Laminar heat transfer with alumina nanofluid in cu tube with different diameters

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Abstract. This study made nano particles-dispersing alumina nano fluid to three sized copper tubes in order to identify the differences in its heat transfer coefficient depending on its concentration. In order to evenly disperse nano particles in the fluid, it was treated with the ultrasonic process. And Thermal conductivities of nanofluid **are** measured via the LAMBDA measuring system by transient hot wire method. And to measure the differences in the nano fluid's dispersion degree depending on its different concentrations that was measured by mean of technique using a UV device. This study found that as the diameter of copper tube size was smaller, the heat transfer coefficient got higher and the fluid's heat transfer coefficient was changed depending on the different Reynolds numbers. Based on the findings of its experiment, this study explained the alumina nano fluid's characteristics in small diameter tubes

1. Introduction

A large number of industrial development and new technologies are limited by existing thermal management [1], and need for high performance cooling. A lot of industrial applications need ultrahigh-performance cooling systems to miniaturize the thermal systems. Nano fluid means the fluid having good thermal characteristics evenly dispersing nano particle on a fluid [2]. It is demonstrated that the advantages of nanofluids have better stability compared with those fluids containing micrometer or millimeter size particles and higher thermal conductive capability than their base fluids. thanks to the development of technology generating the nano particles, there have actively conducted several studies about the nano fluid[3-8] as a new form of heat-transferring fluid using the nano particles in traditional heat transfer fluids such as water, glycol, or oil base fluid [9–12] in recent decades. which was first propose by Dr. Stephen U.S.choi in Argonne National Lab, U.S.A in 1996[13]. And, Thermal conductivities of nanoparticle fluid mixtures have been reported by Eastman et al[14] and Artus[15] by adding a small volume fraction of metal or metal oxide powders in fluids increased the thermal conductivities of the particle-fluid mixtures over those of the base fluids. [16]Maxwell showed the possibility of increasing thermal conductivity of a mixture by greater volume fraction of solid particles. These fluids, containing colloidal suspended nanoparticles, have been called nanofluids. [17]General size of nano particle being used in a nano fluid is ranged from 10nm to 50nm, and the kinds of nano particles having been currently used are the Al2O3, CuO, Cu, Pt, Au single-layer structured nano tube and the multiple-layer structured nano tube. This study aimed to produce various concentrations of nano fluid in use of alumina nano particles among various types of nano particles and to identify the pure water' and the alumina nano fluid's thermal characteristics through a basic heat-transfer experiment depending on different tube sizes.

2. Experimental details

In this experiment, Distilled water (DW) is used for the base fluid for nanofluid in present experiment. the researcher made the nano fluid having the concentrations of 0.5wt%, 1.0wt% and 2.0wt% in order to identify the alumina nano fluid's heat transfer characteristics. Figure 1 showed the distilled water and three nano fluids having different concentrations which were really produced,

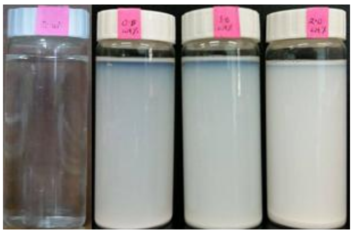

Figure 1. The Image of DW and Al2O3 (0.5wt%,1.0wt% and 2.0wt%)

2.1. Experiment Method

In this experiment, the researcher composed the following experiment tool as shown in the Figure 2 in order to identify the distilled water's and alumina nano fluid's heat transfer coefficient characteristics

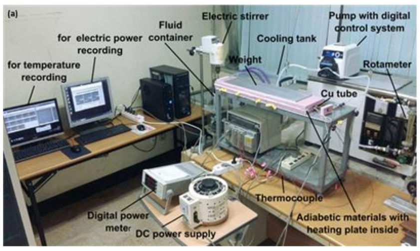

Figure 2. (a) The digtal Photo of experimental apparatus.

First, for the test section to find out the both materials' heat transfer coefficient characteristics, the investigator first prepared a heating plate having its length=0.76m and width=0.12, and experimented with three concentrations of 0.5wt%, 1wt% and 2wt% alumina fluids and distilled water being contained in 0.8mm, 1.6mm and 2mm and 1m-long copper tubes. Outside of copper tubes in the test section, some T-type thermocouples were attached at intervals of 0.152m, and the thermocouples were wrapped with some insulating materials. Concerning the fluids flow, the investigator used pump to supply fluid in a certain flow rate. And the fluid being cooled down in a water tank was transferred by pump to the copper tube and then the fluid was cooled down in a tank again. Like that the fluid was gone through the repetitive process. For the measuring instruments, this experiment used the data logger for storing each fluid's temperature data and the electricity power-meter in order to measure the input calorie. This experiment compared the results of distilled water, 0.5wt%, 1wt% and 2wt% in order to prove this experiment's results. Performance of local heat transfer in terms of convective heat transfer coefficient is calculated by,

$$H(x) = \frac{Q}{A\,(T_w - T_f)_x} = \frac{Q}{lw\,(T_w - T_f)_x}$$

$$= \frac{\ddot{q}}{(T_w - T_f)_x}$$

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So, the actual heat flux can be calculated by the equation

$$\ddot{q} = \frac{Q}{\pi dL} = \frac{Q}{lw}$$

Fluid temperature profile in the test section can be calculated as,

$$T_f = T_{in} + \frac{\ddot{q}Px}{\rho C_p v A}$$

3. Result and discussion

In order to evenly disperse nano particles in the fluid, it was treated with the ultrasonic process. To characterize the dispersion of the Nanofluid suspensions UV measurement system was measured and compared with each date. Fig 3 shows the UV spectra of the distilled water and nanofluid (0.5wt%, 1.0wt%and 2.0wt%). As shown, the lowest absorbance was measured for the 0.5wt% suspension except distilled water. Meanwhile, the 2.0wt% suspension exhibited much higher absorbance than 0.5wt%, 1.0wt%

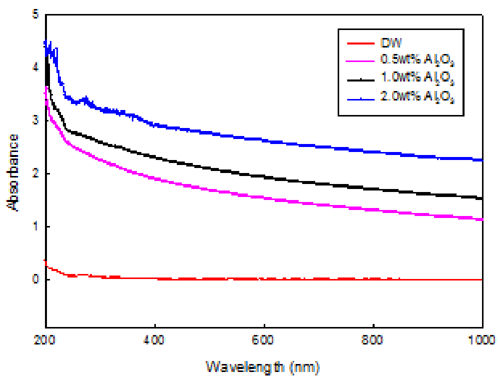
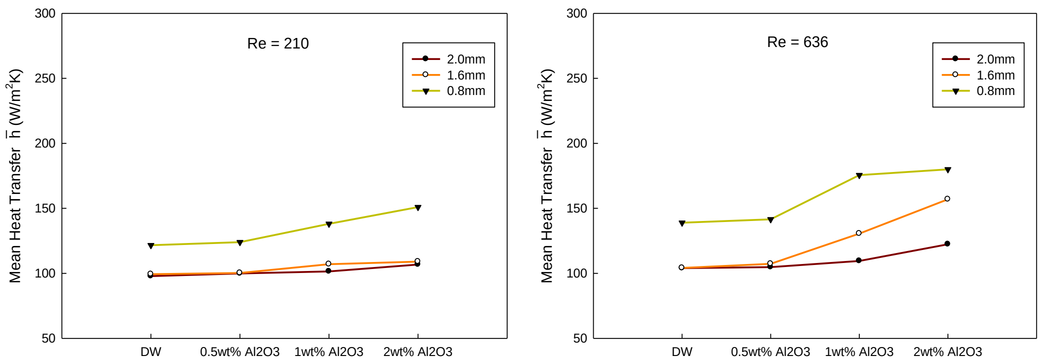


Figure 3. Absorbance test comparing different concentration nano fluids

Figure 4 showed the results comparing different diameter of copper tube depending on different alumina concentrations in each Reynolds number. As the concentration of alumina nano fluid got increased, the heat transfer coefficient tended to be increased, and it could be seen that smaller diameter of copper tube had higher heat transfer coefficient than bigger diameter of copper tube. And it could be seen that as the number of Reynolds was increased, the gap of heat transfer coefficient each tube , and the heat transfer coefficient was increased.



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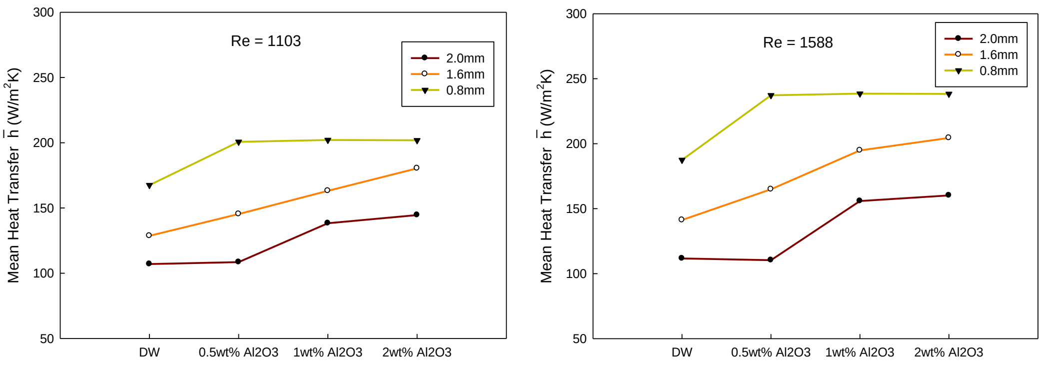

Figure 4. Experimental date for each Reynolds number.

4. Conclusion

This experiment conducted a heat transfer experiment in using the Distilled Water, 0.5wt%, 1.0wt% and 2.0wt% concentration of nano fluid in order to identify alumina nano fluid's heat transfer characteristics, and got the following conclusion.

From this experiment, it was identified that as the concentration of alumina nano fluid was increased, the fluid's heat transfer coefficient was higher, and as the diameter size of tube was smaller, the tube's heat transfer coefficient got higher. Additionally, for the case that the number of Reynolds was 210, the 0.8mm diameter of copper tube's heat transfer coefficient was increased to 131.64% than that of 2mm diameter of copper tube, and for the case that the number of Reynolds was 636, the 0.8mm diameter of copper tube's heat transfer coefficient was increased to 144.33% than that of 2mm diameter of copper tube. And for the case that the number of Reynolds was 1103, the 0.8mm diameter of copper tube's coefficient was increased to 154.899%, and for the case that the number of Reynolds was 1588, the 0.8mm diameter of copper tube's coefficient was increased to 167.53%. Judging from these results, it could be also identified that as the number of Reynolds was increased, the increase margin of heat transfer coefficient was increased according to that.

Nomenclatures

A: Cross-sectional area, [m2]
CP: Specific heat, [J/Kg K]
D: Tube diameter, [m]
DW : Distilled water
H : Heat transfer coefficient, [W/m2K]
K: Thermal conductivity, [W/m K]
L: Length of the test section, [m]
P: Perimeter [m]
Q: Watt [W]
$\ddot{q}$: Heat flux, [W/m2]
w : Width [m]
Re: Reynolds number
T : Temperature, [K]
v: Velocity, [m/s]
vol.%: Volume percentage
wt.%: Weight percentage
X: axial distance from the tube entrance [m]
v: Dynamic viscosity (kg/m.s)

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C_p: Specific heat (J/kgK)
ρ: Density (kg/m3)
δ: Boundary layer thickness (mm)
f :fluid
in: inlet
out:outlet
w:tube wall

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