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# EXPERIMENTAL STUDIES ON CONVECTIVE HEAT TRANSFER COEFFICIENT OF WATER/ETHYLENE GLYCOL-CARBON NANO TUBE NANOFLUIDS

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Keywords: Nano fluid, Heat transfer, CNT and EG

Abstract – An objective of the project is to study the enhancement of convective heat transfer of secondary refrigerants. It is the function of different volume fraction as well as different operating temperatures. This project deals with use of CNT nano fluids with CNT as a Nano particle and EG/ water as a base fluid. In this study the theoretical study of CNT and thermo physical properties were reviewed and discussed. To investigate the convective heat transfer, an experimental set up is to be fabricated. The experimental set up is used to compare the thermo physical properties of CNT nano fluids.

## Abbreviations

CNT    Carbon Nanotube

EG Ethylene Glycol

MWCNT Multi Walled Carbon Nanotube

## I. Introduction

Generally in industrial sectors the major problem is to maintain the cooling effects for various applications. They are number of considerable amount of research and development focusing on heat transfer related operations, major improvements in cooling capabilities have been lacking due to conventional heat transfer fluids have poor heat transfer properties. In that one of the usual method to minimize this problem and increase the surface area available for heat exchanger. It is the essential need to increase the heat transfer rate of conventional heat transfer fluids.

Basically Nano fluids containing metals such as Cu, Ag and Au have to increase the thermal conductivity of working fluid and compared with the base fluid [1]. The thermal conductivity of carbon-based nanostructures is compared with low densities of base fluids. In this study carbon nano tube is considered as a nano particle due to its excellent heat transfer rate and water/EG is taken as a base fluid for this experimental setup. This nano fluid is used to enhance the convective heat transfer of the base fluid and mainly concentrated to preparing the nano fluids without any settling of nano particles and did sedimentation test. They are different samples of prepared nano fluids with different concentration and different surfactants were prepared and stability tests were carried out.

The various property changes of Nano fluids depend on the concentration fraction of nanoparticles, size and shape of the nano material. It shows clearly the Nano fluid flowing in a single pass and multi tubes shell and tube counter flow heat exchanger under turbulent. The different volume concentrations are (0.1%, 0.2%, 0.3% and 0.4%) [12].

The temperature effects on the convective heat transfer coefficient of working medium with the temperature range of 473 K–573 K. The

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measurement is clearly indicate Nusselt number is more than that predicted by the correlations of forced convective heat transfer and the variations decrease as Reynolds number increases. The Nu increases with increasing temperature of working medium in laminar flow [13].

The Effect of imposing mechanical vibration in a heat exchanger with nanofluids is considered. The Imposing mechanical vibrations increase convective heat transfer coefficient with decrease nano-particles deposition remarkably. The Heat transfer increases by increasing the temperature of nanofluid, flow rate, mass fraction of nano fluid and vibration level. [14].

1.1 Nano - Heat Transfer

There are various techniques were proposed to enhance the heat transfer characteristics of base fluid, in order to achieve small heat transfer systems with minimum investment and improve the efficiencies of heat exchanger. It clearly state that solids indicate higher thermal conductivity than liquids, the use of suspensions instead of ordinary heat transfer liquids had been introduced [2]**.** While use of suspensions containing micro particles were exposed to many difficulties, such as particles sedimentation, corrosion of equipments and high pumping power. Generally Nanoparticles are small particles and based on Stokes theory, nano fluids will be much stable than ordinary fluids. In addition these fluids will have minimum corrosion effects and requires minimum pumping power compared to ordinary one [3].

## II. Ultrasonication

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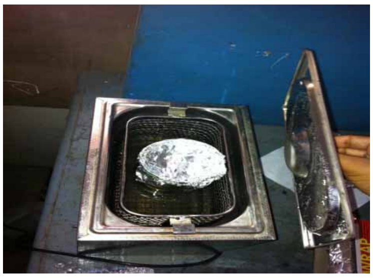

Fig. 2.1 Ultrasonicator

The Fig. 2.1 shows the set-up picture. The electrical energy is converted into mechanical vibrations by help of piezoelectric transducer. The vibrations when being transmitted through the probe are further intensified and introduce pressure waves in the working fluid sample [5]. The induction of pressure waves forms several microscopic bubbles inside the sample, which expand due to negative pressure excursion and positive excursion [6].

## III. Experimentation

### 3.1 Arrangement of Convective heat transfer setup

The experimental set up is used to measure the convective heat transfer coefficient of working fluid as shown in Fig. 3.1.

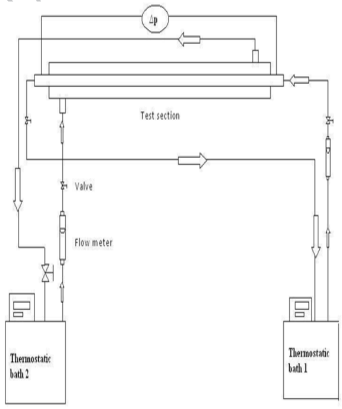


Fig. 3.1 Experimental set up

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The experimental setup consists of a copper tube section, Agilent data acquisition system, and thermostatic bath. The copper tube of 2500 mm length, 10.7 mm inner diameter and 12.7 mm outer diameter was used as a test section. The experiments were conducted under the conditions of varying heat flux using counter flow fluid (water). The test section was fully insulated by insulating material in order to prevent the heat loss from system to surrounding. There are four thermocouples were mounted on the test section at axial distances of 500 mm, 1000mm, 1500 mm and 2000 mm from the inlet of the section to outlet for measure the fluid temperature continuously.

Additionally, till two thermocouples were mounted at the inlet and outlet in order to measure the bulk temperature of the flowing medium at inlet and outlet, respectively.

## IV. Results and Discussions

4.1 Viscosity of Nanofluid

The dynamic viscosity of water-MWCNT nanofluid is measured experimentally at the nanotube volume concentration of 0.15, 0.3 at 25 $^0$C.

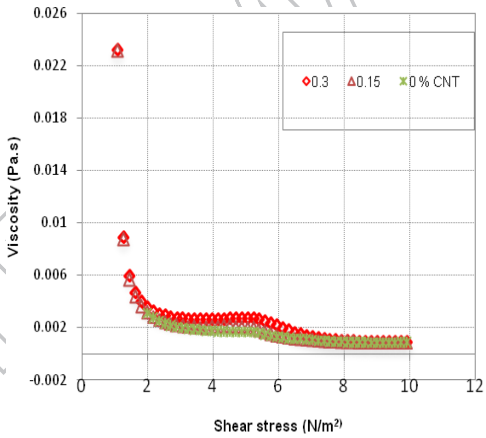


Fig.4.1 Shear Stress vs Viscosity

Figure 4.1 illustrate the viscosity of nanofluid. It clearly indicates viscosity as a function of shear stress. It is clearly shown in the figure that the viscosity of nanofluid decreases as the shear stress varies from

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0 to 2 N m$^{-2}$, which clearly indicates the Non – Newtonian behavior of nanofluid at the lowest shear stress.

4.2 Effect of temperature on thermal conductivity

Figure 4.2 shows the variation of thermal conductivity of the nanofluid at various temperatures. It is observed from the figure that the thermal conductivity of the nanofluid is increased with addition of the carbon nanotubes in the base fluid. The minimum and maximum thermal conductivity for the pure base fluids are measured as 0.55 W/mK at 0 $^0$C, 0.61 W/mK at 30 $^0$C respectively and 0.3 vol % are measured as 0.58 W/mK at 0 $^0$C, 0.64 W/mK at 30 $^0$C respectively.

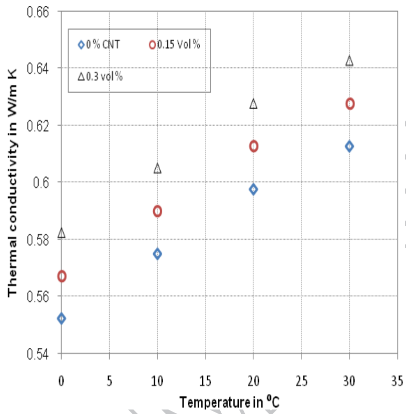


Fig.4.2 Temperature vs Thermal Conductivity

4.3 Effect of Reynolds number in heat transfer enhancement

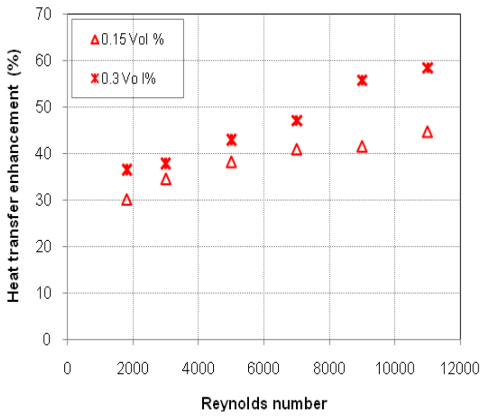


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Fig. 4.3 Reynolds number vs Heat transfer enhancement

Figure 4.3 shows that the heat transfer enhancement under various flow conditions. The heat transfer coefficient enhancement is approximately 30 %, 34.74 % for nano fluid at 0.15, 0.3 vol % of MWCNT respectively. However for the same nano fluids the heat transfer coefficient is enhanced significantly as the flow conditions are changed from laminar to turbulent conditions. This implies that particle interaction with the base fluid is one of the major reasons for the enhanced heat transfer mechanism in the nano fluid.

## V. Conclusion

The convective heat transfer behavior of MWCNT nano fluid based secondary refrigerant is investigated for various flow conditions and concentrations. The experimental results are clearly indicated that the addition of carbon nanotubes in the base fluids can significantly improve the thermal behavior of the system. Thus the benefits of CNT nano fluid in heat transfer application are widely used for attaining the convective heat transfer enhancement and high efficiency.

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## REFERENCES

[1] Huaqing Xie,Hohyun Lee, Wonjin Youn, and Mansoo Choi, "Nano fluids containing multi walled carbon nanotubes and their enhanced thermal conductivities", Journal of applied physics ,Vol. 94(2003), pp. 8.

[2] D. Andrew, Sommers, L.Kirk, Yerkes, "Experimental investigation into the convective heat transfer and system-level effects of $Al_2O_3$ – propanol nano fluid", journal of Nano part, Vol.12(2010), pp. 1003-1014.

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[3] Tessy Theres Baby, Sundara Ramprabhu, “Enhanced convective heat transfer using graphene dispersed nano fluids”, Jornal of Nano scale research letters, Vol.6, (2011), pp.123-126.

[4] Dongsheng Wen, Yulong Ding, “Formulation of nano fluids for natural convective heat transfer applications” International Journal of Heat and Fluid Flow, Vol. 26, (2005), pp. 855-864.

[5] Yulong Ding, Hajar Alias, Dongsheng Wen, Richard A. williams, “Heat transfer of aqueous suspensions of carbon nanotubes (CNT nano fluids)”, International journal of heat and mass transfer, Vol.49, (2006), pp. 240-250.

[6] Ying Yang, Eric A. Grulke, Z George Zhang, “Temperature effects on the Rheological properties of carbon nanotube-in-oil dispersions” Physicochem. Eng. Aspects, Vol.45, (2007), pp 216-224.

[7] Yulong Ding and Chunqing Tan, “Rheological behavior of nano fluids” New Journal of Physics Vol. 9, (2007), pp. 143-156.

[8] Baskar, **“**Heat transfer characteristics of acetone/water mixture in a tubular heat exchanger with turbulator”, International Conference on Advanced Nanomaterials and Emerging Engineering Technologies (ICANMEET) 2013, pp.627 - 630, 24-26 July 2013.

[9] Baskar “Performance Study and Characteristic on a Domestic Refrigeration System with Additive of Zirconium Oxide (Zro2) Nano-Particle as NanoLubricant”, International Journal for Research in Applied Science & Engineering Technology (IJRASET), ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887 Volume 5 Issue X, October 2017- Available at www.ijraset.com.

[10] Baskar “Hybridization of Composites using Natural and Synthetic Fibers for Automotive Application”, IJSRST | Volume 3 | Issue 7 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X.

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[11] Daxiong Wua, Haitao Zhua, Liqiu Wang "Critical Issues in Nanofluids Preparation, Characterization and Thermal Conductivity" Current Nanoscience, Vol. 5, (2009), pp. 103-112.

[12] Siva Eswara Rao, Dowluru Sreeramulu, Rao M.V.Ramana, "Experimental investigation on forced convective heat transfer coefficient of a nano fluid" Materials Today : Proceedings, Volume 4, Issue 8, 2017, Pages 8717-8723.

[13] Yu-Shuang Chen, JianTian, Shen-De Sun, Qiang Sun, YuanF uZhong-Feng Tang, Hai-Hua Zhu, Na-Xiu Wang, "Characteristics of the laminar convective heat transfer of molten salt in concentric tube" Applied Thermal Engineering, Volume 125, October 2017, Pages 995-100.

[14] Hosseinian, Meghdadi Isfahani, Shi an, "Experimental investigation of surface vibration effects on increasing the stability and heat transfer coeffcient of MWCNTs-water nanofluid in a flexible double pipe heat exchanger" Experimental Thermal and Fluid Science, Volume 90, January 2018, Pages 275-285.

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