HEAT TRANSFER THROUGH HEAT EXCHANGER USING AL_2O_3 NANO FLUID AT DIFFERENT CONCENTRATIONS

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Abstract -This article reports an experimental study on the forced convective heat transfer and flow characteristics of a nano fluid consisting of water and different volume concentrations of Al_2O_3 nanofluid (0.3–2)% flow ingina horizontal shell and tube heat exchanger counter flow under turbulent flow conditions are investigated.TheAl_2O_3 nano particles of about 30 nm diameter are use din the present study.

Keywords: Al_2O_3 neno fluid, neno fluids, shell and tube type heat exchanger

I. INTRODUCTION

A decade ago, with the rapid development of modern nano technology, particles of nanometre-size (normally less than 100 nm) are used instead of micrometre-size for dispersing in base liquids, and they are called nano fluids. This term was first suggested by Choi [1] Abu-Nada, et al. [2] used an efficient finite-volume method to study the heat transfer characteristics of natural convection for CuO/EG/water nano fluid in a differentially heated enclosure Cheinand Chuang [3] reported experimentally on micro channel heat sink(MCHS)performance using CuO water nano fluids as coolants. the Brinkman equation [4] for viscosity, the Xuan and Roetzel equation [5] for specific heat, and the Hamilton and Crosser model [6] for thermal conductivity. The results showed that the presence of nano particles creates greater energy absorption than pure water at a low flow rate and that there is no contribution from heat absorption when the flow rate is high. Duangthongsuk and Wongwises [7,8] investigated the effect of the rmophysical properties models on prediction of the heat transfer coefficient and also reported the heat transfer performance and friction characteristic so nano fluid,respectively.The 0.2 volume concentration TiO_2 neno particles are used to disperse in the water.

II. EXPERIMENTAL SETUP

To design a project that could be used to transfer heat from hot water in a heat exchanger to nanofluid stored in a separatet an k and make temperatur ecalibrations for the same by employing two thermocouples. Also, flow meters will be installed in the pipe scarrying nano fluid to check its flow in grate.The complete system will be very dynamic and easy to use. Mechanical structure design is shown is Fig. 1. It consists of two flow loops, a heating unit to heat then a no fluid or the distilled water, and temperature measurement system .The two flow loop scarries heated nano fluid or distilled water and the other cooling water. Each flow loop in cludesa pump with a flow meter,are servoir and a bypass valve to maintain there quired flow rate.The shell and tube heat exchanger is of stainless steel type 316L,248mm long consisting of 37tubes.The tube diameter is 2.4mm with a tube wall thickness of 0.25 mm, having a designed heattransfer are a of 0.05 m^2. Two J type thermocouples with removable bulbsare inserted on the heatexchanger to measure the bulk temperatures of inlet and outlet fluid streams.The pump sare used with maximum delivery rate of 18.3L/min.

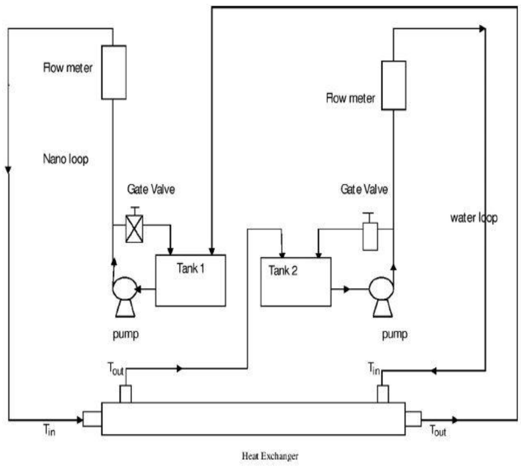


Fig. 1. System diagram.

Fig :1: schmatic diagram of heat exchanger

III. DATA PROCESSING

The nano fluid presented equation are calculated by using of the Pak and Cho [14] correlations, which are defined as follows:

$$\rho_{nf} = (1- \emptyset)\ \rho_f + \emptyset\rho p$$

where ρnf is the density of the nano fluid, ∅ is the particles volume concentration, ρf is the density of the base fluid and ρp is the density of the nano particles. The specific heat is calculated from Xuan and Roetzel [5] as following:

$$(\rho Cp)\ nf = (1-\emptyset)(\rho Cp)\ f + \emptyset(\rho Cp)\ p$$

where Cpnf is the heat capacity of the nano fluid, Cpf is the heat capacity of the base fluid and Cpp is the heat capacity of the nano particles. Heat transfer rate can be defined as

$$Q = mCp\Delta T$$

where Q is the heat transfer rate, mis the mass flow rate and ΔT is the temperature difference of the cooling liquid. The

logarithmic mean temperature difference:
where ΔTlm is the logarithmic temperature difference, Twi is the in let temperature of the water, Two is the outlet temperature of water, Tni is the inlet temperature of the nano fluid and Tno is the outlet temperature of the nanofluid. The overall heat transfer coefficient is where U is the overall heat transfer coefficient and As is the surface temperature

3.1. Thermal conductivity

An alternative formula for calculating the thermal conductivity was introduced by YuandChoi [17], which is expressed in the following form:

$$K_{nf} = kf\frac{(K+2Kf-2\emptyset(Kf-K)}{K+2Kf+\emptyset(Kf+K)}$$

where Knf is thermal conductivity of the nano fluid, Kρ is thermal conductivity of the nano particle and Kf is the base fluid thermal conductivity. The viscosity of the nano fluid Drewand Passman [18] suggested the well-known Einstein′s equation for calculating viscosity, which is applicable to spherical particles in volume fractionsless than 5.0 vol%, and is defined as follows

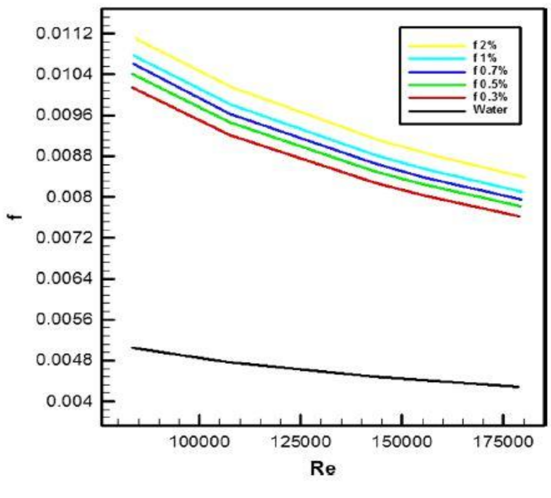
μ_{nf} =(1+2.5 ∅)μw

where mnf is the nano fluid viscosity and mw is the water viscosity. The properties of the nano fluid shown in the above equations are evaluated from water and nano particles at room temperature.

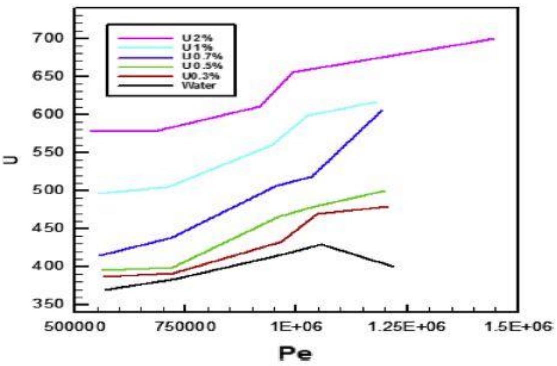
IV. RESULTS AND DISCUSSIONS

In order to apply the nano fluids for practical application, in addition to the heat transfer performance of the nano fluid it is necessary to study their flow features. Study with 0.3, 0.5, 0.7, 1 and 2 volume concentrations suspended nano particles are used to calculate the friction factor for each volume concentration and for all the mass flow rates. Fig. 2 shows the calculated friction factor for a measured value of Reynolds number.

Results indicate same trend of the heat rate for the overall heat transfer rate using distilled water as working fluid. This is because heat rate is directly proportional to the overall heat transfer coefficient.



The overall heat transfer coefficient for distilled water increases with the increase in mass flow rate till the amount of 0.01083 L/s, after that the overall heat transfer coefficient starts to decrease till it reaches the amount of 0.0125 L/s because the value of the temperature difference decreases with the increase in mass flow rate. For the nanofluid, the overall heat transfer coefficient increases with the increase in all the values of the mass flow rates and with the increase in volume concentration of the nanofluid, the maximum value of the overall heat transfer coefficient indicated at the maximum flow rate and at 2% volume concentration of the nanoparticles with an enhancement ratio of 1.754, the reason is that the nanoparticles increase the thermal conductivity and a large energy exchange process resulting from the chaotic movement of the nanoparticles



It was concluded that the heat transfer characteristics of the nanofluid increased. The trends shown by the nanofluid is due to the fact that the nanoparticles presented in the base fluid increase the thermal conductivity and the viscosity of the base liquid at the same time. The enhancement of thermal conductivity leads to increase the heat transfer performance as well as viscosity of the fluid which results into an increase in friction factor and the boundary layer thickness

V. CONCLUSION

The convective heat transfer performance and flow characteristics of Al_2O_3 nano fluid flow ingina horizontal shell and tube heat exchanger has been experimentally investigated. Experiments have been carried out underturbulent conditions. The effect of particlec on centrationand the Reynolds number on the heat transfer performance and flow behavior of the nanofluid has been determined. Important conclusions have been obtained and are summarized as following

(1)Dispersion of the nano particles into the distilled water increases the thermal conductivity and viscosity of the nanofluid, this augmentation increases with the increase in particle concentrations

(2)Friction factor increases with the increase in particle volume concentration. This is because of the increase in the viscosity of the nano fluid and it means that the nano fluid incur little penalty in pressure drop

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