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Multi-walled carbon nanotube mixed with isopropyl alcohol Nano fluid for heat transfer applications

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Abstract

This paper deals on various the heat transfer properties of Multiwall Carbon Nanotubes /IPA Nano fluids flow inside tube heat exchanger. The data's was obtained for laminar flow in the experimental work with the constant wall temperature. The tube wall was kept at constant temperature about 90 °C leading to constant temperature boundary condition. Initially, the nanofluids were prepared with different concentrations to study the thermo physical property along with heat transfer behaviour in laminar flow.

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Keywords: MWCNT, Heat transfer, Nussult number, Laminar flow.

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1. Introduction

Nanofluids are colloidal suspensions consisting of particles of size below 100nm of metal oxides, metals, nitrides, carbides, carbon nanotubes, etc., dispersed in a base fluid. A thorough understanding of the thermal behavior of nanofluids is significant for the manufacture of energy efficient devices. Nanofluids have unique features which vary remarkably from conventional heat transfer fluids prepared by millimeter or micrometer sized particles. The major goal of nanofluid technology is to get the maximum realizable heat transfer ability at minimum nanoparticle concentration.

The thermal conductivity of MWCNT/IPA Nano fluid was finding out by the help KD2 Pro thermal properties analyzer. It comprises of a sensor needle and microcontroller. The sensor needle consists of both thermistor and warming component Xiang et al. (2007). The controller module comprises 16-bit microcontroller, power control and battery. For measuring thermal conductivity assumes heat source as infinitely long and working medium is both isotropic, uniform initial temperature (T0) and homogeneous. Lee et al. (1999) the needle utilized and made of tempered steel consuming a 65 mm length and distance across 1.4 mm. The fluids thermal conductivity can be measured in the range of 0.2 to 2 W/m K by using sensor needle and time taken for measurement is approximately say about 80 seconds.

In initial 30 seconds, the instrument is equilibrating and trailed by heating/cooling of sensor needle about 30 second. The variation in temperature noted for 30 seconds of heating in the range of 0.35 - 0.45 °C (0.01°C/s to 0.0144 °C/s). Bhattacharya et al. (2009) this guarantees the heat pulse agreed by the sensor needle is little consequently, thermally strong-minded convection flows in disposed of thus stays away from any turbulences in the sample through the measurements.

2. Experimental setup

The experiment is done using the water and Nano fluid and the following data’s like inlet temperature, outlet temperature and discharge is obtained for both water and MWCNT. To obtain an optimum result the nanoparticles concentration is varied in the base fluid. With the obtained values from the experimental setup the following data’s like thermal conductivity, density, Nusselt number, specific heat, Reynolds number, kinematic viscosity, dynamic viscosity and effectiveness of both water and Nano fluid is calculated.

Fig.1 Experimental setup

The experiment contains the following parts namely reservoir, calming section, Cooling unit, Pump and test section. Calming section is used to decrease the entrance effect also ensure the smooth fluid flow. The test section dimension is 1100 mm long, 14 mm OD and 12 mm ID. The test section arrangement is shown in above figure 2.1.

The glass wool is used for insulation which is provided over test section for minimize the heat loss. The riser section is used to deliver uniform flow in the setup and it is vertical pipe. The cooling unit is cooled by air cooled heat exchanger type and pump is used to flow the fluid through the test section and riser. The fluid reservoir is made of stainless steel with drain plug with capacity of three liters. The test section is maintained by constant heat flux and six RTDs used with an accuracy of 0.1oC mounted on test section at various locations for measure fluid and wall temperatures. The pressure drop across the test section is measured by U-Tube manometer. The flow rate of the working fluid is measured by flow meter.
The friction factor is calculated by,

$$f = \left(\frac{D_i}{L}\right)\left(\frac{\Delta P}{2\rho u_m^2}\right)$$

The change in pressure is calculated by U tube manometer and heat transfer rate is calculated by,

$$Q = \frac{V^2}{R} = m\,Cp\left(T_{out} - T_{in}\right) = U_0 A_o\left(T_w - T_f\right)$$

Where $$\frac{1}{U_0 A_o} = \frac{1}{h_i A_i} + \ln\left(D_0 - D_i\right)/\left(2\pi k_w L\right)$$

The convective heat transfer co efficient was calculated by following equation

$$Nu = h_i D_i / k_i$$

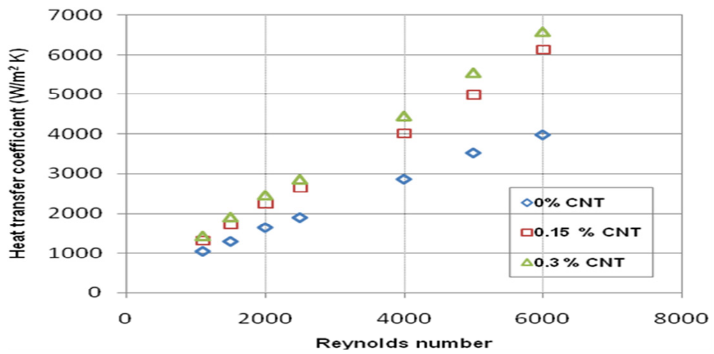

Fig. 2 Reynolds number versus Heat Transfer Coefficient

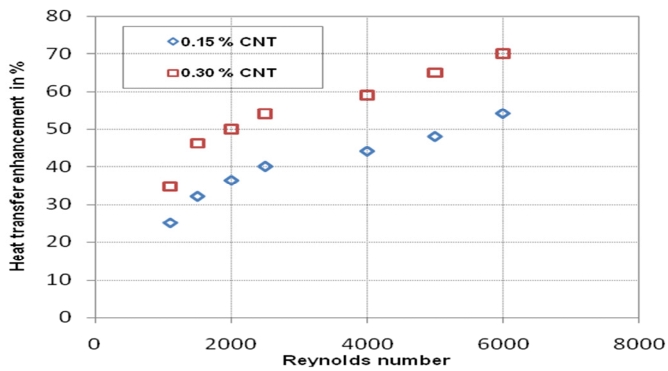

Fig. 3 Reynolds number versus enhancement Heat Transfer Coefficient

Figure 2 shows the variations of convective heat transfer coefficient of nanofluid at various concentrations of, MWCNT as the function of Reynolds number under various flow conditions. It is observed from the figure that the convective heat transfer coefficient of MWCNT nanofluid is higher than, those for the base fluid at a given Reynolds number. It is also seen that the value of enhancement in convective heat transfer coefficient increases with respect to Reynolds number.

Figure 3 shows the variations of convective heat transfer coefficient of nanofluid at various concentrations of, MWCNT as the function of Reynolds number under various flow conditions. At 0.15 vol % MWCNT, the convective heat transfer coefficient is an enhanced to a maximum value of 54.02 % at Re = 6000. It is also noticed that the heat transfer coefficient is not significantly increased with further addition of MWCNT in the base fluid. At 0.3 vol % MWCNT the nanofluid shows an enhancement of 70 %.

3. Conclusions

One of the methods to differ the thermo-physical properties and characteristics of fluids which are found to be particularly effective in nanoparticles form, due to surface area to volume ratio enhancement. The ASTM standard test for the fluid properties dimensions and heat transfer enhancement were described in this study for IPA and Nano fluid adapted by the addition of nanoparticles. The experiment was carried out at different levels for investigate the effects on the thermo-physical properties, performance and thermal conductivity. The experimental work is happening on the effect of various parameters namely preparation time and particle nano size etc.

The experimental work of Nusselt number and behavior of MWCNT/IPA Nano fluids in a tubular heat exchanger was conducted. MWCNT/IPA Nano fluids with various volume concentrations of 0.1%, 0.2 was used in the working fluid. The Nusselt number rises in order of 10 %, 11.2 %, for volume concentrations of 0.1%, 0.2%, respectively. From that experimental reading the Nusselt number raises with nano particle volume concentrations.

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