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Convective heat transfer enhancement of graphite nanofluids in shell and tube heat exchanger

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Abstract: For the heat transfer to be large, the heat transfer area should be large. However by using nanofluids as the working fluid, the required heat transfer can be achieved by using the same apparatus. Current research suggests a promising future for graphite nanofluids. The main focus of this research ison developing higher convective heat transfer behavior of graphite nanofluids through the shell andtube heat exchanger under laminar flow.Graphite nanopowder is brought in the market and is dispersed in the base fluid (water) by varying its concentration such as 0.025%, 0.05%, 0.075%. The temperature of the hot and the cold fluid is noted down for each concentration. Keeping the flow rate of the hotter fluid as constant, flow rate of the colder fluid is varied. Also the effect of the flow rate and concentration on the heat transfer co-efficient has been discussed. It has been found that when the concentration of the graphite is increased, the heat transfer co-efficient increases gradually as the concentration increases.

Keywords: *nanofluids, graphite, concentration, heat transfer co-efficient*

1.0 INTRODUCTION

Nanofluids are suspensions that can be obtained by dispersingdifferent nanoparticles in host fluids with the aim of enhancedthermal properties. Over the past few years, it has been shownthat nanofluids are able to remarkably improve the thermal conductivity,stability and heat transfer coefficient and reduce the consumedpower and the costs. These advantages made agrowing tendency in the use of nanofluids in different types of heatexchangers, due to the optimized energy consumption. Hence, discoveringsuitable nanofluids with improved heat transfer propertiesand high thermal conductivity became a serious challenge. More specifically graphite water-based nanofluids reveal greatimprovements, which is owing to the high thermal conductivity of graphite. The experimental studies have reported significantenhancement on the thermal conductivity and heat transfer coefficientof nanofluids. For example it has been shown thatalumina–water nanofluid at 6 vol% can increase the heat transfercoefficient in the entrance and fully developed regions by 17%and 27%, respectively, when compared with pure water. The heattransfer coefficient of zirconia–water nanofluid increases byapproximately 2% in the entrance region and 3% in the fully developedregion at 1.32 vol%. For nanofluids containing 0.5 wt%CNTs, the maximum enhancement is over 350% at Re = 800, andthe maximum enhancement occurs at an axial distance of approximately110 times of tube diameter. In this paper, graphite nano powder is brought in the market and then they wereused as a nanofluid for enhancement of heat transfer coefficient inshell and tube heat exchanger. The laminar convective heat transfer behavior of graphite nanofluids through a straight tube wasexperimentally investigated. Furthermore, it was attempted to discoverthe effect of different parameters such as temperature andgraphite concentration on convective heat transfer coefficientsof graphite nanofluid.

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2.0 EXPERIMENT

2.1 Preparation of water-graphite suspension

To prepare a aqueous solution of graphite, the graphite powder is mixed with the base fluid-water. The graphite powder is brought in the market and then it is mixed with the water to prepare the aqueous solution of graphite. For making nano fluid suspensions with concentration 0.025%, 0.05%, 0.075% of graphite in water solution were prepared and they were named as WG-1, WG-2, WG-3, respectively. Their composition in terms of weight is shown in the table 2.1 as follows,

Name	Volume of water	Volume of graphite	Concentration
WG-1	150	38	0.025
WG-2	150	76	0.05
WG-3	150	114	0.075

Table 2.1 preparation of water graphite suspension

2.2 Experimental setup:

The experimental setup consists of a pump, a water storage tank of capacity 175 lit, water heater, shell and tube heat exchanger, thermocouples at the entry and the exit to measure the inlet and the outlet temperature. In order to get accurate experimental results, first of all equipment is made stable by passing the water through the shell as well as the tube side area. To establish the laminar flow in the tube side area, the flow rate of the hotter fluid is made constant as 1.0 LPM. Then the flow rate of the colder fluid is varied from 1.0 LPM to 5.0 LPM, by adjusting the flow meter. The schematic diagram of the experimental setup that we use is shown in the below figure,

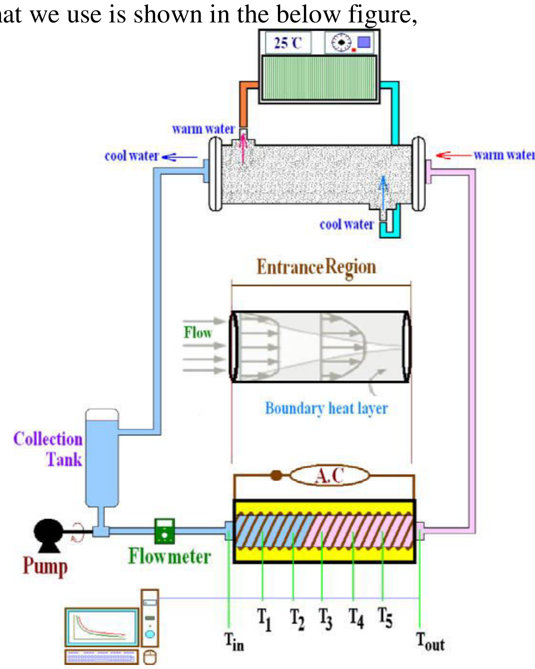

Fig 2.2 schematic diagram of shell and tube heat exchanger

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Thethermal conductivity of the water and the water-graphite suspension is shown in the table as follows,

Name	Thermal conductivity
Water	0.618
WG-1	1.8688
WG-2	3.1282
WG-3	4.3799

Table 2.2 thermal conductivity of water and water-graphite suspension

From the above table, it is clear that the when the concentration of the graphite is increased in the water, the thermal conductivity also increases. The thermal conductivity of water-graphite suspension is calculated by using the rule of mixture formula "thermal conductivity of the water-graphite suspension= (concentration of water* thermal conductivity of the water)+(concentration of graphite added*thermal conductivity of the graphite)".

2.3 Experimental procedure

As said earlier, the equipment is first standardized by passing water through the shell side as well as tube side area. Then the prepared graphite-water suspension is made to pass through the shell side area as the colder fluid and the water which is heated by means of a water heater is allowed to pass through the tube as the hotter fluid. The flow rate of the hotter fluid as constant and that equals to 1.0 LPM, the flow rate of the hotter fluid is varied to about 1.0 LPM to 5.0 LPM. The inlet and the outlet temperature of the hotter and the colder fluid are noted.

3.0 RESULTS AND DISCUSSION

Thermal conductivity is one of the most effective parameterswhich have significant effect on enhancement of heat transfer coefficient. It is found that the thermal conductivity increases with increase in the concentration. With the addition of 0.025%, 0.05%, 0.075%, the thermal conductivity will be approximately in the range of 1.8, 3.2, 4.3, whereas water has only 0.618 W/m-k respectively,

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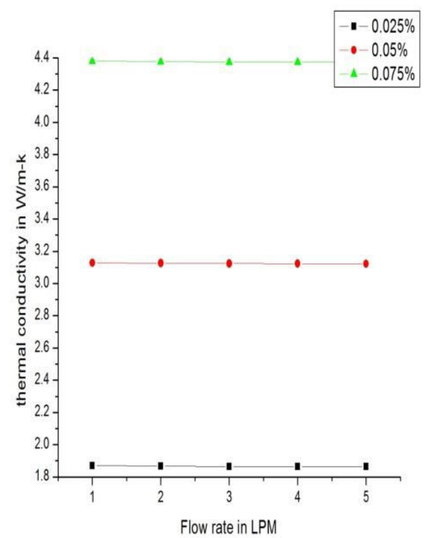

Figure 3.1 thermal conductivity vs. flow rate

It is clear from the graph that thermal conductivities increase gradually when the concentration of the graphite is increased in the base fluid. However there is minute change in all the three curves due to the variation of the flow rate. The thermal conductivity decreases when the flow rate of the colder fluid is increased which affects the overall heat transfer co-efficient.

3.2 viscosity vs. flow rate

The viscosity of the water graphite suspension decreases gradually with the increase in the concentration. The temperature of the liquid decreases with the increases in the temperature which in turn implies that the suspension with higher concentration, heat transfer will take place to a greater extent.

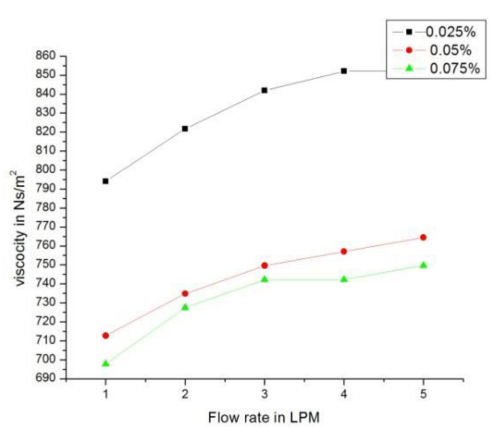

Fig 3.2 viscosity vs. flow rate

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When the concentration of the graphite is increased in the base fluid, viscosity is decreases due to the larger heat transfer rate in the suspension with higher concentration.

3.3 Heat Transfer Co-Efficient Vs. Flow Rate

The heat transfer co-efficient will depend on the flow rate and thermal conductivity. When the flow rate is varied, the heat transfer rate will also increase.

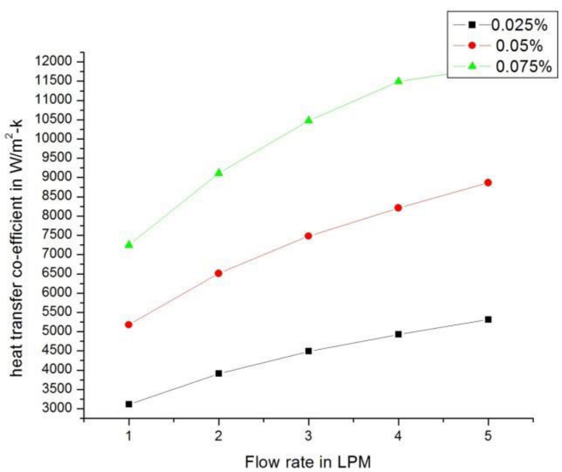

Fig 3.3 heat transfer co-efficient vs. flow rate

It is clear from the above fig. that heat transfer co-efficient increases with the increase in the concentration of the graphite. When the flow rate is increased, the heat transfer co-efficient also increases gradually.

4.0 CONCLUSION

In conclusion the effect of graphite on thermal conductivity of nanofluids is much more than heat transfer coefficient of nanofluids and this effect increases with increasing the concentration of graphite. This matter is related to the difference of thermal conductivity and heat transfer coefficient which respectively are static properties and dynamic properties. The thermal conductivity of graphitenanofluids increases by 1.8, 3.6,4.8 from the thermal conductivity of the base fluid which equals to 0.618 W/m-k at 0.05, 0.075 and 0.1 wt%, respectively. Furthermore with increasing graphite concentration and flow rate of the colder fluid, the heat transfer coefficient of graphite nanofluids is enhanced. By increasing the concentration of graphite from 0.025 wt% to 0.075 wt%, the heat transfer coefficient of grapheme nanofluids increases due to the increase in the thermal conductivity.

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