid. However, it is well know that nanoparticles have a high surface energy which, in turn, leads to aggregation and clustering of nanoparticles and after some time, the particles will clog and settle down at the bottom of container. Partial dispersion may occur in the suspension which cause lower heat transfer enhancement compare to single step method, and hence, high amount of nanoparticles volume fraction is required. This method works well for oxide particle and carbon nanotube; however, it is less successful for metal nanoparticles.

Table 1. Specifications of copper oxide (CuO) nanoparticles

Properties	Copper Oxide
Chemical Formula	CuO
Color	Black
Morphology	Spherical
True Density	6400 kg/m^3
Bulk Density	790 kg/m^3
Thermal Conductivity	18 W/m K
Sp.Surface Area	10 m^2/g
Average particle Size	20-30 nm
Specific Heat	531.020 J/kg K

Experimental setup

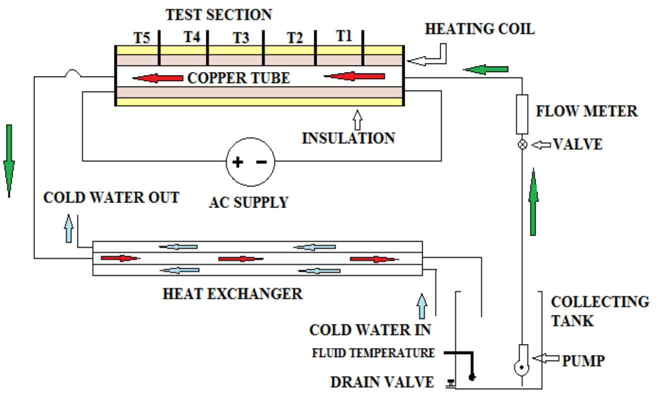

Fig. 1. Schematic view of experimental setup

The above figure shows the experimental setup for "An experimental method to determine the augmentation of heat transfer coefficient by CuO – water nanofluid". The setup mainly consists of the following components namely heating element, heat exchanger, reservoir and pump. Here in the heating element it consist a pipe, which is made up of copper and wounded by the nichrome wire. The ends of the nichrome wire are connected to the AC power supply.

As the power supply to the nichrome wire, it generates the heat due to the resistance of current flow. The copper wire absorbs the generated heat and gets heated. Concentric tube is considered in the heat exchanger. The outer pipe is made up of a galvanized iron (GI) and inner pipe made up of copper. Here the nanofluid made to flow in the inner copper tube and water to flow in the outer tube. The heat exchanger is equipped with valve it is ability to make to flow parallel and counter. The reservoir is made up of mild steel, which is coated with FCR coating to avoid corrosion. Here in reservoir nanofluid is stored which is supplied to the test section. The pump is used to supplied working fluid or nanofluid from reservoir to test section. The experimental setup with the above principle components also consist of measuring components such as flow meter having a maximum capacity 30 cc/sec to measure flow rate of working fluid supplied to the test section using the pump. It is fixed in between the reservoir output and entry section of the heating element. To measure the temperature of working fluid at different states of system the thermocouple are fixed at the different points along the flow of working fluid.

Data Analysis

1.Heat Absorption

$Q = m\,C_p\,\Delta T$

2.Mass Flow Rate

$m = \rho \times \text{Flow Rate}$

3.Density

$\rho_{nf} = (1-\phi)\,\rho_{bf} + \phi\rho_p$

4.Specific Heat

$(\rho C_p)_{nf} = (1-\phi)\,(\rho C_p)_{bf} + \phi\,(\rho C_p)_p$

5.Heat Transfer Coefficient

$h = \frac{Q}{(T_w - T_b)\times\pi\times d\times l}$

6.Heat Transfer Rate

For Hot Fluid

$Q_h = m_h \times C_{ph} \times (T_{hi} - T_{co})$

For Cold Fluid

$Q_c = m_c \text{ x } C_{pc} \text{ x } (Tci - Tc0)$

7.Average Heat Transfer Rate

$Q_{avg} = \frac{Q_h + Q_c}{2}$

8.Surface Area

$A_{os} = \pi \times d_0 \times L$

9.Logarithmic Mean Temperature Difference (LMTD)

$$LMTD = \frac{(T_{hi}-T_{co})-(T_{ho}-T_{ci})}{\ln\frac{(T_{hi}-T_{co})}{(T_{ho}-T_{ci})}}$$

10.Overall Heat Transfer Coefficient

$$U = \frac{Q_{avg}}{A_{os}\times LMTD}$$

$Q_c = m_c \times C_{pc} \times (T_{ci} - T_{co})$

RESULTS AND DISCUSSION

Density of CuO - Water Nanofluid for Different Volume Fraction

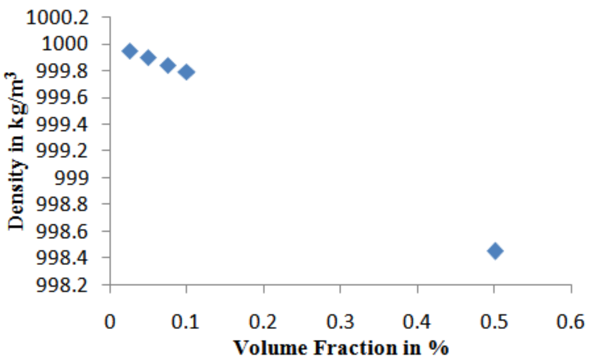

Fig. 2. Density of CuO - Water nanofluid for different volume fraction

Figure shows the variation of density of CuO - Water nanofluid with respect to the volume fraction of CuO nanoparticles. From the Fig., the density of nanofluid decreases by increasing the volume fraction nanoparticles in the fluid because the bulk density of nanoparticles in the fluid is less than the base fluid.

Specific Heat of CuO - Water Nanofluid for Different Volume Fraction

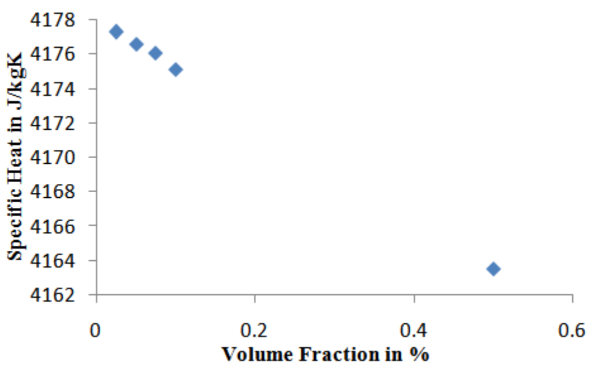

Fig. 3. Specific heat of CuO - Water nanofluid for different volume fraction

Figure shows the variation of specific heat of CuO – Water nanofluid with respect to the volume fraction of CuO nanoparticles. Form the Fig., the specific heat of nanofluid decreases by increasing the volume fraction of nanoparticles. Because the specific heat of CuO nanoparticles is less than the specific heat of base fluid.

Thermal Conductivity of CuO - Water Nanofluid for Different Volume Fraction

Figure shows the variation thermal conductivity of CuO – Water nanofluid with respect to the volume fraction of CuO nanoparticles. Form the Fig., the thermal conductivity of nanofluid increases by increasing the volume fraction of nanoparticles. Because the thermal conductivity of CuO nanoparticles is higher than the thermal conductivity of base fluid.

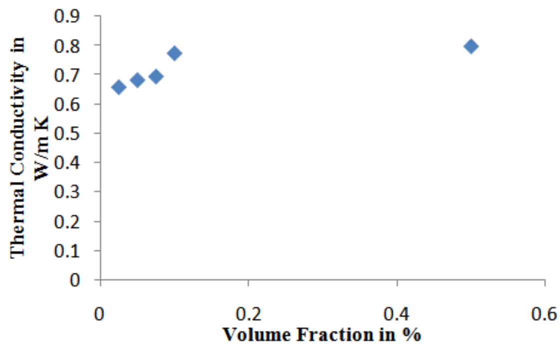

Fig. 4. Thermal Conductivity of CuO - Water Nanofluid for Different Volume Fraction

Heat Absorption of CuO - Water Nanofluid for Different Volume Fraction

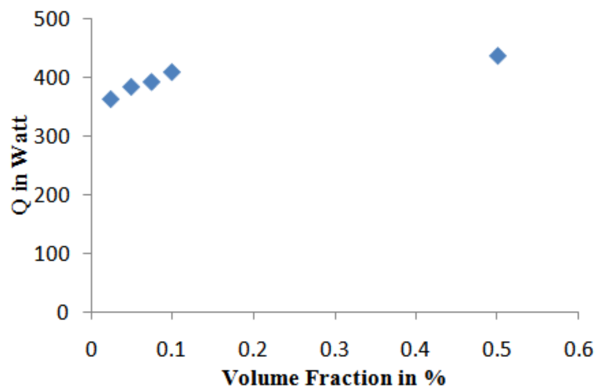

Fig. 5. Heat absorption of CuO - Water nanofluid for different volume fraction

Figure shows the variation heat absorption of CuO – Water nanofluid with respect to the volume fraction of CuO nanoparticles. Form the Fig., it is observed that heat absorption of nanofluid increases by increasing the volume fraction of nanoparticles. Since the thermal conductivity and heat transfer coefficient of CuO nanofluid is increases by increasing the volume fraction results in increases of heat absorption of nanofluid by increasing the volume fraction of CuO nanoparticles.

Heat Transfer Coefficient of CuO-Water Nanofluid for Different Volume Fraction

Figure shows the variation of heat transfer coefficient of CuO – Water nanofluid with respect to the volume fraction of CuO nanoparticles. Form the Fig. it is observed that heat transfer coefficient of nanofluid increases by increasing the volume fraction of nanoparticles. Since the specific surface area of the dispersed CuO nanoparticles increases the available heat transfer area for the fluid and higher thermal conductivity of CuO nanoparticles makes the heat transfer coefficient of the nanofluid increases by increasing the volume fraction of CuO nanoparticles.

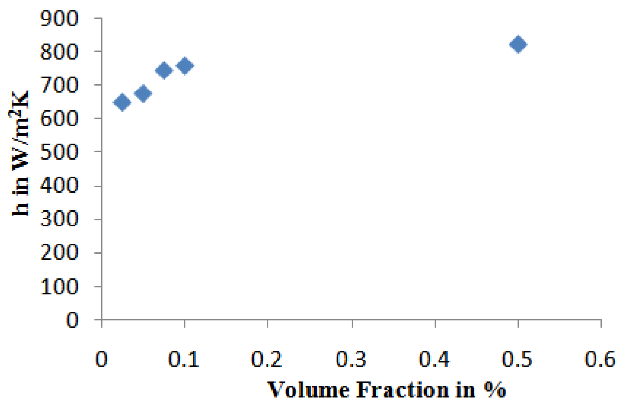

Fig. 6. Heat transfer coefficient of CuO-Water nanofluid for different volume fraction

Heat Transfer of CuO - Water Nanofluid for Different Volume Fraction

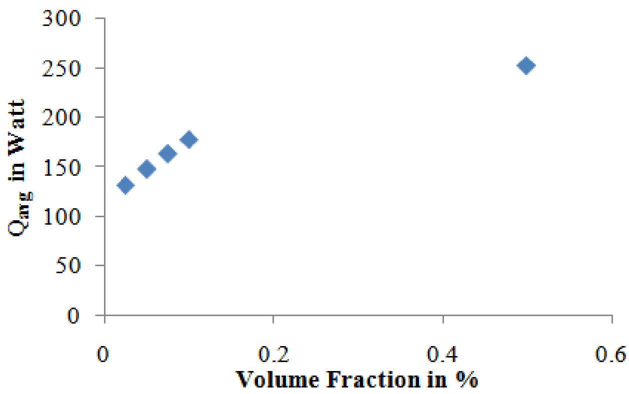

Fig. 7. Heat transfer rate of CuO - Water nanofluid for different volume fraction

Figure shows the variation heat transfer of CuO – Water nanofluid with respect to the volume fraction of CuO nanoparticles. Form the Fig. it is observed that heat transfer of nanofluid increases by increasing the volume fraction of nanoparticles. Since the thermal conductivity and Heat transfer Coefficient of CuO nanofluid is increases by increasing the volume fraction results in increases of heat transfer of nanofluid to cold fluid (Water) by increasing the volume fraction of CuO nanoparticles

Overall Heat Transfer Coefficient of CuO - Water Nanofluid for Different Volume Fraction

Figure shows the variation of overall heat transfer coefficient of CuO – Water nanofluid and cold fluid with respect to the volume fraction of CuO nanoparticles. Form the Fig. it is observed that overall heat transfer coefficient of nanofluid increases by increasing the volume fraction of nanoparticles. Since the specific surface area of the dispersed CuO nanoparticles increases the available heat transfer area for the fluid and higher thermal conductivity of CuO nanoparticles makes the overall heat transfer coefficient of the nanofluid and cold fluid increases by increasing the volume fraction of CuO nanoparticles.

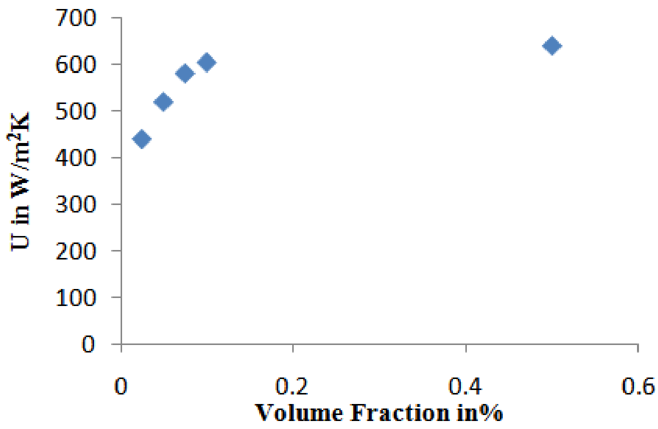

Fig. 8. Overall heat transfer coefficient of CuO - Water nanofluid for different volume fraction

Conclusion

In this work by observing the experimental results for Thermo physical properties of nano fluids and experimental results for test section and heat exchanger the following conclusions can be made.

- The homogeneous and stable nanofluid can be obtained by making mechanical stirring.
- Bulk density of nano particle is lesser than that of base fluid therefore there is decrease in density of the nanofluid by increasing the volume fraction.
- Viscosity of nanofluid increases by increasing the volume fraction, because viscosity of nanofluid sis depends only on the volume fraction of nano particles.
- Specific heat of nano particle is lesser than that of base fluid, which results volume fraction increases in the fluid specific heat of nanofluid decreases.
- Thermal conductivity of nanoparticles is higher than the base fluid hence as volume fraction increases in the range of 0.025 – 0.5% the fluid thermal conductivity of nanofluid increases minimum of 8 % to maximum of 30 % compare to the base fluid.
- Heat transfer coefficient of nanofluid in the test section increases by increasing the volume fraction of nanoparticles. Heat transfer coefficient of the nanofluid increases by increasing the volume fraction of CuO nanoparticles. In the range of 0.025 – 0.5% the fluid heat transfer coefficient of nanofluid increases minimum of 6% to maximum of 34% compare to the base fluid.
- Overall heat transfer coefficient of nanofluid increases by increasing the volume fraction of nanoparticles. Overall heat transfer coefficient of the nanofluid and cold fluid increases by increasing the volume fraction of CuO nanoparticles. In the range of 0.025 – 0.5% the fluid heat transfer coefficient of nanofluid increases minimum of 9% to maximum of 57% compare to the base fluid.

REFERENCES

Fei Duan, 2012. Thermal Property Measurement of Al_2O_3-Water Nanofluids. Smart Nanoparticles Technology, 335-356

Kaufui V.Wong and Omar De Leon, 2009. Applications of Nanofluids: Current and Future, Hindawi Publishing Corporation Advances in Mechanical Engineering Volume 2010, Article ID 519659, 11 pages doi:10.1155/2010/519659

Lee, S. and Eastman, J.A. *et al*. 1999. Measuring Thermal Conductivity of Fluid Containing a Oxide Nanoparticles. ASME Vol. 121, 280-289.

Ra Zvan Silviu Luciu1, Theodor Mateescu, Victoria Cotorobai And Thierry Mare,2009. Nusselt Number And Convection Heat Transfer Coefficient For A Coaxial Heat Exchanger Using Al_2O_3–Water Ph=5 Nanofluid, Sectia, 71-80

Vincenzo Bianco, Oronzio Manca, Sergio Nardini, Kambiz Vafai, 2015. Heat Transfer Enhancement with Nanofluids, CRC Press Taylor and Francis Group, Boca Raton

Xinwei Wang and Xianfan Xu, Stephen U. S. Choi, 1999. Thermal Conductivity of Nanoparticle–Fluid Mixture, *Journal Of Thermophysics and Heat Transfer*, Vol. 13, No. 4.

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