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Theoretical Characterization of Ethylene Glycol Nano Fluid for Automobiles.

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ABSTRACT

The present project work is to explore the convective heat transfer coefficient characteristics of Ethylene glycol/Silver nano fluids for heat transfer applications. Theoretical investigation on heat transfer characteristics are carried out by varying the mass flow rate, length of the tube and particle volume fraction. Heat transfer coefficient increases when the mass flow rate increases and the length of the tube decreases. The convective heat transfer coefficient of EG/Ag nano fluid is higher than that of the base fluid. It is also seen that the value of enhancement in convective heat transfer coefficient increases with respect to Reynolds number. At 0.1 vol % Ag, the convective heat transfer coefficient is enhanced by 7.5 % and 0.4 vol % Ag, the nanofluid shows an enhancement of 30 % respectively.
Keywords: heat transfer, convection, nanofluids, enhancement

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INTRODUCTION

Ever since the adverse effect of greenhouse gases was discovered, leading to the Kyoto Protocol, the search for methods and technological advancement to mitigate the impact of global warming on Planet Earth became a pressing need for the research and industrial communities. The Protocol had exhorted both the developed and developing countries to show intense curiosity with a sense of participation, to find definitive ways to tackle the issue. Subsequent meetings which were held in many countries had called for a gentle decline in the production of greenhouse gases. A reduction in energy consumption is possible by enhancing the performance of heat exchange systems. Heat transfer is one of the most important processes in industrial and consumer products and it is worth addressing its influence over carbon footprints. Masuda et al. [13] studied the thermo-physical properties of the metallic oxide particles (Al_2O_3 and TiO_2) dispersed in water. The transient hot wire method was used for measuring thermal conductivity of nanofluids. It was observed that the thermal conductivity of the nanofluid was significantly higher than that of the base fluid. For 4.3% volume concentration, the thermal conductivity of Al_2O_3 – water nanofluid and Tio_2 – water nanofluid was approximately 32% and 11% respectively higher than that of the base fluid. Pak and Cho [12] reviewed the heat transfer performance of γ - Al_2O_3 and TiO_2 nanoparticles dispersed in water flowing in a horizontal circular tube. Alumina (Al_2O_3) and titanium dioxide (TiO_2) nanoparticles with diameters of 13 nm and 27 nm respectively, were used in their study. They found that the Nusselt number of nanofluids increased with an increase in the Reynolds number as well as the volume fraction. However, they still found that the convective heat transfer coefficient of the nanofluids with 3 vol. % nanoparticles was 12 % lower than that of pure water at a given Reynolds number. This may cause the nanofluids to have larger viscosity than that of pure water, especially at high particle volume fractions. Wen and Ding [9] reviewed the convective heat transfer coefficients in which γ - Al_2O_3 nanoparticles were suspended in deionized water for laminar flow in a copper tube under a constant wall heat flux and focused in particular on the entrance region. Alumina nanoparticles of 27–56 nm in size were used in this study. The results showed that the local heat transfer coefficient varied with the Reynolds number and particle concentration. In particular, it was found that the use of nanofluids at the entrance region resulted in a pronounced increase in the heat transfer coefficient, causing a decrease in the thermal boundary layer thickness which decreased with the axial distance. This behaviour implied that it might be possible to create a ‘‘smart entrance” region to meet the highest performance of nanofluids. Furthermore, the calculated Nusselt number using the Shah correlation for laminar flow and the Dittus–Boelter equation for turbulent flow did not coincide with the experimental results. Lotfi et al. [10] had conducted heat transfer enhancement of multi-walled carbon nanotube (MWNT)/water nanofluid in a horizontal shell and tube heat exchanger has been studied experimentally. Carbon nanotubes were synthesized by the use of catalytic chemical vapor deposition (CCVD) method. The results indicate that heat transfer enhances in the presence of multi-walled nanotubes in comparison with the base fluid. The results shows heat transfer enhancement in the presence of multi walled nanotubes in comparison with the base fluid. Wei et al experimentally investigated the heat transfer properties of Al_2O_3 nanofluids based on the mixture of 45 vol. % ethylene glycol and 55 vol. % water. The viscosity of nanofluid strongly depends on both temperature and volume concentration, and it considerably increases with increasing particle volume fraction, and decreases with enhancement of temperature from

10°C to 60°C.The thermal conductivity of the nanofluids increase with the increasing temperature. The heat transfer coefficients of the nanofluids with 1.0 vol.% and 2.0 vol.% have been found an increase up to 57% and 106%, respectively, when the Reynolds number is 2000. Theoretical investigation on the heat transfer characteristics of Pure EG and EG/Ag nanofluids was carried out using double pipe counter flow heat exchanger by Varying the mass flow rate, Varying the length of the tube and Varying the volume fraction.

EXPERIMENTAL

It comprises of two flow circuits; namely water circuit and Silver/ethylene glycol Nanofluid circuit consists of several units such as pump, flow meter, a constant temperature water tank, nanofluid tank with temperature controller. The Nanofluid circuit also has the above components to circulate the fluid. There is a test section in which temperature and pressure can be measured at regular intervals. The test section consists of a double tube heat exchanger. Silver / Ethylene glycol nanofluid flows in the inner tube while the water flows in the annulus during the test. Ceramic wool is used as a thermal insulating layer surrounding the outer tube. Temperature sensors (RTDs) will be mounted on the inner and outer tube walls at equally spaced intervals to measure the inner and outer tube wall temperatures. In order to measure the pressure drop experienced by the Silver / Ethylene glycol nanofluid, pressure transducers will be fixed at the inlet and outlet of the insulated test section. The specifications of the experimental set up are as length of the tube is 3 m, inner diameter of the tube is 0.0043 m, outer diameter of the tube is 0.00635 m, cross sectional area of the inner tube is $1.452*10^{-5}$ m^2 and cross sectional area of the outer tube is $3.166*10^{-5}$ m^2.

RESULTS AND DISCUSSION

Fig.2. shows the variation of heat transfer coefficient at various mass flow rate of the inner fluid (EG) at constant temperature. It is observed from the figure that the heat transfer coefficient is increased by increasing the mass flow rate of the inner fluid (EG), and keeping the mass flow rate of the annulus fluid (Water) constant. The minimum and maximum heat transfer coefficients for the pure EG are 371.41 W/m^2K at 0.02 kg/s, 1507.93W/m^2K at 0.06 kg/s respectively.

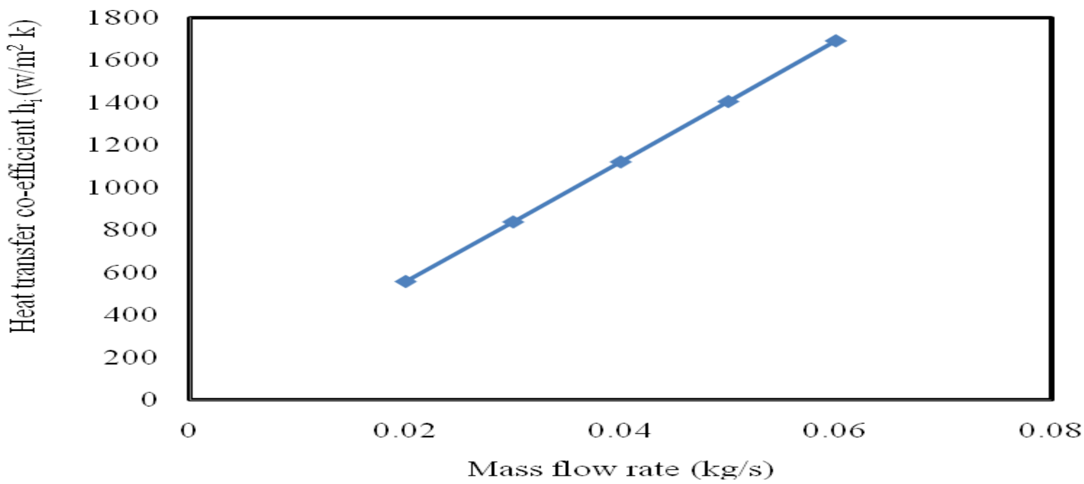

Figure 1: Variation of Heat transfer coefficient on different Mass flow rate at constant temperature

Fig.1. shows the variation of heat transfer coefficient at various mass flow rate of the annulus fluid (Water) at constant temperature. It is observed from the figure that the heat transfer coefficient is increased by increasing the mass flow rate of the annulus fluid (Water),and keeping the mass flow rate of the inner fluid (EG) constant. The minimum and maximum heat transfer coefficients for the pure EG are 556.63 W/m^2K at 0.02 kg/s, 1689.68 W/m^2K at 0.06 kg/s respectively.

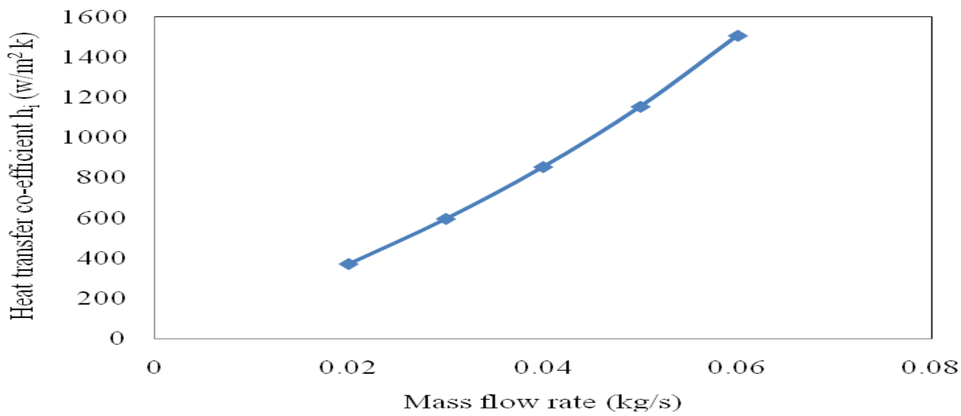

Figure 2: Variation of Heat transfer coefficient on different Mass flow rate

Fig.3. shows the variation of overall heat transfer coefficient at various mass flow rate of the inner fluid (EG) by varying the length. It is observed from the figure that the overall heat transfer coefficient is increased by decreasing the length of the tube and increasing the mass flow rate. The minimum overall heat transfer coefficient are 119.64 W/m^2K at 0.02 kg/s and 299.11 W/m^2K at 0.05 (kg/s) at 10m and the maximum overall heat transfer coefficient are 398.81 W/m^2K at 0.02 kg/s and 997.63 W/m^2K at 0.05 kg/s at 3m respectively.

Fig.4 shows the variations of convective heat transfer coefficient of EG based nanofluid at various concentrations of Silver as the function of Reynolds number. It is observed from the figure that the convective heat transfer coefficient of EG/Ag nanofluid is higher than, those of the base fluid. It is also seen that the value of enhancement in convective heat transfer coefficient increases with respect to Reynolds number. At 0.1 vol % Ag, the convective heat transfer coefficient is enhanced to a value of 7.5 % and 0.4 vol % Ag the nanofluid shows an enhancement of 30 % at Re=8000.

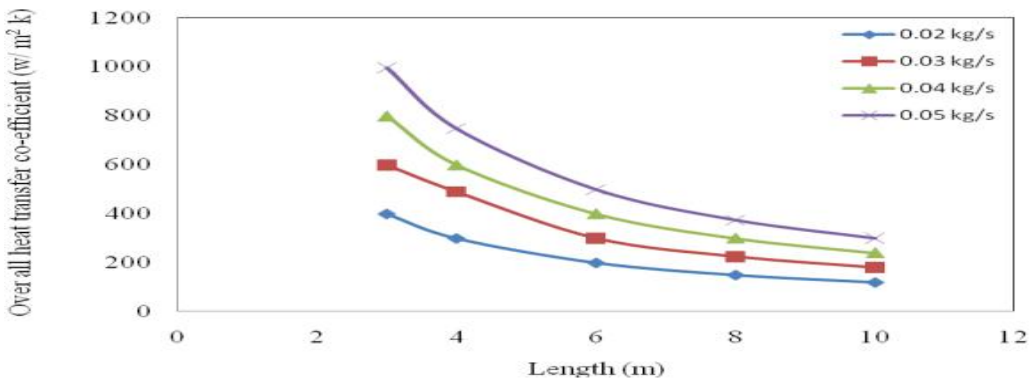

Figure 3: Variation of overall heat transfer co-efficient over different pipe length

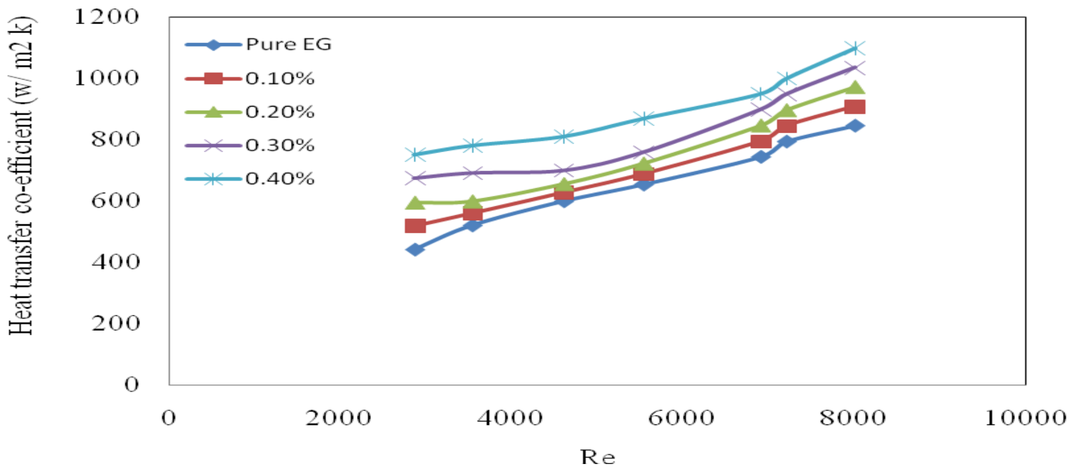

Figure 4: Variation of heat transfer co-efficient on reynolds number

CONCLUSION

The following conclusions are arrived at based on the theoretical investigations. The minimum and maximum heat transfer coefficient for the pure EG are 371.41 W/m^2K at 0.02 kg/s, 1507.93 W/m^2K at 0.06 kg/s respectively, by varying the mass flow rate of the inner fluid(EG) and keeping the mass flow rate of the annulus fluid(Water) constant. The minimum and maximum heat transfer coefficient for the pure EG are 556.63 W/m^2K at 0.02 kg/s, 1689.68 W/m^2K at 0.06 kg/s respectively, by varying the mass flow rate of the annulus fluid(Water) and keeping the mass flow rate of the inner fluid(EG) constant. The minimum overall heat transfer coefficient is 119.64 W/m^2K at 0.02 kg/s and 299.11 W/m^2K at 0.05 (kg/s) at 10m and the maximum overall heat transfer coefficient is 398.81 W/m^2K at 0.02 kg/s and 997.63 W/m^2K at 0.05 kg/s at 3m respectively. The convective heat transfer coefficient of EG/Ag nanofluid is higher than, those of the base fluid. It is also seen that the value of enhancement in convective heat transfer coefficient increases with respect to Reynolds number. At 0.1 vol % Ag, the convective heat transfer coefficient is enhanced by 7.5 % and 0.4 vol % Ag , the nanofluid shows an enhancement of 30 % respectively.

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