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Experimental Analysis of Cu Nano fluids in Shell and Tube Heat Exchanger

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Abstract: **-- Heat transfer in industrial sectors plays a phenomenal role, if the heat transfer enhancement is more which will increase the performance and life span of heat transfer devices. In fluid case the transfer of heat will done by convection process. This work presents an experimental study on the heat transfer of CuO /water Nano fluid flowing through the shell and tube heat exchangers under laminar flow conditions. Effects of important parameters such as hot and cold mass flow rates, temperature, Nano fluid temperature, Nano fluids mass flow rates and Nano fluid concentration on the heat transfer characteristics are investigated in fabricated shell and tube heat exchanger. The results outcome explains the heat transfer of Nano fluids in the exchanger produces the higher value than those of distilled water**

Keywords: Shell and tube heat exchanger, CuO nanoparticles, Cu Nano fluids, volume concentration, and heat transferrate.

I. INTRODUCTION

In the intercoolers, boilers, condensers etc., inside the power producing plants the heat exchanger are widely used for controlling the heat energy. Heat exchanger is a device that regulates the efficient heat transfer from one fluid to another fluid by convection process. And also it plays a major role in chemical process techniques which can simultaneously concentrate on both the energy released and heat transfer. The design parameters for shell and tube heat exchanger explains the various considerations such as process of fluid flow, selection of temperature for shell and tube side, mass flow rates, velocities in tube side etc. in terms of thermal aspects and in part of mechanical side such as tube side pitch, thickness of tube, diameter of the tube, length of the tube and shell. Side thickness, baffles spacing, thermal conductivity of the material [1]. The fluids are separated by a heat transfer surface in heat exchanger and they do not mix or leak inside the device because of flowing of fluid on the tube with the baffle between shell top surface and tube bundle and simultaneously it will increase the heat transfer by creating vortex flow of fluid between the shell inner side and tube bundle in the exchanger [2]. By seeing in this aspect, using of accustomed fluids such as water, oil etc, and addition of solid nanosized particles of metallic, non-metallic in the fluids which results in the intensification of heat transfer. The research work based on dispersing the nanoparticles in base fluid was first implemented by choi [et al].The preparation of various nanofluids by ultra-sonication for 60 minutes and results are tabulated with respect to stability, thermal conductivity, addition of surfactant etc. and more volume concentration of nanoparticles (1, 3, and 5) in base fluid conveys maximum enhancement in thermal conductivity such as 18%, 28%, 31%. Based on the stability of Nano fluids it can be suggested for application purpose [3]. The discussions based on the one step Institute method for various Nano fluids and mentioned their thermo physical properties such as thermal conductivity viscosity and percentage enhancement in conductivity, such that it reveals the heat transfer intensification in various applications [4]. Enhancement in heat transfer by tabulator and with Nano fluid with respect to increase in Nussle's number and also he derives the conclusion that higher volume concentration of nanoparticles in base fluids will intensify the thermal conductivity and out of all heat transfer also ignite to max percentage to those of pure water [5]. Nano fluids preparation by two step method that is purchasing of nanoparticles and then directly dispersing in the base fluid was studied under various concentrations such as 0.15% to 5% and then the thermal conductivity values ranging from 1.012 to 1.15 W/mk [6]. Based on the above literature studies, this present work present the design, fabrication of shell and tube heat exchanger, preparation of CuO Nano fluids by two step method , then the experimental analysis is done for two cases such as (i) hot and cold water

(ii) Hot water and Nano fluids. Finally the results are tabulated for the two cases and enhancement of overall heat transfer is reported.

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II. EXPERIMENTAL DETAILS

2.1 Design and Fabrication:

Initial design was started from calculating the flow of water manually in the tube side and from the mass flow rate was taken by collecting litre of water in beaker with respect to time manually (l/s= kg/s) such that the velocities are calculated in m/s.

Heat exchanger with 3/4" inch in diameter 12 no's of copper tubes with thermal conductivity (390 W/mk) was constructed as tube bundle in the shell and it is made up of cast iron type ERW. The tube was arranged like top 6 no's and bottom 6 no's such it defines the one shell and two pass counter flow arrangement. Tubes are arranged in hemispherical format of 180 degree. Baffle is made up of mild steel with 5 mm in thickness with 50mm of 11 no's pitch with respect to total distance of shell 1.1m.The upper set of 6 tubes are fixed in the baffles from shell inner side of circumference to the end of the upper side of tube bundle and another from the lower middle of the tube bundle to the bottom side of shell inner side. Distance between the baffles is to be arrived from various studies as 5cm interval. So that the flow can be achieved in zigzag path and heat transfer attained is more. J type thermocouple product is used for measuring the temperature in both inlet and outlet. Heater is maintained at 60ċ for shell side inlet for both case as mentioned and for 33ċ for 1st case tube inlet, 29ċ for 2nd case tube inlet. Experimental analysis is done by controlling the valves by manually 25% 50% 100%. Shell and tube heat exchanger image was shown in image files.

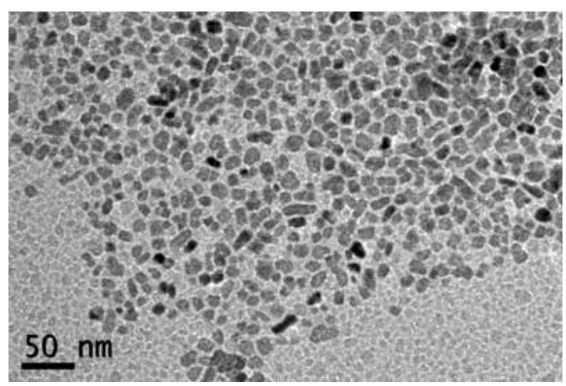
2.2 Preparation of CuO Nano fluids by two step method:

The CuO nanoparticles were purchased from the Nano wings, R&D lab in Andhra Pradesh of average particle size (50 nm) of purity 99. %. The procedure starts from dispersing CuO nanoparticles according to volume concentration in base fluid water. The magnetic stirring is used for initial dispersion of nanoparticles in water. After the magnetic stirring is done for 10 minutes, the probe type ultra-sonication is done for prepared Nano fluid solution for 30 minutes [3, 5and 6]. Finally the solution has to be check for the stability. After more observation the prepared Nano fluid got good stability and it can be for the experimental work and no surfactant is used.

A. Magnetic stirring of CuO nanofluids

B. Ultra-sonication of CuO nanofluids

C. SEM image of CuO nanoparticles



2.3 Procedure for Experimental Analysis:

For 1st case the consideration for shell side the fluid is hot water and for the tube side cold water. The exchanger is place in the frame below and the two tanks which provide the gravity feed for shell side fluid and cold side fluid separately. The heating is done for the shell side water for about 60ċ and cold fluid is maintained at room temperature. Then the valves in the tanks is opened simultaneously for both shell and tube side flow. After few seconds the mass flow rates have calculated and temperature at two inlets and two outlets are noted. For 2nd case the only different is for tube side the cold fluid will take as nanofluid which was prepared. The same procedure is followed and mass flow rates and four temperatures are noted. The readings are noted separately in tabulation.

Experimental arrangement of heat exchanger:

2.4. Formula used for calculation:

Q heat transfer rate

$$Q = \dot{m}cp\Delta T$$

h can found by given below formula

$$Q = hA\Delta T$$

Where $A = \pi dl$

$$\Delta T_{LMTD} = \Delta T1 - \Delta T2/\ln(\Delta T1/\Delta T2)$$

$$\Delta T1 = T_{hin} - T_{Cout}$$

$\Delta T2 = T_{hout} - Tc_{in}$

Non-dimension parameter as follows:

Reynolds number

$$Re = \rho vD/\mu$$

Nussle Number

$$Nu = hd/k$$

PrandtlNumber

$$Pr = \mu Cp/k$$

3. Results and Discussions:

Tabulation 1: For hot and cold water

Sample	T_1 (ċ)	T_2 (ċ)	t_1 (ċ)	t_2 (ċ)	LMTD (ċ)
water	60	52	32	39	20.61
water	60	50	34	42	17.09
water	60	46	37	44	12.16

With three different mass flow rates the above readings are taken for both hot and cold fluids.

Tabulation 2: Hot water Vs CuO nanofluid

Sample	T_1 (ċ)	T_2 (ċ)	t_1 (ċ)	t_2 (ċ)	LMTD (ċ)
1	60	52	27	33	26.32
2	60	50	29	37	22.223
3	60	46	31	41	17.014

The above readings are also taken from three different mass flow rates for both hot water and cold nanofluid.

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Tabulation 3: Regarding Q, U and Efficiency for only one mass flow rate considered for both case

Sample	Q (watts)	h(heat transfer) (W/m^{2}ċ)	Efficiency (%)
1st case	301.67	394.26	---
2nd case	410.78	524.72	25.23%

III. CONCLUSION

The performance of heat exchanger was evaluated by both normal water and nanofluid by dividing into two cases. The CuO nanofluid was prepared by two step method without any surfactant sounds good stability. The prepared CuO nanofluid solution for 100 ml was added to total amount required for flow analysis in heat exchanger by different concentration. As a result looking into the heat transfer part, nanofluid usage in heat exchanger found to be 25.23% greater than water.

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