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Experimental study of heat transfer enhancement in triple tube heat exchanger with CuO & Al_2O_3 Nano fluids

G. V. Wafelkar[1], A. H. Raut[2]

[1]*PG Student, Department of Mechanical Engineering, DYPSOE Ambi (Pune), Maharashtra, India*
[2]Professor, *Department of Mechanical Engineering, DYPSOE Ambi (Pune), Maharashtra, India*

Abstract - *The experimental study is carried out on triple tube heat exchanger by using fresh water as working fluid. Advantages to use the triple tube heat exchanger are to make the overall design compact and increase the productivity per unit time. Also the triple tube heat exchanger provides larger heat transfer area per unit length.. To improve the effectiveness dimples have been made on the intermediate tube. Hot water with temperature range 40˚C to 53˚C will flow through the intermediate annulus area while cold fluid with temperature range of 28 ˚C to 32 ˚C will flow through the inner tube and outer annular space. The experimental investigation is carried to determine the effectiveness of triple tube heat exchanger. Important part of this study is use of Nano fluids with base fluid. CuO & Al2O3 are two Nano fluids are used for the study with 0.033% volumetric concentration. These Nano fluids are mixed with hot fluids. Experimental investigation is carried out for different flow rate of hot fluid. The flow rate of cold fluid is kept constant that is 420 LPH. Comparative results are plotted for CuO & Al_2O_3 nano fluids. Relationship between different performance parameters such as Nusselt number, and Heat exchanger effectiveness also presented.*

Key Words: triple tube, nano fluids, hot fluid, Nusselt number, effectiveness

1. INTRODUCTION

With increased concern for conservation of energy, there has been steady and continuous increase in research and improvement in heat exchangers design and performance. it is required to improve the effectiveness and compactness of double pipe heat exchanger which used in different products such as dairy, solar equipment's, and pharmaceutical industries. A improved version of double pipe heat exchanger is developed to remove the limitations of double pipe heat exchanger is called triple concentric tube heat exchanger. It increases the productivity per unit time.
In this type of heat exchanger one additional passage is provided for the fluid flow. Due to this there is increased surface area contact which will ultimately increase the heat transfer rate. Disturbance to fluid flow will create the turbulence in the flow. Due to turbulence created the heat transfer rate will also increase. Two dimples are introduced to enhance the heat transfer. Size of Nano fluids are less than 100 nm. Enrichment of a base fluid like Water, Ethylene glycol or oil with nano particles in different types like Metals, Oxides, Carbides, Carbon. Mostly generally used Nano fluids are as TiO2 in water, CuO in water, Al2O3 in water, ZnO in Ethylene glycol. By mixing Nano fluids with base fluid, thermal conductivity will increase. Experimental study is carried out to find the effectiveness of triple tube heat exchanger with and without nano fluids.

2. LITERATURE REVIEW

Experimental study of triple tube heat exchanger reveals that various factors are affecting the performance of triple tube heat exchanger. Considerable amount of saving of space & material in this type heat exchanger. Heat transfer rate are greatly affected by number of fins, fin length and fin thickness. (Dharmikumar A. Patel, *et al,* 2014) [1].
An experimental study on triple U tube heat exchanger. It is conclude from the experimentation is that heat performance of triple U tube heat exchanger is greater than conventional model. The model is compact & unique one. The implementation of U tube in double pipe heat exchanger improve the performance is found. (N. R. Parthasarathy, *et al,* 2015) [2].

In this research article, experimental tests was conducted on a new wood-based air-heating system for energy-efficient dwellings are presented. The main objective is to determine the resulting outlet temperatures and the amount of heat recovered by the ventilation air in order to assess feasibility and performance of coupling a mechanical ventilation heat-recovery unit and a triple concentric tube heat exchanger integrated into the chimney of a room-sealed wood-pellet stove to heat an entire house. After introducing the context of this work, the three main components of the combined system developed here, the coupling configuration adopted, as well as the protocol used and the sensors implemented on an experimental setup carried out in a laboratory are detailed in turn. Then, the heat transfer rates obtained from experimentation for the various fluids and effectiveness of the heat exchangers are presented & discussed (Pierre Peigné *et al,* 2013) [3]

Studies demonstrate that nano fluids based on metal oxide nanoparticles have physical properties that characterize them as important fluids, mainly, in industrial area in which high heat flux is there. Water based nano fluids of Al2O3 and ZrO2 were characterized regarding its promising use in different applications. Three different concentrations of dispersed solutions of cited nano fluids were prepared

(0.01% vol., 0.05% vol., and 0.1% vol.) from commercial nano fluids. Experimental measurements were carried out at different temperatures. Thermal conductivity, viscosity and density of the prepared nano fluids were measured (Marcelo S. Rocha *et al) [4]*.

Experimental investigations of heat transfer coefficient of CuO/Water nano fluid are reported in this article. The coefficient of heat transfer coefficient of the CuO/water was determined with the help of double pipe heat exchanger. The nano fluid was prepared by mixing a CuO nano particle in deionized water. CuO/water nano fluid with a nominal diameter of 27nm at different volume concentrations (0.1 &0.3 vol.%) at room temperature were used for this investigations. This experimental result conclude that the convective heat transfer coefficient increases with an increase in time. The Nusselt number also increases with increasing the flow rate of fluid (S. Senthilraja, *et al*) [5].
There has been increasing interest in nano fluid and its use in heat transfer enhancement. Nano fluids are suspensions of nanoparticles in fluids that show measurable enhancement in their properties at optimum nano particle concentrations. Nano fluids are quasi single phase medium containing stable colloidal dispersion of ultrafine or Nano metric metallic or ceramic particles in a given fluid. This article covers recent advances in the last decade by researchers in heat transfer enhancement with nano fluids as the working fluid. A brief overview has been presented to understand the evolution of this concept, possible mechanism of heat conduction by nano fluid and areas of application. In order to put the nano fluid heat transfer technologies into practice, fundamental studies are greatly needed to understand the physical mechanisms (B. N. Kharad, *et al*) [6].

3. EXPERIMENTAL SET UP

Experimental setup comprises of 3 tubes which are concentrically fitted into each other.

Table -1: Specification of Triple tube heat exchanger

Tube No.	Material	Inner Diameter (mm)	Outer Diameter (mm)	Length (mm)
1	Copper	16	19	850
2	Aluminum	32	38	750

For the flow measurement 3 Rota-meters (Acrylic, 0-600LPH) are used for 3 concentric tubes for control over discharge. Two separate tank for hot water and cold water of capacity of each 64 liter. Two pumps along geyser is used to heat the water.

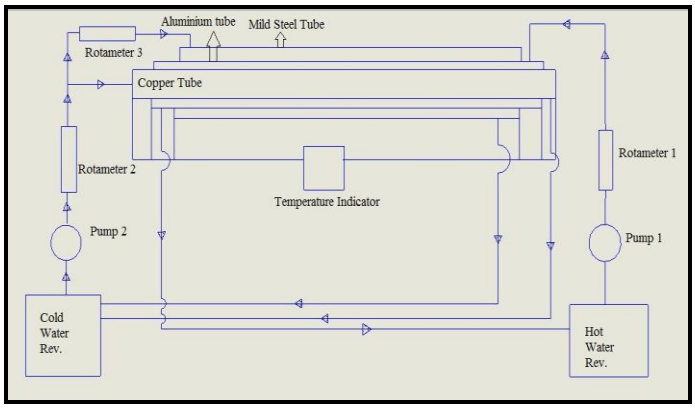

Fig -1: Block diagram of setup

Temperature was measured at six positions that is inlet and outlet of each tube & are connected to the temperature indicator. At various position brass valves are provided to adjust in the tubes whose measurement is done through Rota-meters. Also there is bypass to both pump provided with a valve so that low flow can be obtained by adjusting the bypass valve.

Fig -2: Actual experimental setup

3. EXPERIMENTAL PROCEDURE

Hot and cold water are stored in reservoir at certain temperature. Hot water is made to flow through the geyser through pump because of which it gets heated. In similar way cold water flow through the assembly of heat exchanger till the steady state is achieved. Water starts to drain into collecting tank and simultaneously temperature readings at respective inlet and outlet openings are taken. mass flow rate for cold fluid constant and vary mass flow rate for hot water. To record water inlet and outlet temperature for both hot water & cold water only after temperature of both the fluids attains a constant value. To repeat the procedure for different hot water flow rates ranging from 240 LPH TO 4200 and mass flow rate of cold fluid is 420 LPH.

The readings are taken by fixing the cold fluid flow and varying the hot fluid flow. Flow rates for cold fluid are taken as 420 LPH and Hot fluid flow rates are 240,300,360,420 LPH. The nano particles are mixed with hot fluid & readings are taken for plain water, 0.033 vol % of CuO & Al_2O_3.

3. RESULT & DISCUSSION

For various combination of flow rates of hot fluid keeping flow rate of cold fluid constant observations are noted & different comparative results are plotted.

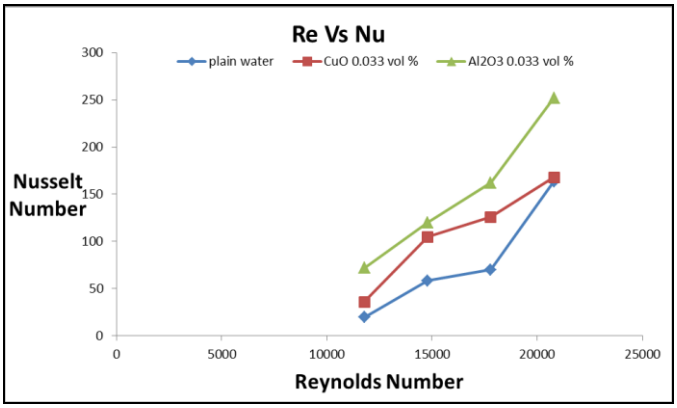

Chart -1: Reynolds number Vs Nusselt number

Chart shows that comparison of Nusselt Number and Reynolds number for different Nano fluids .This study gives the best Nano fluid for using enhancement of heat transfer or increasing convective heat transfer coefficient of tube side at same Reynolds number. The effect of Nano fluid Al_2O_3 at high Reynolds number gives higher Nusselt number because high specific heat and thermal conductivity. Hence Al_2O_3 *is* the best Nano fluid for the passive heat transfer techniques and also reduce the pumping power.

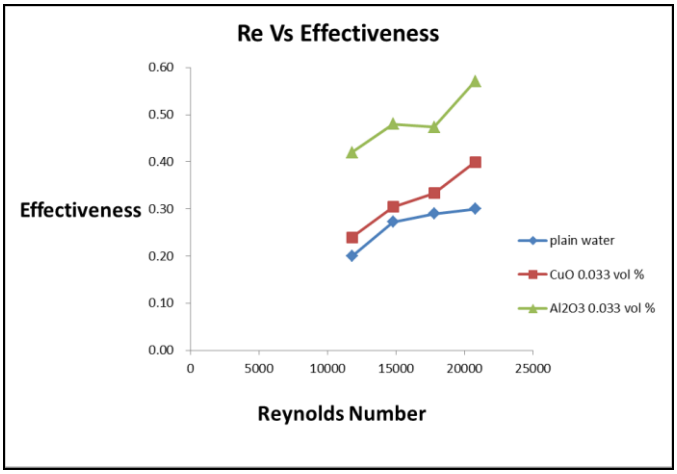

Chart -2: Reynolds number Vs Effectiveness

Above chart shows comparison between plain water, CuO with volumetric concentration 0.033%, Al_2O_3 with volumetric concentration 0.033%. As graph shows the effectiveness is increases respectively. But copper Oxide Nano particle were expensive and give less effectiveness as compare to Aluminum Oxide. While Aluminum Oxide gives maximum effectiveness at volumetric concentration 0.033%.

3.CONCLUSIONS

The effects of the augmentation techniques on the heat transfer enhancement and friction factor behaviors in turbulent flow regimes (2000 <Re <20000) are described. The triple tube HEX with Nano fluids at same temperatures and different hot fluid flow rates are tested using the water as the hot working fluid and other is cold water. The conclusions are drawn as follows:

- For increase of the hot fluid flow rate, increase in heat transfer coefficient and Nusselt number. Also little effect of dimple tube over the heat transfer enhancement.
- Nusselt number of the flow also increases from 20 to 252 for Aluminum oxide nano fluid for concentrations 0.016 to 0.033%.
- The performance ratios of nano fluid at 0.033 % are maximum than any other concentrations in the flow range of 11800 to 28000. This gives most economical solution for use of Aluminum oxide - water nano fluid in heat transfer application.

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