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Enhancement of Convective Heat Transfer of Shell and Tube Heat Exchanger using Nano fluids

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Abstract: *Aim is that the study of convective heat transfer of nanofluids with a base water in shell and tube type heat exchanger. The convective heat transfer rate is changes with the volume concentration. Heat transfer coefficient increases with increase in volume concentration. Different parameter are affect on the transfer rate in horizontal shell and tube type of heat exchanger like friction factor, viscosity, volume concentration etc. The convective heat transfer rate of nanofluids with base fluid is greater than the distilled water. And heat transfer efficiency is also improved by increasing thermal conductivity.*
Keywords: *Al_2O_3 nanofluid, Heat transfer, nanofluids, nanoparticles, shell & tube type heat exchanger*

I. Introduction

Nanofluids are defined as the particles of nanometer size normally less than 100 nm are suspended in the base fluid like water. Before nanoparticles revolution, liquids like water, ethylene glycol etc. are used for heat transfer and cooling purpose. But recent developments of modern technology instead of convectional fluids, nanofluids are use. There are various nanofluids available in industry such as water base Aluminum oxide, titanium dioxide, copper oxide; magnesium oxide etc. when nanoparticles are suspended into base liquid creates greater energy absorption than pure water at a low flow rate. In this project we are using Al2O3/water nanofluid with particle varying in the range of 0.01-0.3% which is circulating in the tube of 2mm internal diameter & 3mm outer diameter. By changing the concentration of nanofluid in base fluid we can control and achieve desired heat transfer rate. When nanoparticles are suspended in liquid they form the conductive bridge of nanoparticle which enhances the conduction as well as convection rate. When concentrations are change it increase the temperature difference and also increases the convective heat transfer rate. Greater temperature differences will occur by using nanofluids. For this experiment we are using the shell and tube heat exchanger which having water base Al2O3 and TiO2 are circulating in the tubes of heat exchanger. Because of its compact design we are using this heat exchanger. Also higher heat transfer rate is obtained by this type of heat exchanger than other type.Shell and Tube heat exchanger consist of outer casing in which the heated water is circulated called as shell and the nanofluid is pass through inner tubes, the baffle plates are used for supporting the tubes and to hold the heated water for more time in shell for greater heat transfer. There are 2 inlets and 2 outlets for water and nanofluid respectively. The pumps are used to pumping the nanofluids and water into shell and tubes. The thermometers or thermocouples are used for the temperature measurements at inlet and outlet respectively. Numbers of tubes used in the shell are affected on the heat transfer rate, while more number of tubes leads to more complex design but also leads in more heat transfer.

II. Problem Statement

Before the nanofluids micro fluids and convectional fluids are used for the heat transfer purpose. The micro fluid are the micro particle dispersion in base fluid but heat transfer difference between these fluids and water are not appreciable also heat exchanger was use is of convectional type which also leads in less heat transfer.

III. Objective

With the recent development in nanotechnology nowadays the nanofluids are used and also better design of heat exchanger is used for heat transfer applications.This idea of suspension of these nanoparticles in base fluid for improving thermal conductivity has been proposed recently. Due to their small size nanoparticles are fluidize easily in base fluid hence problem of clogging of channels & erosion in channel walls is avoided and these fluids used in micro channels also.

IV. Literature Review

Jaafar Albadr et.al, reports an experimental study on the convective heat transfer and flow characteristics of a nanofluid consisting of water and different volume concentrations of Al2O3 nanofluid (0.3–2) % flowing in a horizontal shell and tube heat exchanger counter flow under turbulent flow conditions are investigated. The Al2O3 nanoparticles of about 30 nm diameter are used in the present study. The results show that the convective heat transfer coefficient of nanofluid is slightly higher than that of the base liquid at same mass flow rate and at same inlet temperature. The heat transfer coefficient of the nanofluid increases with an increase in the mass flow rate, also the heat transfer coefficient increases with the increase of the volume concentration of the Al2O3 nanofluid, however increasing the volume concentration cause increase in the viscosity of the nanofluid leading to increase in friction factor. It consists of two flow loops, a heating unit to heat the nanofluid or the distilled water, and temperature measurement system. The two flow loops carries heated nanofluid or distilled water and the other cooling water.

Gabriela Huminic et.al, the purpose of this review summarizes the important published articles on the enhancement of the convection heat transfer in heat exchangers using nanofluids on two topics. The first section focuses on presenting the theoretical and experimental results for the effective thermal conductivity, viscosity and the Nusselt number reported by several authors. The second section concentrates on application of nanofluids in various types of heat exchangers: plate heat exchangers, shell and tube heat exchangers, compact heat exchangers and double pipe heat exchangers.JonathanCox et.al, proposed suspensions of nanoparticles (less than 100nm) in a base fluid, have shown enhanced heat transfer characteristics. In this study, thermal performances of nanofluids in industrial type heat exchangers are investigated. Three mass particle concentrations of 2%, 4%, and 6% of silicon dioxide–water (SiO2–water) nanofluids are formulated by dispersing 20 nm diameter nanoparticles in distilled water. Experiments are conducted to compare the overall heat transfer coefficient and pressure drop of water vs. nano fluids in laboratory-scale plate and shell-and-tube heat exchangers. Experimental results show both augmentation and deterioration of heat transfer coefficient for nanofluids depending on the flow rate and nano fluid concentration through the heat exchangers. The measured pressure drop while using nanofluids show an increase when compared to that of the base fluid which could limit the use of nanofluids in the industrial applications.

Manjunatha.k et.al, proposed ultrahigh performance cooling is one of the important needs of many industries. However, low thermal conductivity is a primary limitation in developing energy-efficient heat transfer fluids that are required for cooling purposes. Nanofluids are engineered by suspending nano particles with average sizes below 100 nm in heat transfer fluids such as water, oil, diesel, ethylene glycol, etc. Innovative heat transfer fluids are produced by suspending metallic or non-metallic nanometer-sized solid particles. Experiments have shown that nanofluids have substantial higher thermal conductivities compared to the base fluids. These suspended nanoparticles can change the transport and thermal properties of the base fluid. The aim of this project is to summarize recent developments in research on nanofluids, and to carry out cfd analysis for four different nano fluids and the result is analyzed, two fluids are selected for experimentation work and finally the experimented result is compared with the cfd results to draw out the conclusion.

K. Hamid, W. H. Azmi, studied experimental investigation of nanoparticle mixture ratios on TiO2-SiO2 nanofluids heat transfer performance under turbulent flow, in this the convection heat transfer experiment is conducted under the turbulent region with Reynolds number from 3000 to 24000. Five composite mixtures in volume percent of TiO2 and SiO2 nanoparticles are prepared with mixture ratios of 20:80, 40:60, 50:50, 60:40 and 80:20 for a constant volume concentration of 1.0%. The heat transfer performance and friction factor were evaluated for the bulk temperatures of 30, 50 and 70 degree Celsius. High performance was seen at a 40:60 mixture ratio with heat transfer enhancement of 35.32% at 70 degree Celsius.

V. Experimental Setup & Working

It consists of two flow loops, a heating unit to heat the nanofluids or the distilled water, and temperature measurement system. The two flow loops carries heated nanofluid or distilled water and the other cooling water. Each flow loop includes a pump with a flow meter and reservoirs. The shell and tube heat exchanger is of stainless steel type 316L, 250 mm long consisting 37 tubes and having internal diameter of shell is 70 mm and outer diameter is 72 mm. also having tubes with internal diameter of 2 mm and outer diameter 3 mm. The heated water is passing through shell and nanofluid are passing through tubes. The flow of water and nanofluid is counter flow.

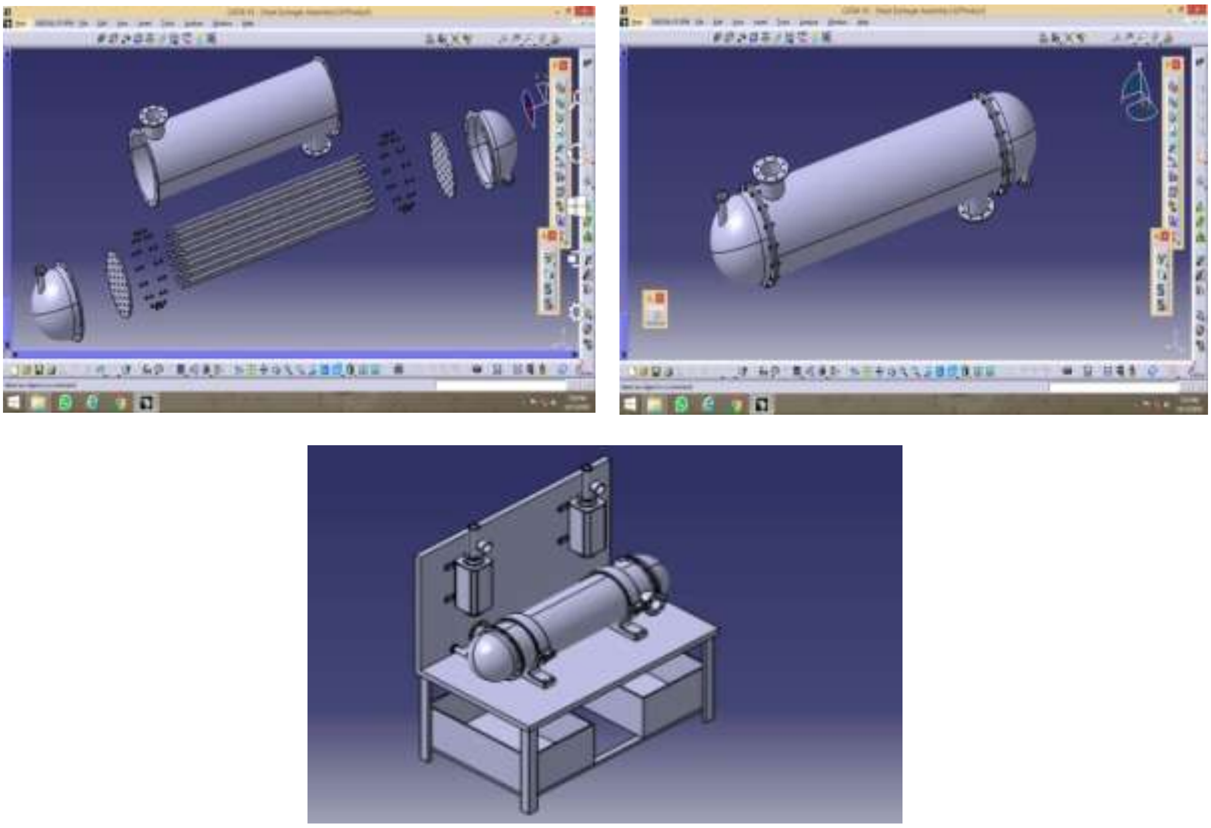

Fig.1 Catia Model

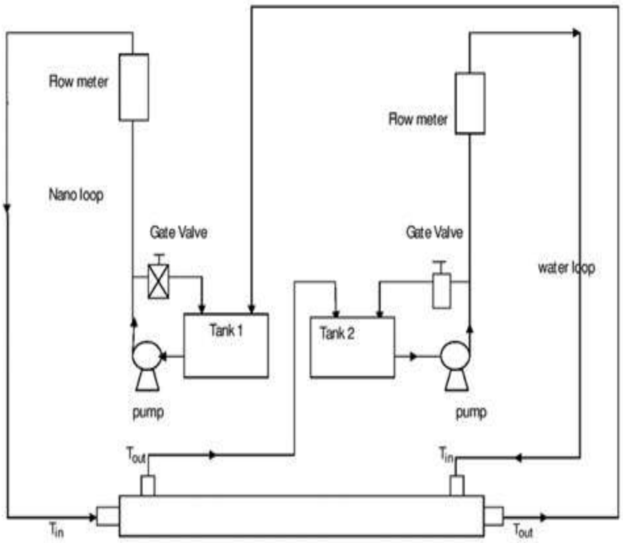

Fig.2 Experimental Setup

First we pass the distilled water from inner tubes of heat exchanger and hot water from shell and record the temperature difference at inlets and outlets. In the second stage we pass Al_2O_3 / water nanofluid varying with 2% volume concentration from the inner tubes and record the temperature difference at inlets and outlets after some period of time. At the last stage we pass the TiO_2 / water nanofluid varying with volume concentration of 2% from inner tubes of heat exchanger and record the temperature difference at inlets and outlets. We compare this two Al_2O_3 and TiO_2 nanofluids readings with distilled water and calculate the convective heat transfer rate and other parameters.

VI. Conclusion

Dispersion of nanoparticles into the distilled water increases the thermal conductivity and viscosity of the nanofluids. By using water- nanofluids gives significantly higher heat transfer characteristics than the distilled water. Also its overall heat transfer is approximately twice than distilled water. Friction factor of the fluids increases with increase in volume concentration. By using nanofluids we get maximum waste heat recovery. It improves the efficiency of plant.

Conflict of interest the authors declare that there is no conflict of interests regarding the publication of this paper.

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