DEVELOPMENT AND OPTIMIZATION OF HEAT TRANSFER PERFORMANCE ON THERMAL CONDUCTIVITY USING NANOFLUID

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ABSTRACT

Suspension of Nano particles in traditional liquid has positive potential in improving heat transfer performance. The objective of the work is to prepare nanofluids & study thermal conductivity with specially designed parallel plate thermal conductivity (PPTC) apparatus. Nano sized carbon nanotubes were weighed & suspended with 0.1, 0.25, and 0.35 wt% concentration in ethylene glycol. From the results an optimum concentration of Nano fluid having higher thermal conductivity to obtain efficient heat transfer via the nanofluid with experimental analysis was found. Nanofluids are a new class of fluids emerging in today's world which improve the challenges in heat transfer applications in today's automobile industries.

KEYWORDS: Nanofluids, Parallel Plate, Heat Transfer

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INTRODUCTION

The traditional heat exchange fluids, for example water, ethylene glycol, and thermic liquids, are generally utilized in different modern applications including refrigeration and cooling, transportation, solar power based thermal and microelectronics. As the years cruise by, advancement of thermal system assumes an essential job in vitality utilization since vitality prices have been taking off quickly. Notifying that the regular thermal liquid has low thermal conductance, researchers make accessible of various designing techniques on the cooling system in improving heat transfer.

Nanofluid is termed as Nano meter sized particles dispersed in base fluids such as silicone oil, ethylene glycol, water, oil, etc. Nanofluids have great advantage over conventional heat transfer fluids. A very little quantity of nanoparticles when uniformly scattered in base fluids can provide drastic change in thermal properties of fluids. Nano particles have shapes such as spheres, disks, rods, tubes etc. These particles have higher surface area which carries more amount of heat than milli and micro sized particles.

Thermal Conductivity of Nanofluids

Thermal conductivity is the proportion of the capacity of Nanofluids to exchange heat. The thermal conductivity is the thermal energy exchanged per unit time and per unit surface region, partitioned by the temperature contrast. Fig.1 indicates the factors affecting thermal conductivity of nanofluids

Figure 1: Factors Effecting Thermal Conductivity.

Carbon Nanotubes

Carbon Nanotubes (CNTs) are allotropes of carbon with a round and empty nanostructure. These tube shaped carbon molecules have uncommon properties, which are significant for nanotechnology, equipment and distinctive fields of materials science and advancement. Attributable to the materials outstanding quality and solidness, nanotubes have been created with length-to-breadth extent of up to 132,000,000:1, altogether bigger than for some other material by and large greater than for some other material. In addition, attributing to their exceptional thermal conductivity, mechanical, and electrical properties, carbon nanotubes find applications as added substances to various fundamental materials. Fig.2 describes the methodology followed in investigation. Fig.3 indicates the experimental setup used for the present investigation.

METHODOLOGY

Figure 2: Methodology.

Process Involved

- Ethylene glycol,
- MWCNT Powder
- MWCNT + Ethylene glycol
- Sonication
- PPTC Test section
- PPTC Apparatus

Figure 3: Experimental Setup.

Steady State Parallel Plate Method

The determination of the thermal conductivity with the parallel plate principle surely represents the method with the longest tradition. However, the long measuring time and insufficient measuring accuracy in spite of complex corrections are the main reasons for the fact that parallel plate instruments are hardly used as standard technology so far. Nevertheless, the method offers remarkable advantages such as the simple geometrical configuration. The planar form of the measuring volume allows measurements not only for fluids and bulk materials, but also for solid bodies. Exact adjustment and determination of the temperatures, the geometrical parameters of the measuring volume, the heating power for the heating plate allow absolute estimations of the thermal conductivity for many kinds of materials with 97% confidence and 3% error.

Figure 4: PPTC Design.

Parallel-Plate Apparatus Design and Method

The consistent-state parallel plate technique utilize basic heat transfer idea to gauge thermal conductivity of material sample by utilizing one dimensional heat conduction equation and idea of thermal resistance. The fluid example is set between upper copper plate and the lower copper plate. An O-ring is utilized to make a space between upper copper plate and the lower copper plate to fill in a fluid example. The heat flux streams toward the path from radiator to the lower copper plate.. After consistent temperature, contrast between the upper surface of upper copper plate and lower surface of lower copper plate is achieved; the thermal conductivity of material example can be determined from one-dimensional heat conduction equation. Any instrument to be designed needs specific software's, since we have used Autodesk inventor, CATIA, ANSYS fluent for simulation and designing instrument. While designing, the errors which were found in previous levels were tried to be eliminated, specifically improved experimental test section height and area. It is made flexible for removal of used solution (Nano fluids).

- The apparatus is altogether calibrated so as to ensure precise estimation results.
- The consistency and in general precision of PPTC device has been calibrated utilizing Ethylene glycol.
- The PPTC apparatus displays an error of about 3% with 97% confidence.
- Graph which depicts the calibration with ethylene glycol is given below.

Equations used for the analysis are described below

One-Dimensional Heat Conduction Equation

$$k_F = \frac{L_F}{A \cdot \left(\frac{T_H - T_C}{Q_x} - \frac{2L_{Cu}}{k_{Cu} A} \right)} \quad (1)$$

Predicted Models

Hamilton and Crosser Model

$$\frac{k_{\text{eff}}}{k_f} = \frac{k_p + (n-1)k_f - (n-1)\phi(k_f - k_p)}{k_p + (n-1)k_f + \phi(k_f - k_p)} \quad (2)$$

Koo and kleinstreuer model

$$\frac{k_{\text{static}}}{k_f} = \frac{k_p + 2k_f + 2(k_p - k_f)\phi}{k_p + 2k_f - 2(k_p - k_f)\phi} \quad (3)$$

$$k_{\text{brownian}} = 5 * 10^4 * \beta \phi \rho_f c_{pf} \sqrt{\frac{k_B T}{\rho_p d_p}} f \quad (4)$$

$$k_{nf} = k_{\text{static}} + k_{\text{brownian}} \quad (5)$$

RESULTS AND DISCUSSIONS

The experiment was conducted at different heat inputs. Five reading are noted down at different concentrations i.e., 0.05%, 0.1%, 0.15%, 0.25%, 0.35% by varying voltage from 40V to 80V. From readings obtained, the value of the thermal conductivity of nanofluid was found. The reading were tabulated in the Table.1.1 to 1.3.

Table 1: Observation

Observation Table of Ethylene Glycol and 0.1wt% MWCNT						
S.No	Voltage (V)	Current (A)	Avg. Temperature of the Fluid(°C)	T _h (°C)	T _c (°C)	K (W/mk)
1	40	0.24	34.58	36	31	0.427
2	50	0.3	42	43	35	0.417
3	60	0.4	49.58	52	40	0.445
4	70	0.48	60.16	64	46	0.395
5	80	0.57	74.16	78	50	0.361

Table 2: Observation

Observation Table of Ethylene Glycol and 0.25wt% MWCNT						
S.No	Voltage (V)	Current (A)	Avg. Temperature of the fluid(°C)	T _h (°C)	T _c (°C)	K (W/mk)
1	40	.22	35.25	36	32	.528
2	50	.32	43.91	45	37	.480
3	60	.39	51.91	54	42	.467
4	70	.48	65.41	68	48	.401
5	80	.57	76.83	80	54	.419

Table 3: Observation

Observation Table of Ethylene Glycol and 0.35wt% MWCNT						
S.No	Voltage (V)	Current (A)	Avg. Temperature of the Fluid(°C)	Upper Surface Temp. Of Copper Plate T_{hz} (°C)	T_c (°C)	K (W/Mk)
1	40	.23	36.5	36	30	.340
2	50	.31	39.5	43	33	.343
3	60	.39	47.25	53	36	.304
4	70	.48	56.58	65	39	.286
5	80	.56	68.58	80	43	.267

Figure 5: Thermal Conductivity Vs Concentration.

Fig. 5 shows the relation between thermal conductivity (K) Vs concentration (%). Fig. shows upgrade in the thermal conductivity of nanofluids with various weight portions of the MWCNT. A significant increment in the thermal conductivity was found with the expansion in the MWCNT focus for nanofluid. As graph shows, thermal conductivity was found to be increased upto an optimum level of 0.25 wt% concentration, further it decreases with increasing concentration. The decrease in thermal conductivity was assumed due to Agglomeration of nano particles at higher concentration, which shows that optimum addition of nanoparticles to nanofluids gives better results of thermal conductivity in CNT- Ethylene glycol based nanofluids. An enhancement in thermal conductivity of 53.03% was observed at $\phi=0.25\%$. The large enhancement for CNT-based nanofluids is due to a very high thermal conductivity of carbon nanotubes compared to other nanoparticles reported in the studies just cited. There are four other conceivable clarifications for the odd increment of thermal conductivity, Brownian movement of the nanoparticles, atomic dimension layering of the fluid at the fluid/molecule interface, the nature of heat transport in the nanoparticles, and the impacts of nanoparticle grouping.

CONCLUSIONS

The present work concerns the measurement of thermal conductivity of ethylene glycol based MWCNT-Nanofluids with the help of PPTC apparatus. The PPTC apparatus designed was calibrated with Ethylene glycol and showed 3% error with 97% confidence. The tests are done to interpret the discrepancies between the deliberate & predicted data. The thermal conductivity was found to be increased upto an optimum level of 0.25 wt% concentration. Further it decreases with increasing concentration. The decrease in thermal conductivity was assumed due to Agglomeration of nanoparticles at higher concentration.

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