Force Convective Heat Transfer through MWCNT/Nano Fluids

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Abstract

The transfer of thermal energy between fluids is one of the most important and frequently used processes in engineering and industries due to which subject of potential heat transfer enhancement in conventional fluids receives great attention in research. As the conventional fluids like water, ethylene glycol and engine oil etc. generally used in thermal devices such as heat exchanger have poor heat transfer performance. During earlier research, in order to increase the convective heat transfer rate in fluids, micro or millimeter sized particles having high thermal conductivity are diffused in base fluid but there have been problem by means of corrosion of pipes, clogging, large pressure drops and sedimentation. To overcome this problem, the use of nanometer sized particles dispersed in base fluids and thermal conductivity enhancement is obtained. The nanoparticles used in nanofluids are typically made of metals, metal oxides, carbides and carbon nanotubes. And nanofluids are obtained by a liquid suspension of nano sized particles in base fluid. Nanofluids found to possess better heat transfer properties such as high thermal conductivity, improved stability and reduced particle clogging etc. Thus the evolution of nanofluids as a new class of heat transfer fluids have become the topic of much interest for researchers.

Keywords— *Put your keywords here, keywords are separated by comma.*

I. INTRODUCTION

Transfer of thermal energy in fluids plays a significant role in many industries including power stations, production processes, aerospace industries, transportation and electronics etc. One of the most important requirements of industries is the high performance and optimization of heat transfer equipments. In order to achieve the ever increasing need of effective thermal equipments, it is necessary to intensify the heat transfer rate in fluids. However the conventional fluids such as water, ethylene glycol and engine oil etc. Generally used in thermal devices such as heat exchanger etc. have poor heat transfer performance because of their low thermal conductivities. To enhance the thermal efficiency of heat transfer equipments, the thermal capacity of the working fluid need to be increased. So many research and development activities have been implemented to improve the thermal properties of these conventional fluids. As solid metallic materials such as silver, aluminum, copper, iron etc. And non-metallic materials such as aluminum oxide, CuO, SiC and carbon nanotubes have much higher thermal conductivities than conventional fluids. Maxwell (1873) initiated a novel concept of dispersing these solid particles into the conventional fluids to enhance the thermal conductivity of fluids. These earlier research, however includes millimeter and micrometer size of particles in order to raise the rate of heat transfer but there have been problem by means of clogging, poor suspension stability, extra pressure drop, corrosion and erosion. To overcome this problem, the use of nanosized particles dispersed in a base liquid, and the thermal conductivity enhancement is obtained firstly by Choi (1995). Consequently, the fluids with suspended solid nano particles of metal or metal oxide are expected to have better heat transfer fluids. Choi also generates the term “nanofluids” for this new form of heat transfer fluids. A broad range of observational and theoretical studies has been performed on convective heat transfer in different nanofluids within the past decade. The convection heat transfer performances of the graphite nanofluids were also examined.

To understand about the heat transfer intensification in thermal equipments by using nanofluids, firstly it is necessary to know about term heat transfer, its mechanism and its importance.

II. HEAT TRANSFER AND ITS MECHANISM

Heat is a form of energy and the transfer of that energy occurs at the molecular level as a result of a temperature difference. Thus the heat transfer may be defined as “the transmission of energy from one region to another as a result of temperature gradient” [1]. According to the Second Law of Thermodynamics, the direction of transfer of heat always occurs from a hotter body to a colder body.

As the heat transfer can be occurred in three basic modes which are conduction, convection and radiation.

- Conduction involves the transfer of heat by the interaction between adjacent atoms or molecules of a material through which the heat is being transferred. It occurs usually in solids due to the collisions, diffusions or vibrations of the random motion molecules. In conduction, there is a greater rate of heat transfer.

- Convection heat transfer occurs between a surface and a moving fluid at different temperatures. It involves the transfer of heat by the mixing and motion of macroscopic portions of a fluid between a surface i.e. convection involves the combined effects of conduction and fluid motion.
- Radiation or radiant heat transfer involves the transfer of heat by electromagnetic radiation that arises due to the temperature of a body. Radiation does not require any type of medium, they itself can be occurred in a vacuum condition.

III.EXPERIMENTAL SETUP

In order to investigate the convective heat transfer in nanofluid flowing through the copper tube under varying flow rate and temperature conditions an experiment setup is constructed. The experiment setup consists of a closed flow loop system containing several sections such as test section, cooling system, flow measuring unit, peristaltic pump, heating unit, nanofluid reservoir tank, U-tube manometer and thermocouples etc. which are connected together in a regular manner. The experiment system setup with the test section design was based upon the various studies and the experimental setup's design used in various researches.

The experiment setup is based upon some basic laws of heat transfer such as Law of conservation of energy, Law of conservation of mass, Law of convection i.e. Newton's law of cooling etc. The "Law of Conservation of Energy" states that energy can neither be created nor be destroyed, but it can be converted and transferred into another form [30].

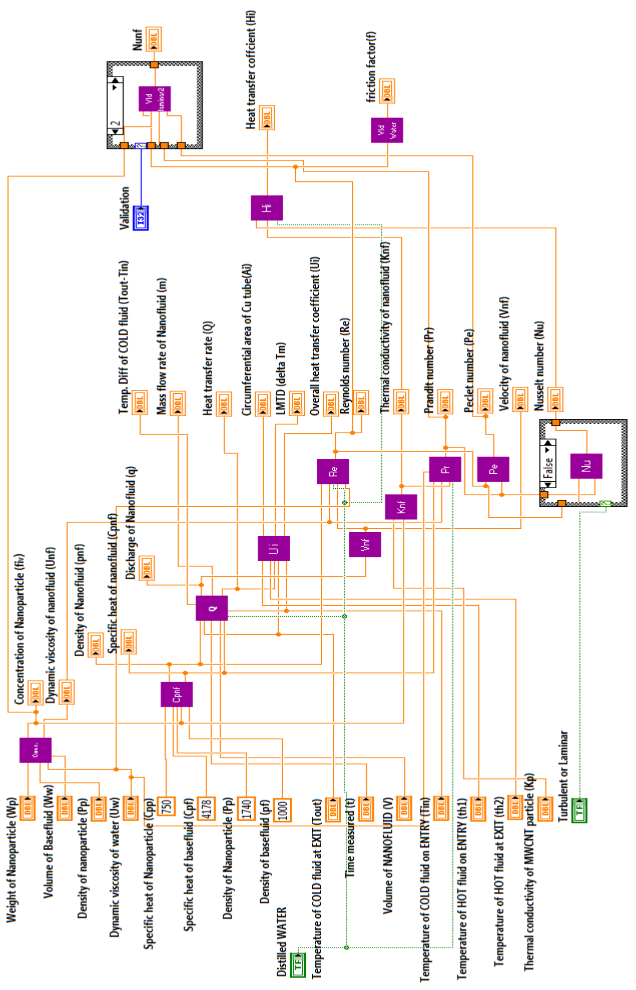
IV.DATA ANALYSIS

The Multiwall carbon nanotube powder was provided from the Nanotechnology Department of Guru Jambheshwar University of Science & Technology, Hisar. The MWCNT is 20-25nm in diameter and 10-50µm in length. The MWCNT powder mixed in water and three samples are prepared at different concentrations such as 0.01%, 0.02%, and 0.05% with the help of sonication of 1hr for each. Then the prepared MWCNT/water nanofluid is used for the analysis of convective heat transfer with the aid of experimental setup.

The thermal analysis in experiment setup test section which is based on the simple concentric tube configuration in which nanofluid flows through the inner pipe and hot water flows through the annular section within a larger cylindrical sheath with openings at the ends. The test section configuration typically involves two flowing fluids such as hot water and cold nanofluid separated by a solid wall in a counter flow arrangement on the basis of our requirement. The minimum temperature jump from one fluid to another is called the 'temperature approach'.

Analysis of a heat transfer in a system is always begins with the conclusion of the overall heat transfer coefficient. Heat transfer from one fluid to the other is combined convection-conduction-convection process across the separating solid surface. Heat is transferred from the hot fluid to the solid wall by convection, through the solid wall by conduction and from the wall to the colder fluid by convection again. Thus the overall heat transfer coefficient may be defined in the terms of individual thermal resistances of the system.

The temperature difference between the hot water and cold nanofluid varies along the length of test section tube. Therefore it is convenient to have a mean temperature difference in determining overall heat transfer coefficient.



4.1 Block Diagram

V. CALCULATION

In order to investigate the performance of nanofluid, we provide a mathematical approach to our experimental work. We design a block diagram by using LabVIEW software in order to calculate various parameters such as Nusselt number, Reynolds number, Prandtl number, Peclet number, heat transfer coefficient, pressure drop, friction factor etc. The convective heat transfer coefficient is also calculated from the block diagram. The LabVIEW program contains various virtual instruments (VI). Then the front panel will provide with controls and indicators, which are the interactive input and output terminals of the VI, respectively. Thus the simulation results are obtained on the front panel window of the software.

First of all, experimental setup was run on Distilled Water (DW) as a cold fluid. Then mathematical calculations have been made on LabVIEW by using the data or readings such as temperature, discharge etc. are collected from the experiment setup. Various parameters have been measured such as the convective heat transfer coefficient, pressure drop and friction factor. Also various dimensionless numbers i.e. Reynolds number, Nusselt number, Prandlt number, Peclet number etc. have been manipulated. All these parameters are presented in tabular form and appropriate graphical representations can also be made in this chapter. Again, the whole procedure is repeated for MWCNT/water nanofluid with various concentrations such as 0.01%, 0.02% and 0.05% as cold fluid in the experiment. Also thermo physical properties of nanofluid such as density, specific heat, viscosity are evaluated with prescribed criteria in LabVIEW. The comparison is also made by DW and various concentrations of MWCNT/water nanofluid. Distilled Water is used as a base fluid in the preparation of the nanofluids. DW has many properties like constant Specific Heat, Density and Viscosity on particular temperature and pressure values. We first calculated different parameters for DW in order to compare the results with the results obtained from the calculations of nanofluid. Reynolds number, Nusselt number, Peclet number etc. are calculated and different values are shown in tabular form as follows.

Re	766.132	908.49	1079.15	1329.96	1573.47
Nu	5.41363	5.66215	5.94422	6.32772	6.6725
Pe	3815.26	4518.08	5365.21	6603.34	7803.95
hi	335.645	351.054	368.542	392.318	413.695
Ui	102.301	126.855	147.174	189.086	233.771

Table 5.1 Different Parameters of Distilled Water(DW)

Different parameters at 0.02% volume concentrations of MWCNT/water have been calculated by using thermo physical properties like as constant specific heat, density, viscosity and thermal conductivity of nanofluid at particular temperatures.

VI. RESULT

After experimenting with all here I got result, its comparison graph is given below.

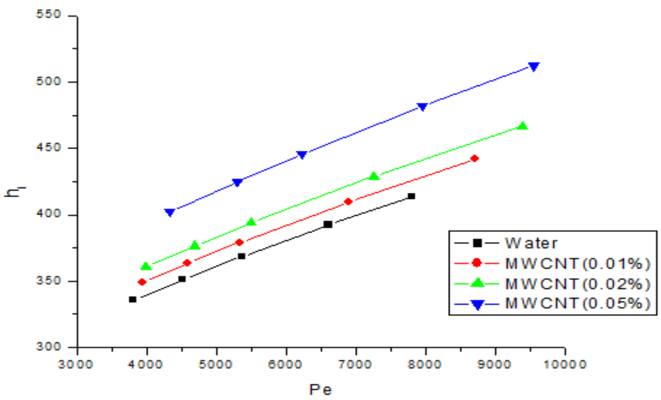


Fig 6.1 Graph between Heat Transfer Coefficient and Peclet

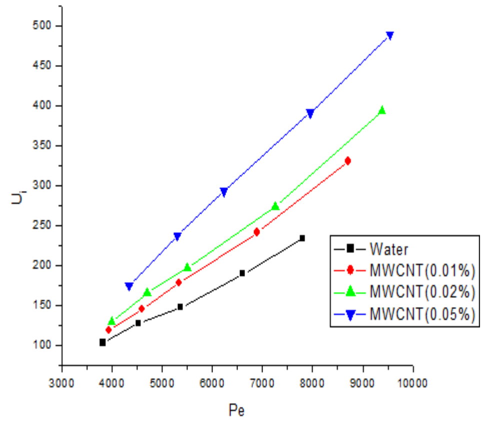


Fig 4.16 Graph between Overall Heat Transfer Coefficient and Peclet number

VII. CONCLUSIONS

Based on experimental results, it was found that MWCNT were found to be able to prepare a stable nanofluid with distilled water. The experimental analysis shows that the effective enhancement on convective heat transfer coefficient in MWCNT/water nanofluid has been obtained. Summarizing the mean experimental results of this dissertation work, the following generalized conclusions can be drawn:

1. In order to obtained better enhancement result of convective heat transfer coefficient comparison between MWCNT/water and distilled water has been performed. As a result

it is shown that MWCNT/water provides better results than distilled water.

2. Heat transfer enhancement is strongly affected by volume concentrations i.e. different volume concentrations of MWCNT in water have been performed. On the basis of data analysis, better heat transfer enhancement in 0.05% volume concentration as compare to 0.02% and 0.01% volume concentration.
3. Experimental results are also represented with the help of graphs which shows that Heat transfer coefficient and Overall Heat transfer coefficient are increases with Reynolds and Peclet number.
4. The comparison of experimental values and predicted values of heat transfer coefficient has shown a good agreement between the predicted and experimental results i.e. experimental Nusselt number and predicted Nusselt number are found to be almost same which indicating the validation of the experimental and theoretical results.

REFERENCES

[1] R.K. Rajput, "Heat and mass transfer," S. Chand & Company Ltd., Third Edition, pp. 2, 2009.

[2] S. Zeinali Heris, S. G. Etemad, and M. Nasr Esfahany, "Experimental investigation of oxide nanofluids laminar flow convective heat transfer," International Communications in Heat and Mass Transfer, vol. 33, no. 4, pp. 529–535, Apr. 2006.

[3] S. U. S. Choi, "Enhancing thermal conductivity of fluids with nanoparticles," in Developments and Applications of Non-Newtonian Flows, D. A. Singer and H. P. Wang, Eds., vol. 231, pp. 99–105, 1995.

[4] Y. Li , J. Zhou , S. Tung , E. Schneider and S. Xi, "A review on development of nanofluid preparation and characterization," Powder Technology, vol. 196, no. 2, pp. 89–101, 2009.

[5] Yu, W. France, D. M., Routbort, J. L., and Choi, S. U. S., "Review and Comparison of Nanofluid Thermal Conductivity and Heat Transfer Enhancements," Heat Transfer Eng., vol. 29, no. 5, pp. 432-460, 2008.

[6] Y. Xuan and Q. Li, "Heat transfer enhancement of nanofluids," vol. 21, pp. 58–64, 2000.

[7] Y. Xuan and Q. Li, "Investigation on Convective Heat Transfer and Flow Features of Nanofluids," Journal of Heat Transfer, vol. 125, no. 1, pp. 151, 2003.

[8] S. Zeinali Heris, M. Nasr Esfahany, and S. G. Etemad, "Experimental investigation of convective heat transfer of Al2O3/water nanofluid in circular tube," International Journal of Heat and Fluid Flow, vol. 28, no. 2, pp. 203–210, Apr. 2007.

[9] Y. Ding, H. Chen, L. Wang, and C. Yang, "Heat Transfer Intensification Using Nanofluids," Kona, vol. 25, no. 25, pp. 23–38, 2007.

[10] W. Daungthongsuk and S. Wongwises, "A critical review of convective heat transfer of nanofluids," Renewable and Sustainable Energy Reviews, vol. 11, no. 5, pp. 797–817, Jun. 2007.

[11] C. V Popa, S. Fohanno, G. Polidori, and C. T. Nguyen, "HEAT TRANSFER ENHANCEMENT IN MIXED CONVECTION USING WATER – γ AL 2 O 3 NANOFLUID 1 Introduction 2 Problem formulation," no. 2001, 2008.

[12] D. P. Kulkarni, D. K. Das, and R. S. Vajjha, "Application of nanofluids in heating buildings and reducing pollution," Applied Energy, vol. 86, no. 12, pp. 2566–2573, Dec. 2009.

[13] U. Rea, T. McKrell, L. Hu, and J. Buongiorno, "Laminar convective heat transfer and viscous pressure loss of alumina–water and zirconia–water nanofluids," International Journal of Heat and Mass Transfer, vol. 52, no. 7–8, pp. 2042–2048, Mar. 2009.