IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 11, Issue 2 Ver. I (Mar- Apr. 2014), PP 29-33
www.iosrjournals.org

Application of Al_2O_3 Nanofluid for Enhance Heat Transfer Rate in Shell and Tube Heat Exchanger

Ramesh R[1*], Dr. R.Vivekananthan[2]
[1] ME. Thermal Engineering, [2] Assistant Professor*
Dept. of Mechanical Engineering, Government College of Engineering, Salem, Tamilnadu, India-636011

Abstract: *This project is to enhance the heat transfer rate of shell and tube heat exchanger in temperature process station by using Al_2O_3 nanofluid and Ethylene glycol. Al_2O_3 and copper nano particles are found to have good thermal conductivity for the heat transfer in shell and tube heat exchanger in Temperature process station. The presence of nano particles changes the flow structure so that besides of thermal conductivity increment in a temperature process station of heat exchanger. Al_2O_3 has been mixed with water as a base fluid to increase the heat transfer rate. The experimental and numerical investigation has to be performed and the results have been compared to validate the performance of the heat Exchanger.*
Keywords: *Al_2O_3 nanofluid, shell and tube heat exchanger, heat transfer, coolant, temperature process station.*

I. Introduction

Heat transfer is a process in which the heat energy is transfers from one medium to another medium due to temperature difference. The understanding of heat transfer is to analyzing a thermodynamic process, such as those that take place in heat engines and heat pumps. The heat transfer takes place in three modes namely, conduction, convection and radiation. Radiation can transfer heat through empty space, while the other two modes require some form of matter-on-matter contact for the heat transfer. Heat exchanger is a device built for efficient heat transfer from one medium to another, whether the media are separated by a solid wall so that they never mix, or the media are in direct contact. A mechanical device used to rapidly reduce the temperature of the worth. Heat exchangers find several industrial and engineering applications. The major difficulty in designing a heat exchanger is to make the equipment compact and high heat transfer rate with minimum pumping power. This exchanger is built of round tubes mounted in large cylindrical shells with the tube axis parallel to that of the shell. They are widely used as oil coolers or power condensers, pre-heaters in power plants and steam generators in nuclear industry application. Coaxial condensers and coaxial evaporators are used in refrigeration system. These exchangers are suitable for thermal expansion and clean fluids, because cleaning them is impossible. In parallel-flow heat exchangers, the two fluids enter the exchanger at the same end, and travel in parallel to one another to the other side.

1.2 NANOFLUID

This section reviewed the heat transfer characteristics of the nanofluid. Nanofluid is suspensions of metallic or nonmetallic nano powders in base liquid and can be employed to increase heat transfer rate in various applications. Traditional heat transfer fluids such as water, ethylene glycol and oil have inherently low thermal conductivity relative to metals and even metal oxides. Therefore, fluids with suspended solid particles are expected to have better heat transfer properties compared to conventional heat transfer fluids. Preparation of nano particles suspension is the first step in applying nanofluid for heat transfer enhancement. In the present study γ-Al_2O_3/water nanofluid was employed. Al_2O_3 nanoparticles with an average diameter of 20 nm were dispersed in water. In our study no dispersant or stabilizer was used. This is because of the fact that addition of any agent may change the fluid properties. The nanofluid with six different Al_2O_3 nanoparticle concentrations (0.2%, 0.5%, 1.0%, 1.5%, 2.0% and 2.5% volume fraction) were prepared and used to study enhanced heat transfer. Then the required mass of nanoparticles for Al_2O_3/water nanofluid suspension determined as follows,

$$m_s = 1 \times 10^{-3} \times \nu \times \rho_s$$

Where,

ρ_s - Nanoparticle density (kg/m^3)
ν - Nanoparticle volume fraction (%)

After preparing required volume of the powder, using the equivalent weight of the solid, nanoparticles were mixed with distilled water in a flask and then vibrated for 8–16 hr in ultrasonic mixer system. No sedimentation was observed for 0.2–2.5% volume suspension after 24 hr.

II. Experimental Setup

In manual mode of operation the Temperature control is made by built in OP-AMP based analog P controller technique. In manual mode V to I converter gets input from OP- AMP based P controller the process variable goes internally to the controller. In Auto mode V to I converter gets input from PID controller this input depends on set temperature & actual Temperature of the process operation controlled by Auto mode.

This equipment consists of centrifugal pump and reservoir. The water is pumped from a built in reservoir and return to the reservoir through control valve and the rotameter, Orifice plate with Differential Pressure Transmitter (DPT). The control valve only controls the rate of flow. The control valve gets the regulated pressure input from current to pressure converter (I to P). This in turn accepts the pressure input from air regulator (1.2kg\ cm^2 max) and it regulates the input pressure into the controller pressure output (3 to 15 psi), the regulated pressure output is proportional to the current input (4 to 20mA). The I to P converter gets current input from V to I converter. The V to I converter converts the voltage (0-5V) to the proportional current in terms of (4-20mA). The orifice plate and Temperature Transmitter is fixed in-between the process pipeline for feedback purpose. It gives the corresponding output voltage to the Temperature rate of water. The Al_2O_3/Water nanofluid is pumped into the heat exchanger for removing the heat from the refrigerant then it flows through the chiller unit for rejection of heat and store in the reservoir. For measurement Tb1 and Tb2 are measured from the temperature indicator, for desired Tw (working temperature of the heat exchanger), which is Tw1 and Tw2. The flow rate is controlled and measured by using Labview software. The heat transfer data is calculated for desire range of the flow rate for distilled water initially and nanofluid with different volume fraction separately. The Fig.1 as shows the experimental setup.

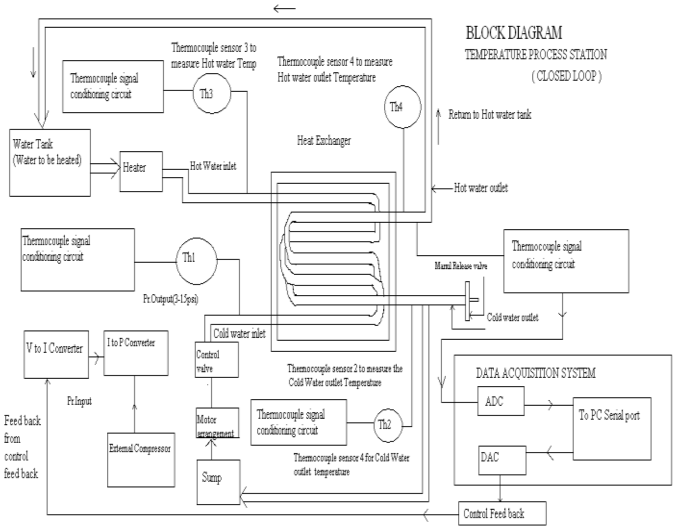

Fig.1. Schematic diagram of experimental setup

Experimental setup

III. Results And Discussions

3.1 Results for Ethylene glycol

Experiments were performed for a wide range of mass flow rate to the Ethylene glycol. Experimental results for Ethylene glycol shell and heat exchanger are shown in Fig.2

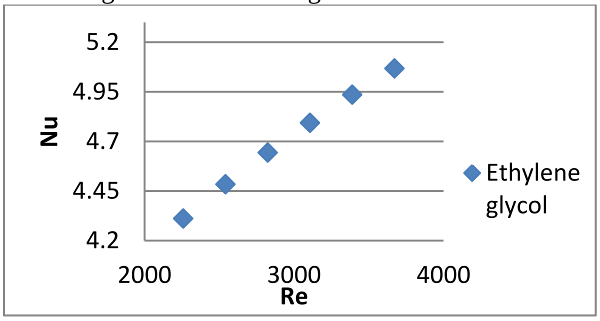

Fig.2. Nusselt number variations to the Reynolds number.

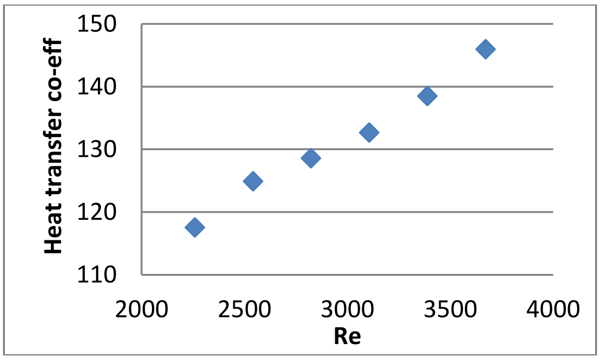

Fig.3. Heat transfer co-efficient to the Reynolds number.

3.2 Standard Correlations for Al_2O_3/Water Nanofluid

The results for Al_2O_3/water nanofluid are calculated from the Seider-Tate correlation for laminar flow which is shown in the Fig. shows the results of Al_2O_3/water nanofluid.

The Nusselt number variation to the Reynolds number is shown in the Fig.4. The Nusselt number variation to the Prandtl number is shown in the Fig. 5.

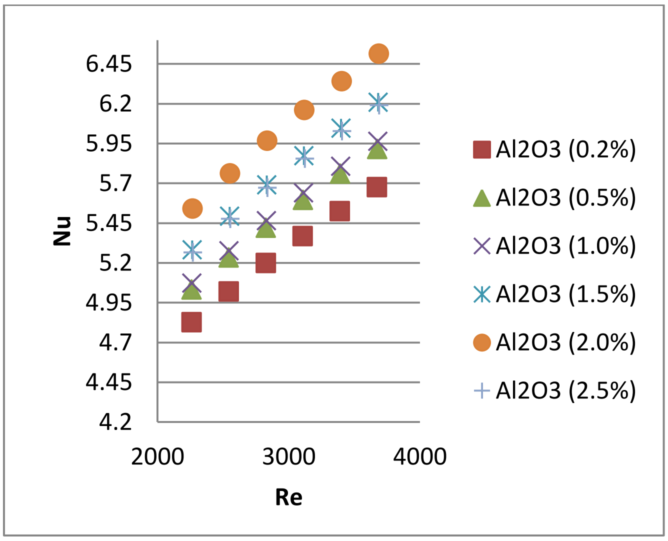

Fig.4. The Nusselt number variation to the Reynolds number for Al_2O_3 nanofluid.

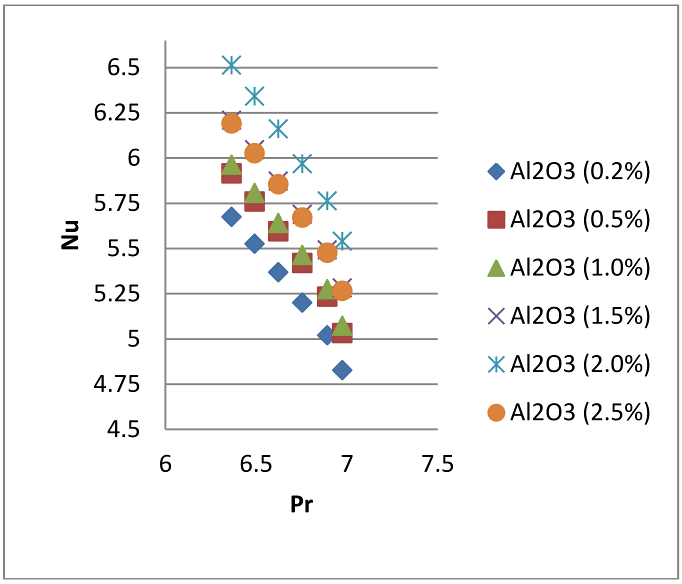

Fig. 5. The Nusselt number variations to the Prandtl number for Al_2O_3 nanofluid.

From the figures it is observed that, the Nusselt number is increases with increase in Reynolds number but increment in Nusselt number is higher than the Ethylene glycol and Nusselt number deceases with increase in Prandtl number. This is because of increasing thermal conductivity of the fluid and particle size.

3.3 Volume Fraction of Al_2O_3 Nanoparticle

Comparison between the Al_2O_3/water nanofluid and the Ethylene glycol is shown in the Fig.6.

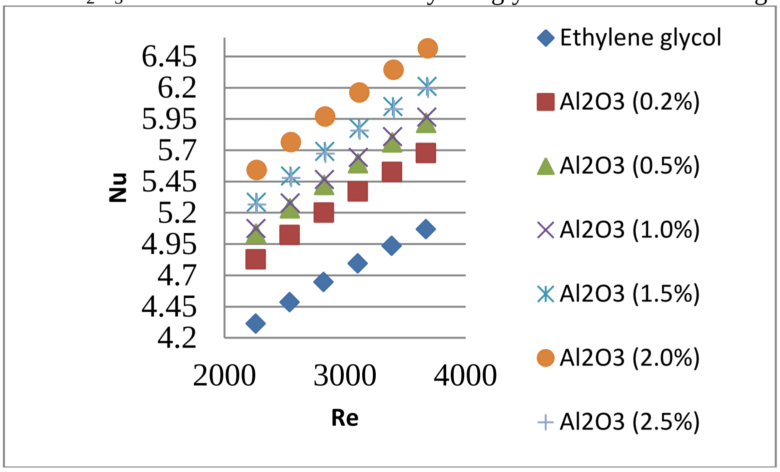

Fig.6. Comparison between Al_2O_3/water nanofluid and Ethylene glycol.

From the figure it is study that Nusselt number of Al_2O_3/water nanofluid is much better than the Ethylene glycol.

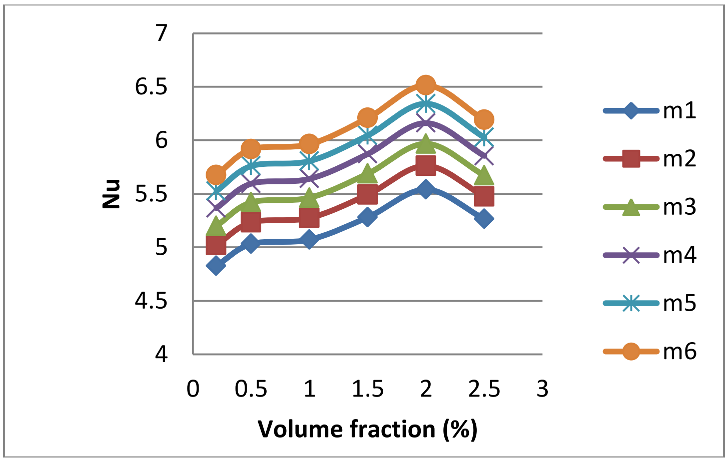

Fig.7. The increment in Nusselt number to the volume fraction of the Al_2O_3 nanoparticle in base fluid

The volume fraction of Al_2O_3 nanoparticle is plays a major role in increment of heat transfer rate. The Fig.7 shows the increment in Nusselt number to the volume fraction of the Al_2O_3 nanoparticle in base fluid. The Fig.8 shows the percentage increase in Nusselt number to the volume fraction of the Al_2O_3 nanoparticle in base fluid.

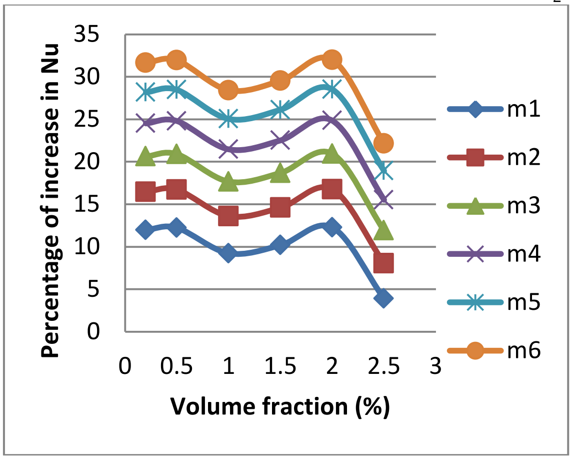

Fig.8. The percentage increase in Nusselt number to the volume fraction of the Al_2O_3 nanoparticle in base fluid.

IV. Conclusion

Experimental results emphasize the enhancement of heat transfer due to the Al_2O_3 nanoparticles presence in the fluid. Heat transfer coefficient increases by increasing the concentration of nanoparticles in nanofluid up to certain level. At 2% volume fraction Nusselt number increases up to 30% for different Reynolds number. To interpret the experimental results and deviation from the experiment equations it should be noted that enhancement of heat transfer greatly depends on particle type, particle size, base fluid, flow regime and specially boundary condition. The presence of Al_2O_3 nanoparticles in fluid changes the flow structure so that besides of thermal conductivity increment, chaotic movements, dispersions and fluctuations of nanoparticles especially near the tube wall leads to increase in the energy exchange rates and augments heat transfer rate between the fluid and the tube wall. The increase in heat transfer coefficient due to presence of Al_2O_3 nanoparticles is much higher than the conventional fluids and hence the shell and tube heat exchanger using nanofluid as a coolant has higher heat transfer rate than the conventional shell and tube heat exchanger.

References

[1] Choi S.U.S., (1995) 'Enhancing thermal conductivity of fluid with nanoparticles'. In: Siginer D.A., Wang H.P. (Eds.), Developments and Applications of Non-Newtonian Flows, FED-V.231/ MD-V.66. ASME, New York, pp. 99–105.
[2] Das S.K., Putra N., Roetzel W., (2003) 'Pool boiling characteristics of nano-fluids'. International Journal of Heat and Mass Transfer 46, 851–862.
[3] Das S.K., Putra N., Roetzel W., (2003) 'Pool boiling of nano-fluids on horizontal narrow tubes'. International Journal of Multi Phase Flow 29, 1237–1247.
[4] Das S.K., Putra N., Roetzel W., (2006) 'Pool boiling characteristics of nano-fluids'. International Journal of Heat and Mass Transfer 27, 3–19.
[5] Ding Y., Wen D., (2005) 'Particle migration in a flow of nanoparticle suspensions' Powder Technology 149, 84–92.
[6] Eastman J.A., Choi S.U.S., Li S., Yu W., Thompson L.J., (2001) 'Anomalously increased effective thermal conductivities of ethylene glycol-based nanofluids containing copper nanoparticles'. Applied Physics Letters 78, 718–720.
[7] Eastman J.A., Choi S.U.S., Li S., Yu W., Thompson L.J., (1998) 'Anomalously increased effective thermal conductivities of ethylene glycol-based nanofluids containing copper nanoparticles'. Applied Physics Letters 67, 518–527.
[8] Hamilton R.L., Crosser O.K., (1962) ;Thermal conductivity of heterogeneous two component systems'. I & Ec Fundamentals 1, 187.
[9] Hundy G.F., Trott A.R., Welch T.C., (2005), "Air Conditioning And Refrigeration". International journal of refrigeration 24, 73-87.
[10] Keblinski P., Phillpot S.R., Choi S.U.S., Eastman J.A., (2002) 'Mechanism of heat flow in suspension of nano-sized particle (nanofluids)'. International Journal of Heat Mass Transfer 45, 855–863.
[11] Khaled A.R.A., Vafai K., (2005) 'Heat transfer enhancement through control of thermal dispersion effects'. International Journal of Heat and Mass Transfer 48, 2172.
[12] Lee S., Choi S.U.S., Li S., Eastman J.A., (1999) 'Measuring thermal conductivity of fluids containing oxide nanoparticles', J. Heat Transfer 121 280–289.
[13] M. Raja A*, R.M. Arunachalam B And S. Suresh C Experimental Studies On Heat Transfer Of Alumina /Water Nanofluid In A Shell And Tube Heat Exchanger With Wire Coil Insert (IJMME), Vol. 7 (2012), No. 1, 16–23.