International Journal of Engineering Research and Technology.
ISSN 0974-3154 Volume 6, Number 5 (2013), pp. 675-680
© International Research Publication House
http://www.irphouse.com

Analysis of Heat Transfer Coefficient of CuO/Water Nanofluid using Double Pipe Heat Exchanger

S. Senthilraja[1] and KCK. Vijayakumar[2]

*[1,2]Faculty, Department of Mechanical Engineering,
Kavery College of engineering, Mechery, India.*

Abstract

Experimental investigations of heat transfer coefficient of CuO/Water nanofluid are reported in this paper. The heat transfer coefficient of the CuO/water was measured with the help of double pipe heat exchanger. The nanofluid was prepared by dispersing a CuOnano particle in deionized water. CuO/water nanofluid with a nominal diameter of 27nm at different volume concentrations (0.1 &0.3 vol.%) at room temperature were used for this investigations. This experimental result showed that the convective heat transfer coefficient increases with an increase in time also the Nusslet number increases with increasing the liquid flow rate.

Keywords: Heat transfer coefficient, nanofluid, Nusselt number.

1. Introduction

The modern trends in device miniaturization and process intensification have resulted to develop the alternate and effective heat dissipation methods from micro electronics systems and packages. Conventional heat removal methods have been found rather inadequate to use in high intensities of heat fluxes. Many researchers have been proposed different heat transfer techniques to increase the efficiency of the heat transfer systems. After the invention of high accuracy microscopes like Scanning Electron Microscope (SEM), Transfer Electron Microscope (TEM) etc. the researchers are trying to synthesize the materials in nanometer size. Over the past few decades there has been remarkable increase in interest in nanotechnology among the science and engineering communities. The US government now funds about $1 billion per year for the National Nanotechnology Initiatives (NNI). The Nano science and

Foundation (NSF) predicts the market for nanotechnology related products will exceed 1 trillion in US alone by 2015 [1].The **Fig**.1. Shows the summary of R&D funding for nanotechnology related research work by the US Government from 2001 to 2012.

The conventional heat transfer fluids like water, ethylene glycol, propylene glycol etc. are widely used to remove the heat from the mechanical systems. However these conventional fluids have poor heat transfer properties. The Fig.2 shows the comparison of thermal conductivity of different conventional heat transfer fluids and solids. Because of these poor heat transfer characteristics the researchers showed their interest to develop a new kind of heat transfer fluids to enhance the efficiency of the systems. These special kinds of heat transfer fluids are named as "Nano fluids". Nano fluids are relatively new class of fluid containing suspension of nanometer sized particles in the base fluids like water, ethylene glycol, propylene glycol, oil etc. In the year of 1993 the scientist S.U.S. Choi developed a special kind of fluid by dispersing particle with a diameter of 1~100nm in the base fluids for his "Advanced fluid program" project at Argonne National Laboratory (ANL). The term Nanofluid was coined by Choi in 1995 [2].Many researchers have been carried out their research to measure the thermal conductivity of different Nano fluids. From the previous investigation results, Nano fluids have been found to possess enhanced thermal conductivity compared to base fluids. Choi et al [3], [4] have suspended various metal and metal oxide nanoparticles in different base fluids. They found that the thermal conductivity of Ethylene glycol + Copper nanofluid (0.3 vol %) is increased upto 40% compared to base fluids. Many researchers [5] – [17] were investigated the thermophysical properties of different nanofluids with different volume fractions. Their investigation results clearly showed that the thermophysical properties of nanofluids always increase with the base fluids.

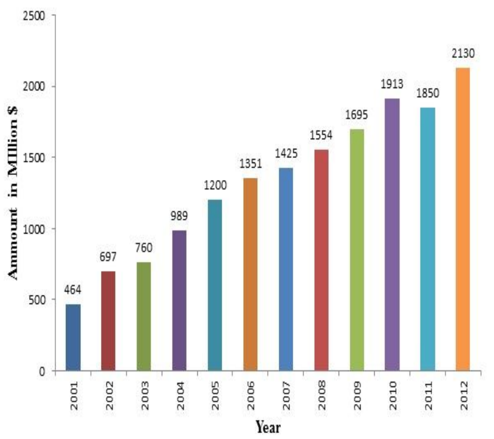

Fig. 1: Summary of R&D funding for nanotechnology related research work by the US Government from 2001 to 2012.

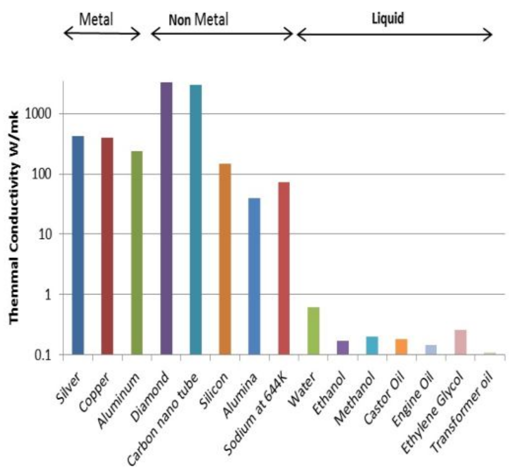

Fig. 2: Comparison of thermal conductivity of different conventional heat transfer fluids and solids

2. Preparation of Nanofluid

In the present study CuO nanoparticle was purchased from Sigma Aldrich chemicals Limited, India. The deionized water was used as a base fluid for this study. The nanofluids of different volume concentrations were prepared by dispersing different quantity of CuO nanoparticles in deionized water. The solution was sonicated continuously for 1hour using a probe sonicator to disperse the nanoparticle uniformly. Following this, the nanofluid was stirred continuously for 3-4 hours to obtain uniform dispersion of nanoparticles in base fluid. The physical properties of CuO nanoparticle and water are shown in Table.1.

Table 1: Physical properties of CuO nanoparticle and water.

S. No	Nanoparticle /fluid	Mean Diameter (nm)	Specific surface (m2/g)	Density (Kg/m3)	Thermal conductivity (W/mK)	Specific Heat (J/kg K)
1.	CuO	27	29	6310	32.9	550.5
2.	Water	-	-	997.5	0.628	4178

3. Experimental Setup

The setup used in this experiment as shown in Fig.3. This experimental setup consists of two tanks (tank ’A‘ and 'B‘) with a capacity of 10ltrs were used to store the water. 2kW immercible heater is fitted in the tank ‘A‘to heat the water. Two centrifugal pumps were used to circulate the water into the test section. One pump is used to circulate the cold water in the outer tube and the other pump is used to circulate the hotwater in the inner tube. The outer pipe of the test section is made of Galvanized Iron (GI), 33.2mm outside diameter and 27.8mm inner diameter with a heat exchange length of 1m. The inner tube is made from smooth copper tubing with 9.53mm outer diameter and 8.13mm inner diameter and 1.5m length. To reduce the heat loss from the system the test section is perfectly insulated by using rockwool. The K- type thermocouples are used to measure the temperature at the inlet and outlet side tubes.

4. Result and Discussion

The Fig. 4.shows the relationship between the convective heat transfer coefficient and the Reynolds number. This figure clearly shows that the convective heat transfer coefficient increases with an increasing Reynolds number also the heat transfer coefficient of the CuO/water nanofluid is higher than that of water at a given Reynolds number. The highest heat transfer coefficient is obtained by using 0.3 Vol% of CuO/water nanofluid.The Fig. 5.shows the comparison of Nusselt number of the nanofluids. It clearly shows that the Nusselt number increases with an increasing Reynolds number.

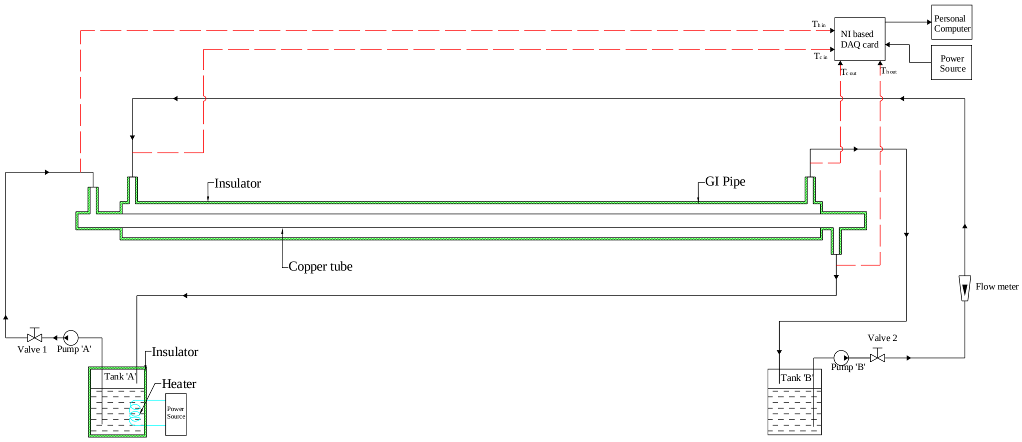

Fig. 3: Schematic diagram of the experimental setup.

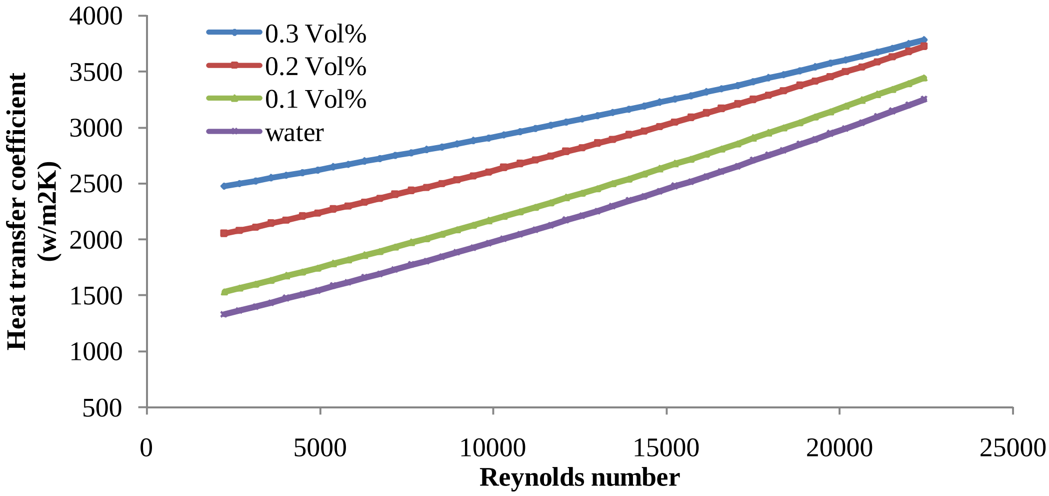

Fig. 4: Comparison of heat transfer coefficient between water and different Vol% ofCuO /water nanofluid

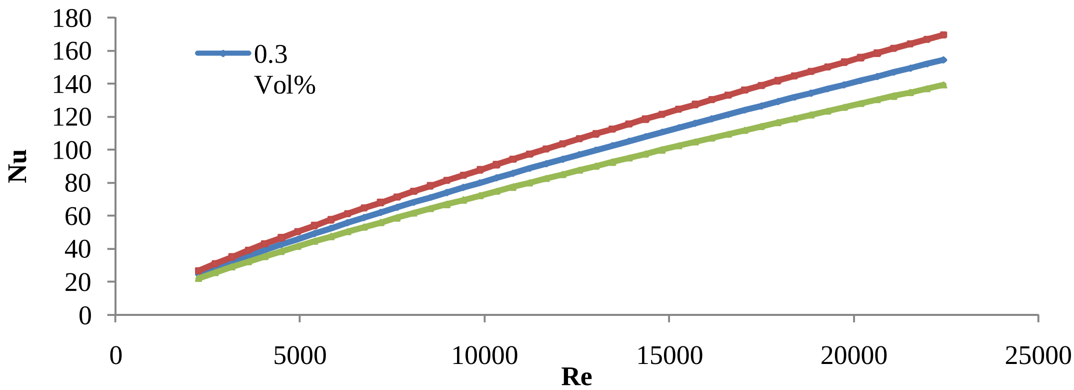

Fig. 5: Comparison of Nusselt Number and Reynolds number for different Vol% ofCuO /water nanofluid.

5. Conclusion

The convective heat transfer coefficient of a CuO/water nanofluid flowing in a double pipe parallel flow heat exchanger was investigated. The nanofluid was prepared by dispersing CuO (27nm) particles in deionized water. This experimental result showed that the convective heat transfer coefficient and Nusselt number of nanofluids were remarkably increase compared to base fluid (water). Theenhancement of nanofluid is directly proportional to the particle volume concentration.

References

[1] http://www.nano.gov/about-nni/what/funding

[2] S.K .Das, S.U.S Choi, Wenhua Yu, T. Pradeep (2007) :Nanofluids: Science and Technology. 1 edition. Hoboken, NJ: John Wiley & Sons, Inc.

[3] S.U.S.Choi (1998),Nanofluid technology: current status and future research. Vienna, VA, US: Korea-U.S. Technical Conference on Strategic Technologies.

[4] S.Lee,S.U.S.Choi, S.Li,J.A.Eastman, Measuring thermal conductivity of fluid containing oxide nanoparticles, ASME Journal of Heat Transfer, 121, PP 280–289.

[5] H.Masuda, A.Ebata, K. Teramae, andN.Hishinuma, (1993) "Alteration of Thermal conductivity and Viscosity of Liquid by Dispersing Ultra-fine Particles." NetsuBussei (Japan), 7(4), PP 227-233.

[6] J.A.Eastman, S.U.S.Choi, S.Li, L.J.Thompson, and S. Lee, (1996) "Enhanced thermal conductivity through the development of nanofluids." Fall Meeting of the Materials Research Society (MRS), Boston, USA.

[7] B.C. Pak, and Y.I. Cho, (1998) "Hydrodynamic and Heat Transfer Study of Dispersed Fluids with Submicron Metallic Oxide Particles." Experimental Heat Transfer, 11(2), PP 151-170.

[8] X.Wang, X.Xu, and S.U.S.Choi,(1999) "Thermal Conductivity of Nanoparticle - Fluid Mixture." Journal of Thermophysics and Heat Transfer, 13(4), PP 474-480.

[9] S.Lee, S.U.S.Choi,S.Li, and J.A.Eastman,(1999) "Measuring thermal conductivity of fluids containing oxide nanoparticles." Transactions of the ASME.Journal of Heat Transfer, 121(2), 280-289.

[10] H.E. Patel,S.K.Das,T.Sundararajan,A.Sreekumaran Nair,B.George,and T. Pradeep. (2003), "Thermal conductivities of naked and monolayer protected metal nanoparticles based nanofluids: manifestation of anomalous enhancement and chemical effects." Applied Physics Letters, 83(14), PP 2931-2933.

[11] HuaqingXie, Jinchang Wang, Tonggeng Xi, Yan Liu, Fei Ai, and Qingren Wu, (2002) "Thermal conductivity enhancement of suspensions containing nano sized alumina particles." Journal of Applied Physics, 91(7), PP 4568-4572.

[12] R. Prasher, P. Bhattacharya, and P.E.Phelan, (2005), "Thermal Conductivity of Nano scale Colloidal Solutions (Nanofluids)." Physical Review Letters, 94(2), 025901.

[13] S. Krishnamurthy, P.Bhattacharya,P.E.Phelan, and R.S. Prasher, (2006), "Enhanced Mass Transport in Nanofluids." Nano Letters, 6(3), PP 419-423.

[14] M.S.Liu, C.C. Lin,I.T.Huang, and C.C. Wang, (2006), "Enhancement of thermal conductivity with CuO for nanofluids." Chemical engineering and technology, 29(1), PP 72- 77.

[15] S.M.S.Murshed, K.C. Leong, and C. Yang, (2005), "Enhanced thermal conductivity of TiO2-water based nanofluids." International Journal of Thermal Sciences, 44(4), PP 367- 373.

[16] Z.W.Li,C.J. Ho, L.C.Wei, (2010), "An experimental investigation of forced convective cooling performance of a micro channel heat sink with Al2O3/water nanofluid ." Applied Thermal Engineering 30, PP 96–103.

[17] S. Ravikanth, Debendra K. Das, Praveen K. Namburu, (2010), “Numerical study of fluid dynamic and heat transfer performance of Al2O3 and CuOnanofluids in the flat tubes of a radiator.” International Journal of Heat and Fluid Flow 31, PP 613–621.