SIMULATION OF DOUBLE PIPE HEAT EXCHANGER FOR INCREASE THE HEAT TRANSFER RATE

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Abstract : Abstract : The working fluid is water at atmospheric pressure. Hot water is supplied to the inner tube stream by using hot water pump. Cold water is being circulated in the annular space of double pipe heat exchanger through gravity pressure by using over head water tank. In this paper, effort on design & development of double pipe heat exchanger and experimental obtained results are validated with results obtained by CFD analysis. Experimental results are found in good agreement with results obtained from CFD in counter fluid flow arrangement.

IndexTerms - Double pipe Heat exchanger, CFD, Mass flow rate, Heat transfer coefficient, overall heat transfer.

1.Introduction

Function of heat exchanger is to transfer thermal energy between two or more fluids, between a solid surface and a fluid, or between solid particulates and a fluid, at different temperature and a thermal contact. Major objective may be to recover or reject heat, or sterilize, pasteurize, distill, concentrate, or control a process fluid. In few heat exchangers, the fluids exchanging heat are in direct contact. In most heat exchangers, heat transfer between fluids takes place through a separating wall in a transient manner. In many heat exchangers, the fluids are separating by a heat transfer surface, and ideally they do not mix each other. Such heat exchangers are referred as direct transfer type, or simply recuperate. In contract, exchanger in which there is intermittent heat exchanger between the hot and cold fluids via thermal energy storage and release through the exchanger surface are referred to as indirect transfer type, or simply regenerators. Such exchangers usually have fluid leakage from one fluid stream to other, due to pressure differences value switching. The common examples of heat exchanger, are shell and tube exchangers, automobile radiators, condensers, evaporator, air pre-heaters, and cooling towers in the industries. If no phase change occurs in any of the fluids in the exchanger, it is sometimes referred to as a sensible heat exchanger. There could be internal thermal energy sources in the exchangers such as in electric heaters and nuclear fuel elements. Combustion and chemical reaction may take place within the exchanger, such as in boilers, fired heaters, and fluidized bed exchanger. Mechanical device may be used in some exchanger such as in scraped surface exchanger, agitated vessels, and stirred tank reactors. Heat transfer in the separating wall takes place by conduction. However, in a heat pipe heat exchanger, the heat pipe not only acts as a separating wall, but also facilitates the transfer of heat by condensation, evaporation, and conduction of the working fluid inside the heat pipe. Usually, there is no moving part in a double pile heat exchanger.

Regarding pressure problem occurs that parameters which increase the heat transfer also increases the pressure drop of the fluid flowing in a pipe which increases the cost of pumping the fluid. Therefore, design of heat exchanger which increases the heat transferred, but simultaneously could keep the pressure drop of the fluid flowing in the pipes to permissible limits, is very necessary. A common problem in industries is to extract maximum heat from a utility stream coming out of a particular process. Traditional design method of heat exchangers involves the consideration of all the design variables with a laborious procedure of trial and error, taking all possible variations into consideration. Though this time consuming procedure reduced somewhat by making some reasonable assumptions as described by Peters & Timmerhaus [1]. But still no convenient method has been developed for optimal design of double pipe heat exchangers. In other optimum design methods, such as Lagrange multiplier method, the optimum results are again obtained in a long time by changing one variable at a time and using a trial-error or a graphical method. Soylemez [2] has focused on optimizing the area of the heat exchanger irrespective of the different flow rates of the utility that can be used. Using this pressure drop is not minimized to the fullest extent. This fact can be avoided through the design method discussed in the paper. They have considered the design of a double pipe heat exchanger in which its cost is optimized by considering three main parameters – the inner and outer diameter of the heat exchanger and the flow rate of the utility. The design of heat exchanger has been formulated as a geometric programming with a single degree of difficulty. It is assumed that the flow rate, the inlet and the required outlet temperature of the process fluid and the inlet temperature of the utility are known for the specific design of heat exchanger.

2.Design & Development of Double Pipe Heat Exchanger.

In order to study the heat transfer rate, heat transfer coefficient and pressure drop on large tube side for transient flow in a double pipe heat exchanger, a fully instrumented experimental setup is developed. The schematic of the experiment system is shown in Fig. 1. The experiment system has two cycles, i.e., hot water cycle and cold water cycle. M.S tank was prepared for capacity required water storage of approx 500 liter. Entire tank is covered with standard insulating material. To heat the water tank, four numbers of electric heaters capacities of 1.5 kW are used. To maintain uniform temperature of hot water tank a mechanical stirrer was used. Hot water is circulated in the small tube-side by pump to conduct the heat exchange process. Then after transfer heat in the double pipe heat exchanger, and finally collected in separate water tank. The water is heated up around 87°C thermostatically and maintained at that temperature in reservoir on small tube side. The mass flow rate of hot water can be adjusted by the flow control valve. For the cold water cycle, the pipe line is directly connected to the system from the over head water tank, which passes through the annulus area of the double pipe heat exchanger. The mass flow rate of water is also adjusted by the flow control valve of double pipe heat exchanger as shown in Fig.1. To record the temperature at various point. Five RTD temperature sensors are used in double pipe heat exchanger at inlet and outlet flow of DPHE. This temperature gradient shows us the amount of heat transfer taking place with the concentric tube in tube heat exchanger. Temperature scanner is also used to measure temperature during the experimentations. The flow measurement of water in the double pipe heat exchanger setup, an orifice meter is designed & fitted. Pressure across the orifice is recoded through U-tube manometer. For calibration of orifice meter high standard rotameter has been used. Schematic view of experimental setup of DPHE is show in Fig.1. Two different diameter (small tube 1 inch & large tube 2 inch) of pipe has length two meter concentrically fabricated by Gas welding process. For inner tube stainless steel material has been used for hot water circulation. The outer tube is selected of G.I material for cold water circulation. There are four control valves are used for varying the flow rates.

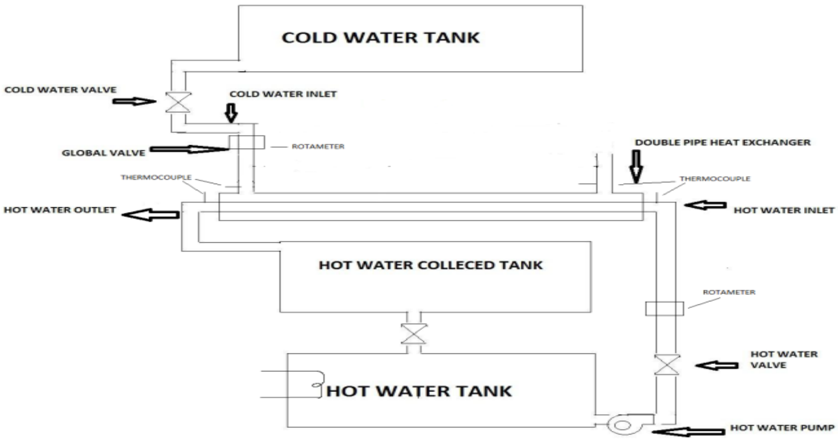

Fig.1. Layout of double pipe heat exchanger

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3.Result & Discussion

Various sets of experiment are performed on developed DPHE experimental set up. Hot water flow is circulated through inner tube with help of hot water pump. Hot water control valve is used for varying the mass flow rate. Atmospheric cold water is circulating through large tube of DPHE with constant flow rate. The numerical simulation is performed with dimensional, steady state, turbulent flow system; segregated solver and standard k-e model are employed. Sieder and Tate [3] heat transfer coefficient relationship are used.

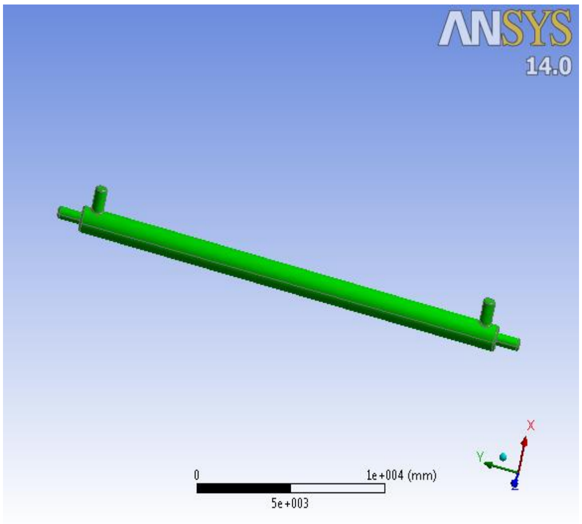
Hot fluid is on the tube side, cold fluid is on the shell side

The log mean temperature difference is set up for current flow 1000 LPH

PARAMETERS				
Inside Pipe Thermal Conductivity	kp	80	W m^{-1}K^{-1}	
		Hot Fluid	Cold Fluid	
Inlet Temperature	T_{in}	63	30	C
Outlet Temperature	T_{out}	53	38	C
Thermal Conductivity	k	0.65	0.628	W m^{-1}K^{-1}
Specific Heat Capacity	Cp	4184	4178	J kg^{-1} K^{-1}
Viscosity	m	0.000489	0.000695	Pa s
Density	rho	984.3	993	kg m^{-3}
Mass Flow Rate	m	0.21	0.16	kg s^{-1}
Inside Diameter	di	0	0.03	m
Outside Diameter	do	0.0255	0.0508	m
Pressure Loss Coefficient	Kp	1.23	1.23	
CALCULATIONS		**Hot Fluid**	**Cold Fluid**	
Heat Transfer	Q	8786.4	5347.84	W
Prandtl Number	Pr	3.147655	4.623742	
Flow Area	A	0.000511	0.00132	m^2
Hydraulic Diameter	Dh	0.0255	0.0208	m
Heat Transfer Surface Area	As	0.165028	0.328761	m^2
Fluid Velocity	V	0.417755	0.122069	m s^{-1}
Reynolds Number	Re	21442.74	3627.721	

4.CFD WORK

For computational fluid flow, analysis is done by latest ANSYS 14.0 as a post processor. Obtained test readings are presented.



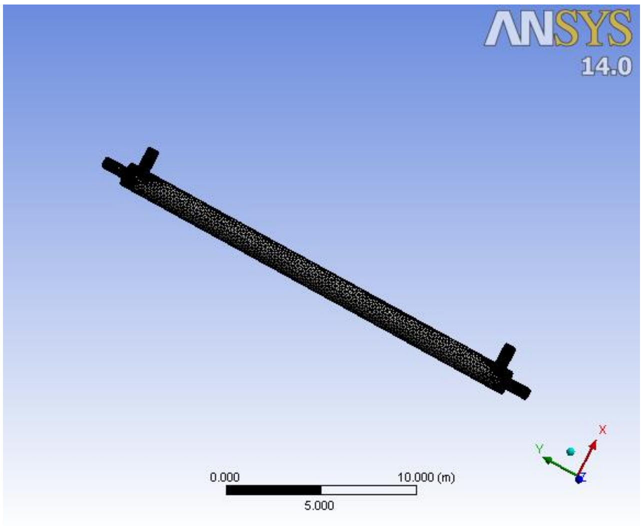
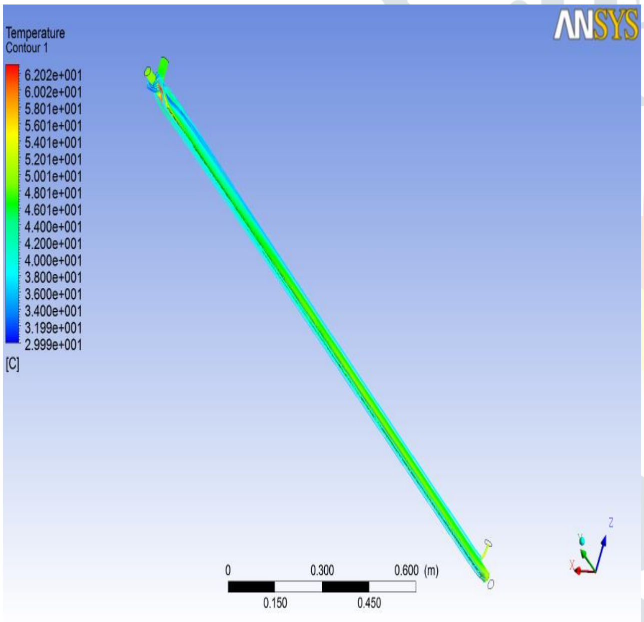


Fig.2. Fluid model of DPHX

Fig.3 Meshing



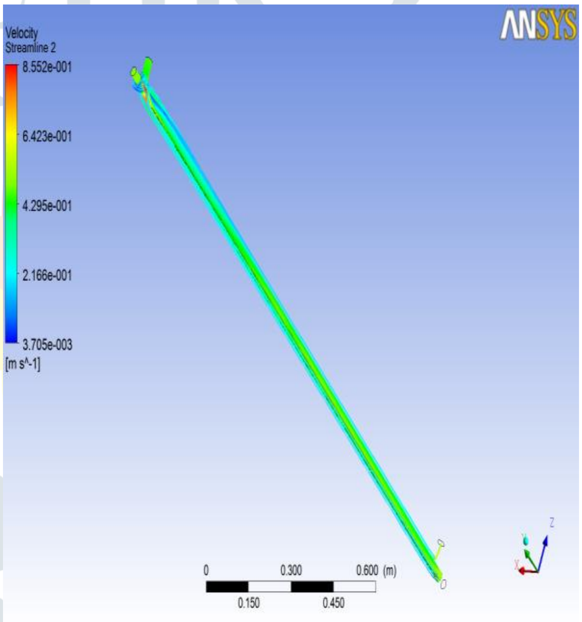


Fig.4. Temperature Contour
Massflowrate-0.22kg/ sec

Fig 5 Stream Line contour
Massflowrate-0.22kg/sec

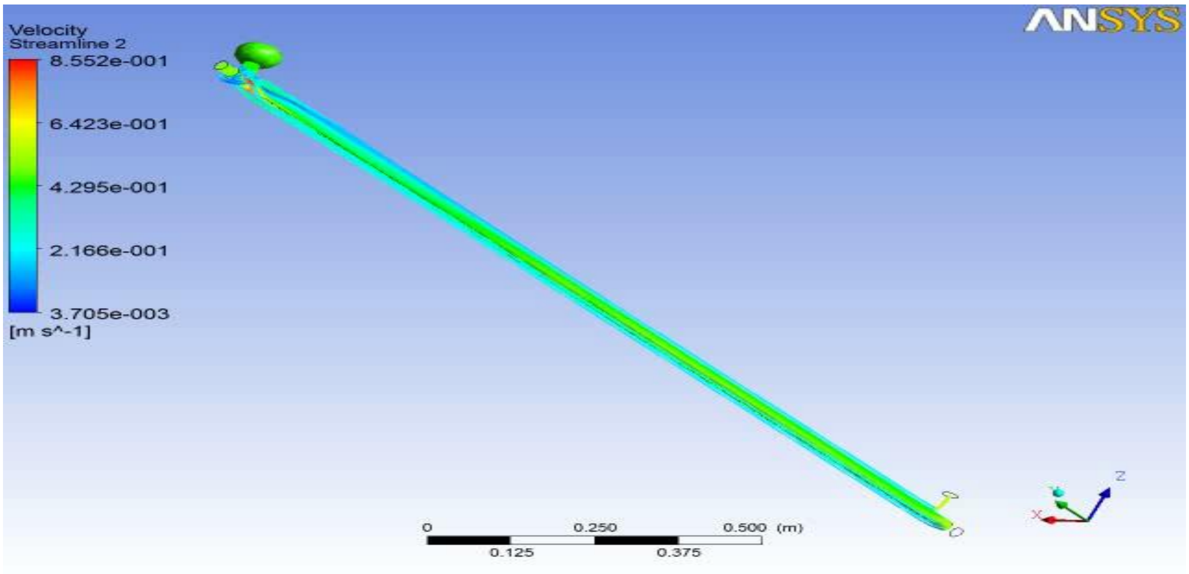


Fig.6 Streamline Animation

RESULTS:

Mass flow rates Kg/sec	Cold water temp k		Hot water temp k	
	IN	OUT	IN	OUT
0.1	302.1	326.96	337.15	325.96
0.16	302.1	322.60	337.15	322.47
0.22	302.1	318.33	337.15	321.50

Conclusions

- The heat transfer rate is increased due to the turbulence flow.
- The increase in the mass flow rate decreases the heat transfer rate.
- Heat transfer of fluid is depend upon the material of heat exchanger.

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