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PERFORMANCE ENHANCEMENT OF PASSIVE METHODS IN A DOUBLE PIPE HEAT EXCHAN GER

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Abstract: A heat exchanger is a system that transfers heat between two fluids that are separated by a solid wall and have di fferent temperatures. In this research, passive method techniques were used to increase the heat transfer rate in a double pip e heat exchanger. The working fluid is considered to be water in a turbulent field and the experimental analysis is performe d on a double pipe heat exchanger with copper and steel inner and outer tubes. The results of the numerical analysis were c ompared to the experimental results for confirmation and the percentage of error was less than 3%. To improve heat transfer rate, a fluent analysis is performed for a double pipe heat exchanger with a strip that runs in the same direction and a 90-degree rotation elliptical leaf strip with different angles. The major to minor axes ratios of single elliptical leaves are c alled 2:1, and the distance between two leaves is 50mm. The leaves are spaced at various angles from 0^0 to 180^0 with 10^0 in tervals. Because of more turbulences, high surface area, and secondary flows near the tube walls, 60^0 leaf angles have the h ighest heat transfer rate of all elliptical leaf angles.

Keywords: Shell and tube heat exchangers, elliptical leaf strips, heat transfer, pressure drop, and double pipe heat exchang ers.

Introduction: Heat transfer's role in process industries is to transfer the energy between the fluids. They are called heat exchangers. These are utilized in power plants, chemical plants and all process industries. The efficiency of heat exchanger depends upon different design parameters and fluids. Heat transfer analysis using RSM (Response Surface Methodology) with Sio_2 Nano fluid is considered. [1]. Heat transfer rate enhanced due to Nano particles dispersed in water and also increase with increase of mass flow rate. Heat exchanger with the modification of extended surfaces, twisted tape, and louvered strips are resulted greater heat transfer rate as compared to heat exchanger without modification [2]. The average heat transfer coefficient inside tube increases with increase in the flow rate of fluid in each case. The overall heat transfer coefficient was compared for both parallel and counter s is found to be less Here it was observed that, even though there is more pressure drop, more temperature difference exists between fluids[3, 4]. The heat transfer rate is enhanced with Al2O3/water Nano fluid& twist ratios of (Y/ w= 3.5, 4, 4.5) with 0.3% volume concentration, were 5% higher than water. The twist ratio of 3.5 counter flow increase heat transfer rate compared to other twist values [5, 6]. For increase heat transfer rate helical-tape inserts have used which causes swirl flow introduces at outside of inner tube which continuously disrupts the thermal boundary layer of fluid on the tube [7]. The performance ratio increased from 1.13% to 1.16% with simple twisted tape to tabulator attached with twisted tape insert. It has been observe that Nu and U was increase with respect to increase in Reynolds Number and friction factor is decreased with increasing Reynolds Number [8]. The heat transfer analysis is in the horizontal double pipes with helical fins in the annulus side. Different helical pitch of 50mm, 75mm and 100mm, are utilized to calculate the rate of heat transfer and heat transfer coefficient [9]. As we increase the fin thickness the temperature of the cold fluid at the outlet of the heat exchanger increases. We get high temperature profile at outlet in case of Aluminum and copper compared to steel material. By decreasing the mass flow rate for there is increasing the value of temperature up to 609k and 577 K [10]. Insertion of twisted tape in double pipe heat exchanger improved the heat transfer coefficient on both tube side and annulus side of heat exchanger.

The attempt to study the fin effect produced by the twisted tape in the modified heat exchanger revealed that the twisted tape exhibit significant fin effect which is an advantage not covered by the OER criterion. The streamline design methodology of spiral tube heat exchanger is used to improve the thermal efficiency [11, 12]. The experimental comparison of different types of heat transfer enhancement techniques in heat exchangers by extended surfaces, obstruction devices and swirl flow device. Finally, from the experimental and analytical results it is concluded that the annular method reached higher heat transfer than other methods [13]. Among the three models of the heat exchangers, effectiveness is observed to be higher for model-3 i.e., heat exchanger with fins attached to the outer surface of the copper tube. It is concluded that effectiveness of heat exchanger with fins attached to outer surface of copper tube is higher among the three models of heat exchangers. Three methods and techniques are done here extended surfaces, obstruction devices and swirl flow device [14, 15]. Fluent analysis of the half-length twisted tape insertion on heat transfer and pressure drop characteristics in a U-bend double pipe heat exchanger have been studied [16]. The heat transfer coefficient and friction factor increase with the decrease in baffle spacing compared with smooth tube. Inserted semi-circular disc baffle (15 and 45 cm) proves the heat transfer rate by 1.9 and 1.3 times that of smooth tube respectively [17].The experimental results indicates enhancement in heat transfer coefficient at 7.69 twist ratio when compared with plain tube at Reynolds number range of 2300 – 10,000.It is observed that swirl flow increases residence time of water in the tube, resulting improvement in conductive heat transfer in double pipe heat exchanger [18].

In this present study a double pipe heat exchanger with strip is considered for numerical analysis. The strip having elliptical leafs and these elliptical leafs are located at 50mm distance at 90^0 rotation towards the shaft. The elliptical leafs are arranged at an inclination of 0^0 to 180^0 (0^0 – 180^0) at 10^0 interval. The heat transfer rate and pressure drop along the length of heat exchanger are measured while changing the elliptical leaf angles.

Experimental Setup: The double pipe heat exchanger with inner and outer pipes was taken as an experimental device. The outer pipe and inner pipe are made up of stainless steel and copper. The experimentation is considered as an incompressible turbulent flow. The water from the tank is divided into two streams, one is cold fluid directly circulated through annual side and the other is hot fluid, which is heated by an electrical heater with a temperature control device and passes through inner pipe. The hot and cold fluid mass flow rates are calculated by different flow meters and these are controlled by valves. The temperatures of hot and cold fluids are measures by using thermocouples and these are located at different places of inlet and outlet paths as shown in Figure.1. The energy transfers from hot fluid to cold fluid along the length of the heat exchanger. The hot fluid rejects the heat to the cold fluid and gradually decreases its temperature from inlet to outlet and at the same time the cold fluid receives the heat from the hot fluid and increases its temperature. At steady state condition the heat transfer rate is calculated.

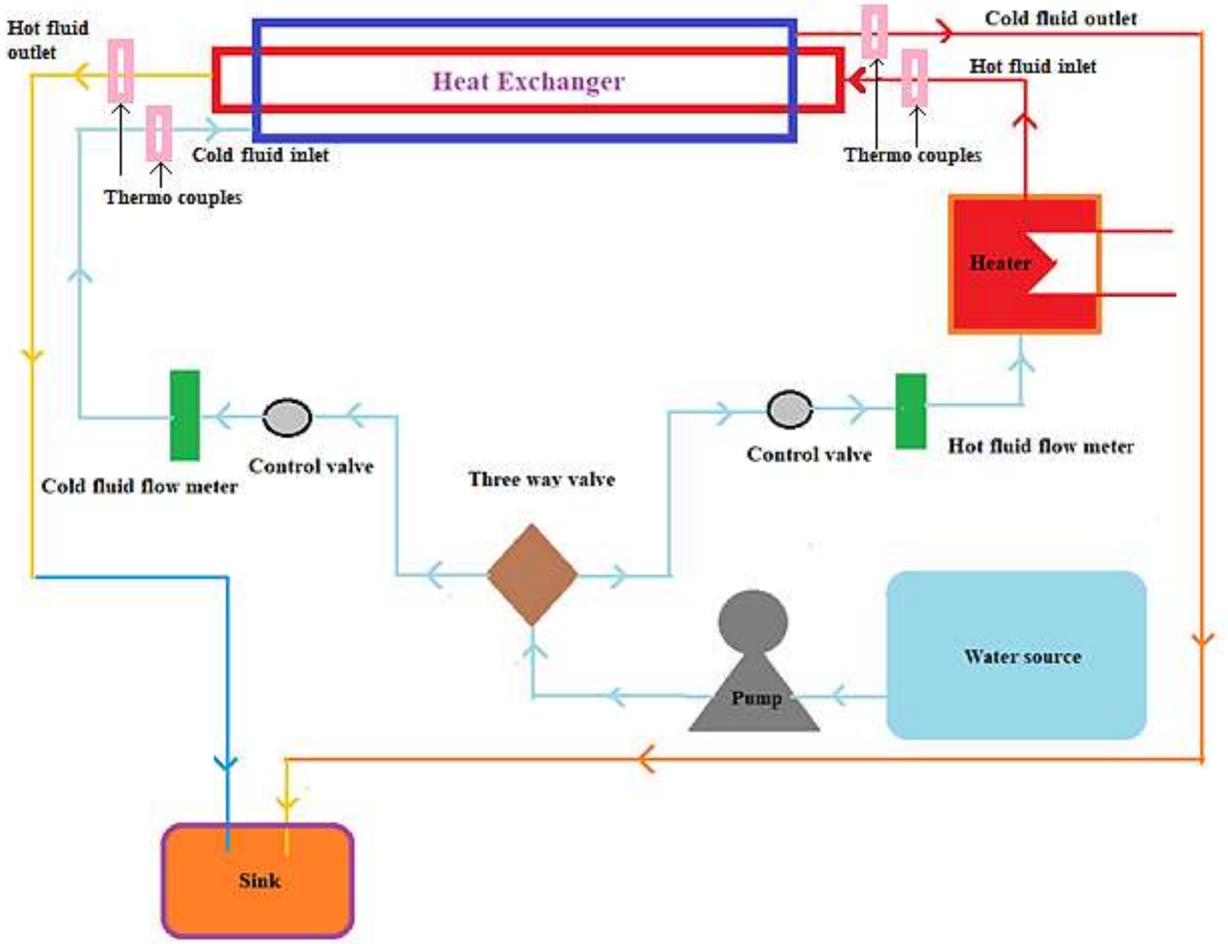


Fig.1 Experimental setup of double pipe heat exchanger

Inlet, Outlet and Boundary Conditions: At a temperature of 348 K, hot water is circulated at various mass flow rates in the inner vessel. Various mass flow rates, such as 0.15785, 0.3827, 0.55763, and 0.71782 kg/s, are provided at the inlet of the inner pipe nozzle. Different mass flow rates of 0.34589, 0.8403, 1.2245, and 1.5762 kg/s are passed through the annual side at 298 K. The outlets are defined as atmosphere pressure, and the flow is defined as atmosphere pressure. The flow is believed to be chaotic and incompressible. The inner surfaces of inner and outer pipes do not have any slip conditions. The boundary flow was assumed to be natural. Both fluids have hydraulic diameters at their inlet nozzles.

Different Strips with Elliptical leaves: On a double pipe heat exchanger with different elliptical leaves, a numerical analysis is performed. The major to minor axes ratio of the elliptical leaves is 2:1, and the thickness is 1mm. These elliptical leaves are 50mm apart and rotate 900 degrees towards the shaft. As shown in Figure.2, the elliptical leaves are spaced at 100 intervals at an inclination of 0^0 to 180^0(0^0 – 180^0).

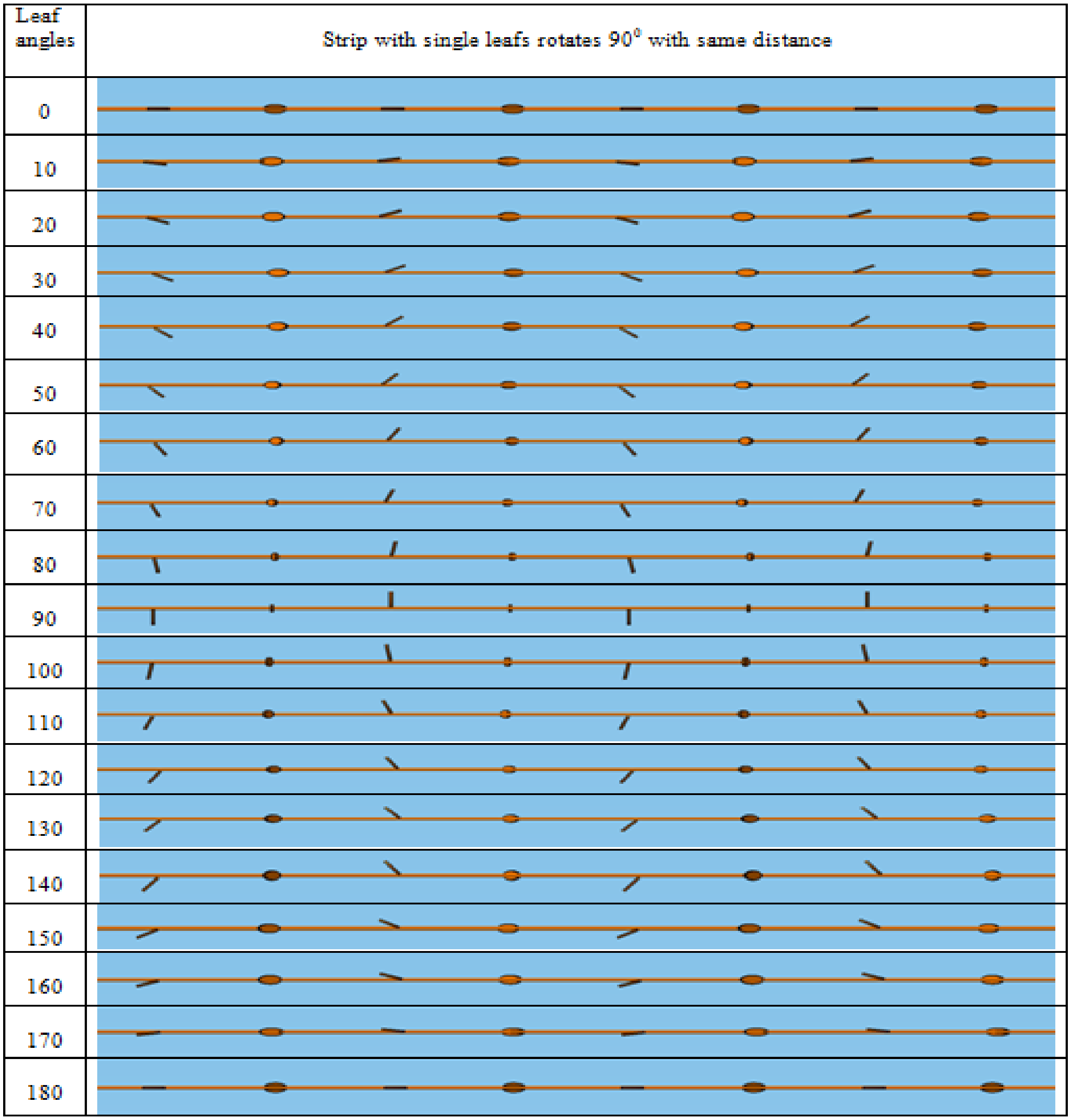
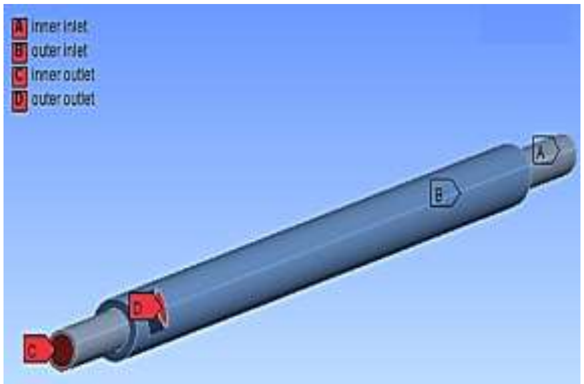
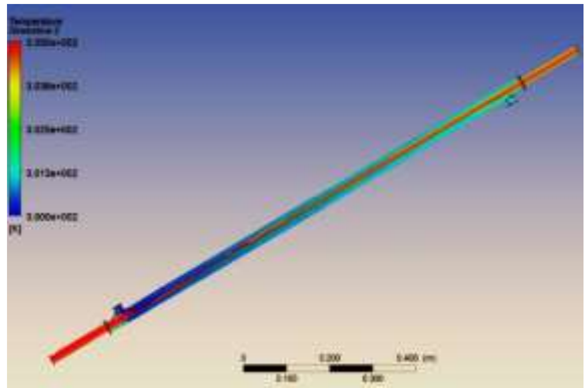


Fig.2 Strip with different elliptical leaf angles

Numerical analysis and validation: The actual model is interpreted as a virtual computer model using the CATIA software package for numerical analysis, and analysis is carried out using a finite volume approach as a computational fluid dynamics (CFD) tool. The governing equations were solved using the CFD solver FLUENT. The Basic algorithm was used to overcome the pressure-velocity field coupling. For discretization pressure, momentum, energy, turbulent kinetic energy, and turbulent dissipation speeds, the second-order upwind scheme was used.



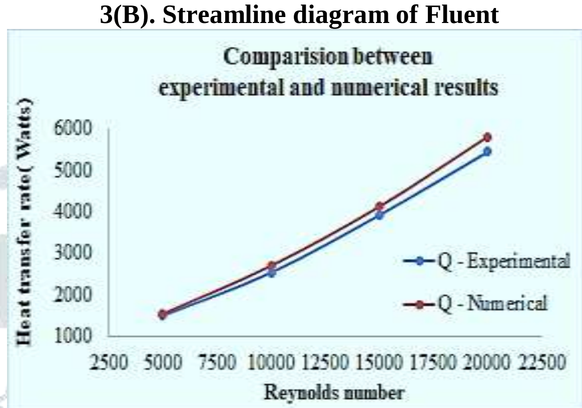
3(A). Boundary conditions of virtual model



3(B). Streamline diagram of Fluent

Reynolds number	Temperature (K)		Heat Transfer(Watts)		% Of Error
	Cold fluid	Hot fluid	Experimental value	Numerical value	
5000	298	348	1498.269	1541.12	2.86
10000	298	348	2634.972	2700.32	2.48
15000	298	348	4018.789	4123.68	2.61
20000	298	348	5638.546	5804.32	2.94

3(C). Experimental and numerical results



3(D). Comparison between experimental and numerical results

Fig.3 (A), (B), (C), (D) Comparison between experimental and numerical results

The above geometry parameters and fluid properties are considered for numerical analysis. The virtual model is constructed as a scale of 1:1. By using above geometry, fluids, inlet, outlet and boundary conditions numerical analysis is conducted and these results are compared with experimental results. The numerical results are approaching to experimental results and the percentages of error between these are less than 3% as shown in Figure.3. So the above inlet, outlet and boundary conditions are valid for further numerical analysis of heat exchanger with different elliptical leaf strips.

Results and discussion: Different strips with elliptical leaves are introduced to change the flow parameters. In order to increase the heat transfer rate in the flow, more surface area is introduced, and a mathematical model is reformed for more numerical analysis. The velocity pattern depicted in the figure 4 shows the fluid is distributed near elliptical leaves.

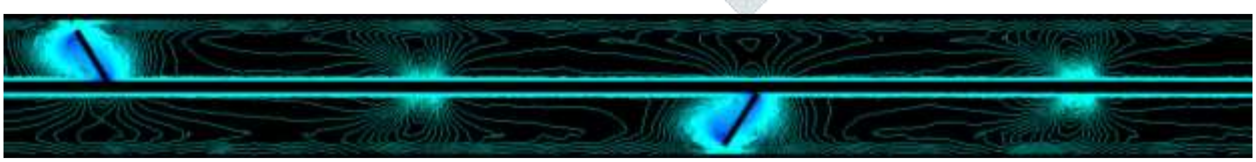


Fig.4 Fluid flow in between elliptical leaves

The elliptical leaf's inclination is crucial in determining the thermal efficiency of a double pipe heat exchanger. The heat transfer rate and pressure drop was calculated using different elliptical leaf angles ranging from 00 to 1800 at 100 intervals. To analyze the thermal behavior of a double pipe heat exchanger, 19 models at four mass flow rates in the turbulent region were considered.

Heat transfer analysis: By using different strips with elliptical leaf inclinations, the effects of heat transfer rate in the double pipe heat exchanger are studied. The use of elliptical leaf strips in a tube provides a simple passive technique for improving convective heat transfer by introducing swirl into the heavy flow, disrupting the boundary layer at the tube surface due to rapid changes in surface geometry. Such tapes generate turbulence and swirl flow within the boundary layer, which increases heat transfer rates.

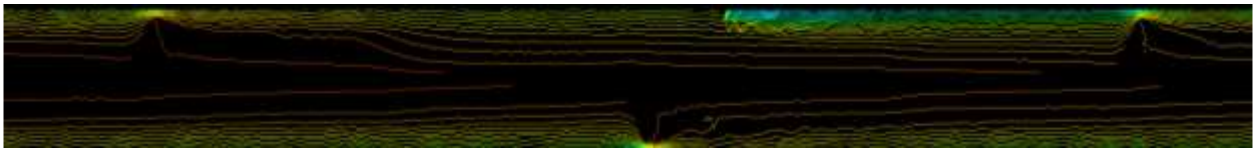


Fig.5 Pressure distribution along the length of heat exchanger

The figure 5 indicates along the length of a double pipe heat exchanger, the temperature distribution contour near the elliptical strip and the inner walls is at its highest. The heat transfer rate increases when the elliptical leaf inclination changes from 00 to 600 and decreases when the elliptical leaf inclination changes from 00 to 1800, according to the temperature distribution in Figure.6. In the case of a 60^0 elliptical leaf angle, the flow length increases, that increases the heat transfer rate along the axis in which it flows.

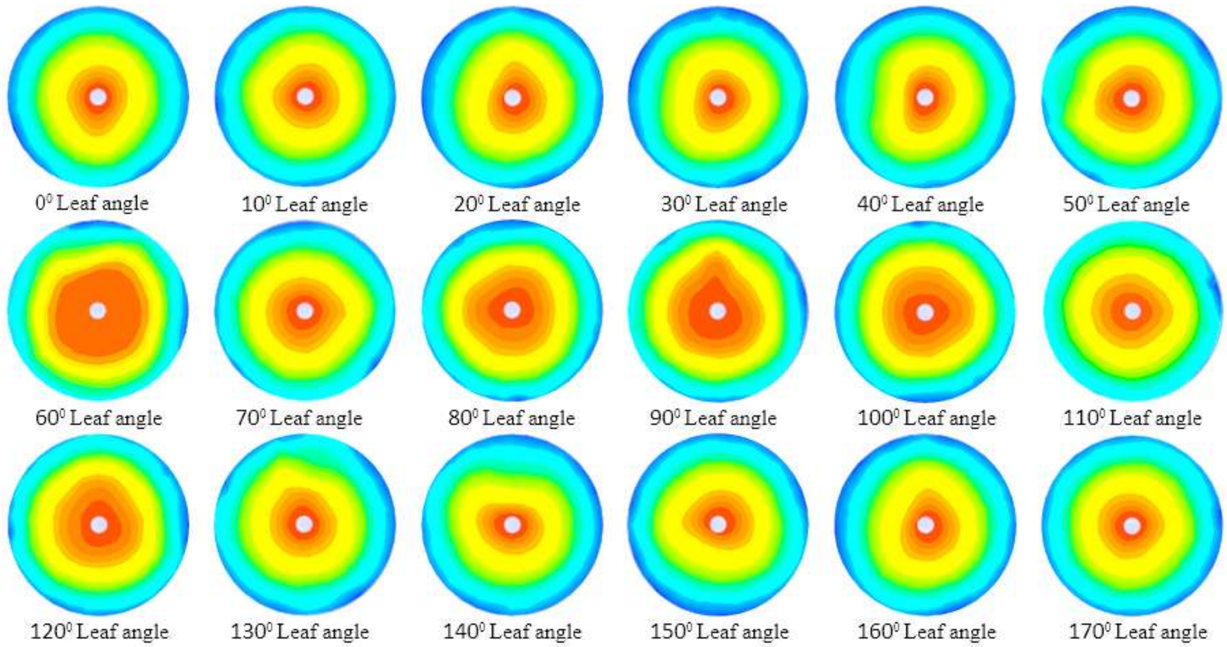
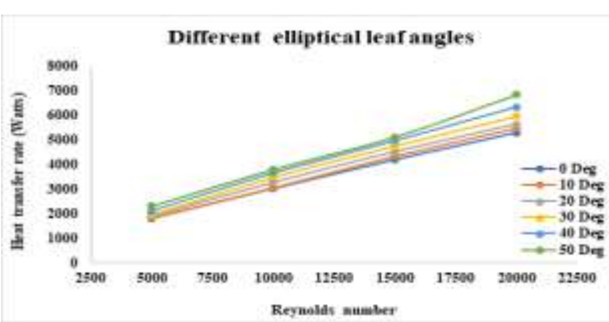
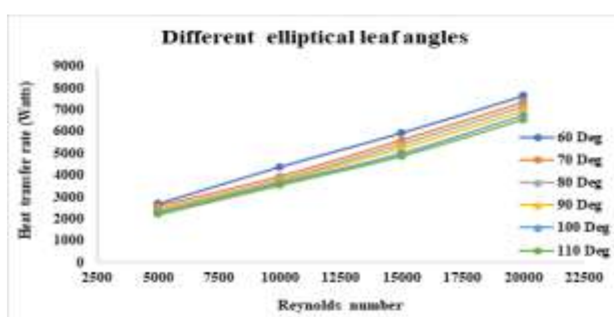


Fig.5 Temperature contours of elliptical leafs at different inclinations

At different elliptical leaf angles (0^0, 10^0, 20^0…. 180^0) the temperature flow at the middle of the heat exchanger are as shown in Figure.5. From all graphs (Figure. 6), it shows that the heat transfer rate increases with an increase of Reynolds number. Temperature flow for vector diagram indicates the heat transfer rate increase with increase in surface area and by inserting strips. Stream line flow for elliptical tube with strip inserts of STHE visualizes more heat transfer performance due to creation of turbulence over liquid by strip insert. Taking a gander toward the culmination of the heat exchanger, the stream nearest to the inside wall of the funnel encounters a greater amount of the heat exchange to the chillier liquid of the external funnel and The stream nearest to the exterior wall of the inward pipe gets a greater amount of the thermal energy and along these lines higher temperature closest the internal funnel for the colder external stream.





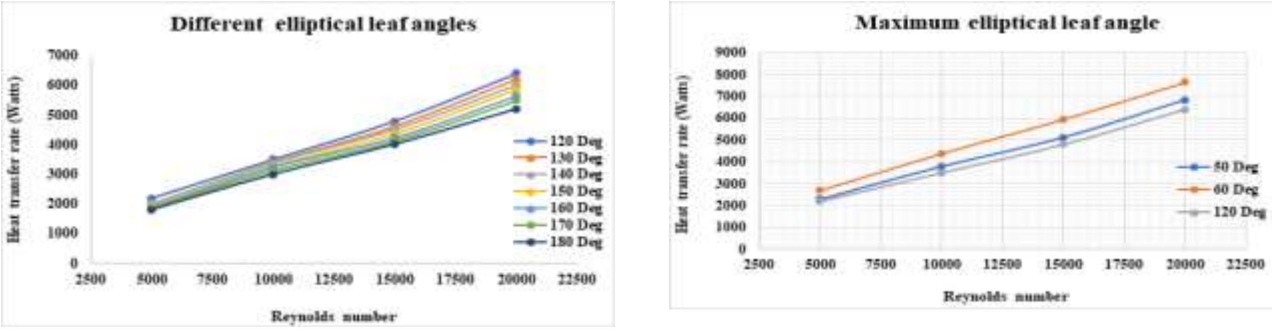


Fig.6 Heat transfer variation at different elliptical leaf angles

Pressure Drop Analysis: For a fluid flow, the three interdependent parameters are pressure, length, and temperature. When the temperature difference between hot and cold fluids is large, heat transfer is high, and pressure drop is also large. A sudden high pressure drop in a heat exchanger, on the other hand, is not recommended. A uniform transfer of heat energy through the heat exchanger is necessary to prevent a high pressure drop in the heat exchanger. With this perspective, the pressure drop with various arrangements is measured for improved heat exchanger efficiency. Figure.7 shows the vector contours in a mathematical model for a heat exchanger with bar, which display pressure drop difference in the tube side with different elliptical leaf inclinations. Figure.8 shows that as the Reynolds number increases, the pressure drop increases, rising from 0^0 to 90^0 elliptical leaf angle and decreasing from 90^0 to 180^0 elliptical leaf angle.

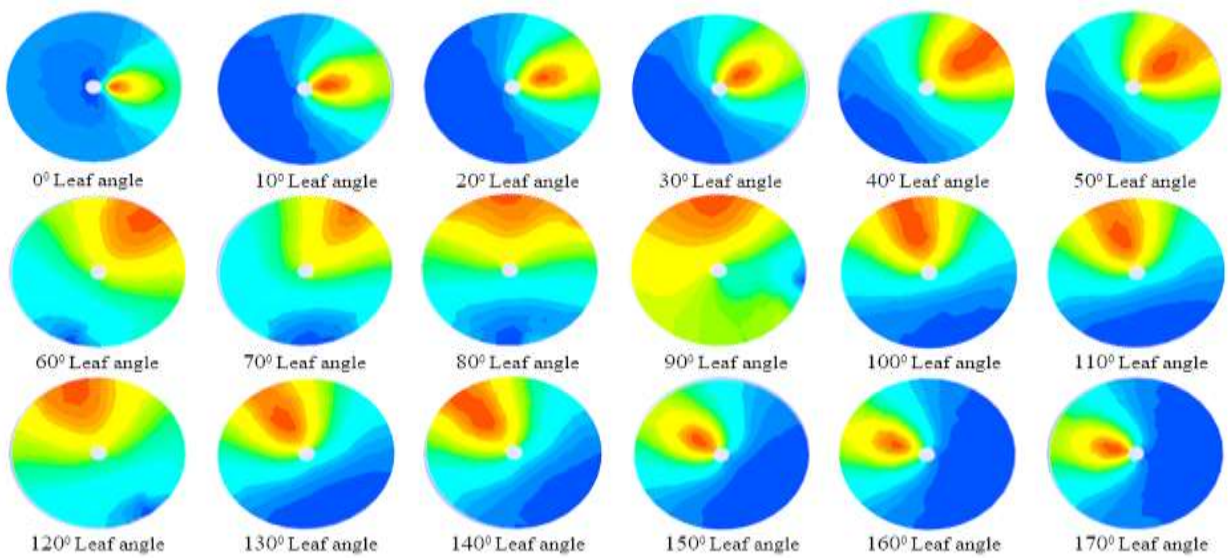
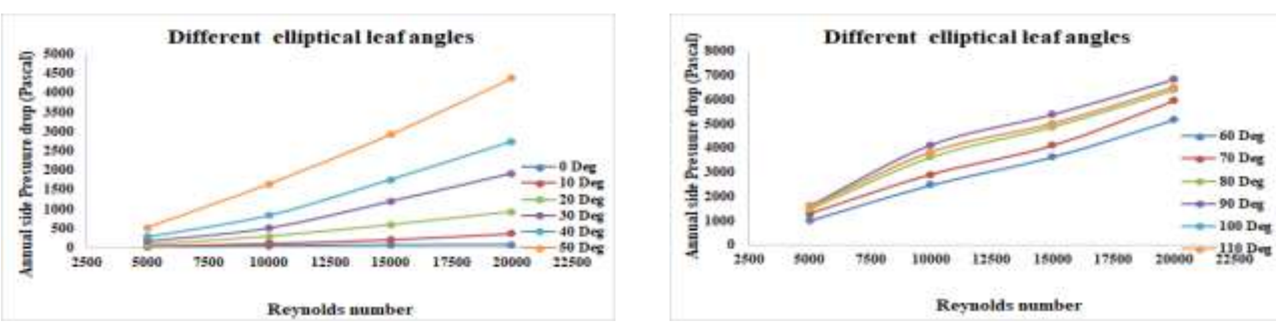


Fig.7 Pressure contours at different elliptical leaf angles



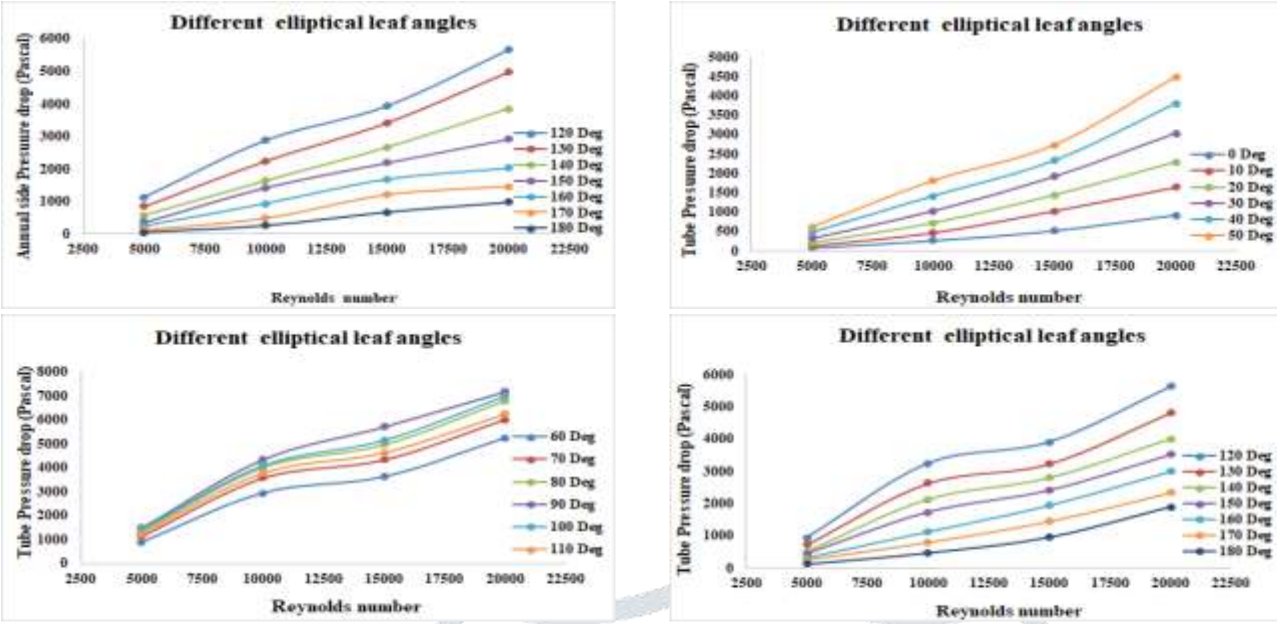


Fig.8 Annual and Tube side pressure drop variation at different elliptical leaf angles

Conclusion: To improve the heat transfer rate, numerical analysis is carried out on a double pipe heat exchanger with different inclined elliptical leaf angle strips. The heat transfer rate increases from 00 elliptical leaf angles to 600 elliptical leaf angle and decreases from 600 elliptical leaf angle to 1800, according to the fluent data. With an increase in Reynolds number, the heat transfer rate and pressure drop increase. The average heat transfer rate with the 600 elliptical leaf angle strips is 18% higher than the current double pipe heat exchanger in the Reynolds number range of 5000 to 20,000.

References:

1. Farhad Fadakar Kourkah et.al "Optimization of Double Pipe Heat Exchanger with Response Surface Methodology Using Nanofluid and Twisted Tape" Fluid Mechanics 3(3): pp.20-28, 2017.
2. H. S. Patel et.al "A Review on Performance Evaluation and CFD Analysis of Double Pipe Heat Exchanger" Paripex - Indian Journal Of Research, ISSN - 2250-1991 , Volume 2,pp.84-86, Issue 4 ,April 2013.
3. Kadari Deepika et.al "Design and fabrication of Concentric Tube Heat Exchanger" International Journal of Latest Trends in Engineering and Technology (IJLTET), ISSN: 2278-621X, Volume 7; pp.82-91, issue 3, June 2016.
4. Suresh Babu Koppula et.al "Design Criteria for Hot Fluid Flowing in Inner Pipe of a Double Pipe Heat Exchanger " International Journal of Engineering Technology Science and Research(IJETSR), ISSN 2394 – 3386, Volume 4,pp.50-67, Issue 8, August 2017.
5. Govindharajan. B et.al " Effect Of Twisted Tape Inserts In Double Pipe Heat Exchanger Using Al2o3/Water Nano Fluids" International Journal of Advances in Engineering Research(IJAER), e-ISSN: 2231-5152/ p-ISSN: 2454-1796, Vol. No. 10,pp.242-257, Issue No. VI, December 2015.
6. S. Perumal et.al "Study On Double Pipe Heat Exchanger Using Different Enhancement Techniques" Imperial Journal of Interdisciplinary Research (IJIR), ISSN: 2454-1362,Vol-2,pp,455-464, Issue-2 , 2016.
7. Bharat Bhushan Verma et.al "CFD Analysis and Optimization of Heat Transfer in Double Pipe Heat Exchanger with Helical-Tap Inserts at Annulus of Inner Pipe" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 13, Issue 3 Ver. VII , PP 17-22, (May- Jun. 2016).
8. Pragneshkumar Prajapati et.al "Increase The Heat Transfer Rate of Double Pipe Heat Exchanger With Quadratic Turbulator (Baffle) Attached Twisted Tape Insert" International Journal of Advance Engineering and Research Development(IJAERD), e-ISSN (O): 2348-4470 or p-ISSN (P): 2348-6406, Volume 3,pp.204-212, Issue 5, May - 2016.

9. N Sreenivasalu Reddy et.al “Experimental Investigation of Heat Transfer Enhancement of a Double Pipe Heat Exchanger with Helical Fins in the Annulus Side” International Journal of Dynamics of Fluids, ISSN 0973-1784, Volume 13, pp. 285-293 , Number 2 (2017).
10. Kuruva Umamahesh et.al “Design And Anaysis Of Double Pipe Heat Exchanger Using Computational Method” International Journal of Professional Engineering Studies (IJPES), Volume V,pp.59-74 ,Issue 2 ,July 2015.
11. Ranjith et.al “Numerical analysis on a double pipe heat exchanger with twisted tape induced swirl flow on both sides” International Conference on Emerging Trends in Engineering, Science and Technology (ICETEST-2015), pp.436 – 443, Procedia Technology 24 (2016).
12. Jay J. Bhavsar et.al “Design and Experimental Analysis Of Spiral Tube Heat Exchanger” International Journal of Mechanical and Production Engineering, ISSN: 2320-2092, Volume-1, pp.37-42, Issue-1, July-2013.
13. M.Kannan et.al “Experimental And Analytical Comparison Of Heat Transfer In Double Pipe Heat Exchanger”International Journal of Automobile Engineering Research and Development (IJAuERD) , © TJPRC Pvt. Ltd.,ISSN 2277-4785, Vol.2, pp.1-10,Issue 2, Sep 2012.
14. V. Vara Prasad et.al “Experimental Analysis To Enhance The Effectiveness Of Heat Exchanger Using Triangular Fins” International Journal of Mechanical and Production Engineering Research and Development (IJMPERD), © TJPRC Pvt. Ltd.,ISSN 2249-6890,Vol. 3,pp.1-10. Issue 2, Jun 2013.
15. M.Kannan et.al “Experimental And Analytical Comparison Of Heat Transfer In Double Pipe Heat Exchanger” International Journal of Automobile Engineering Research and Development (IJAuERD), © TJPRC Pvt. Ltd.,ISSN 2277-4785,Vol.2,pp,1-10, Issue 2, Sep 2012.
16. Anil Singh Yadav et.al “Effect of Half Length Twisted-Tape Turbulators on Heat Transfer and Pressure Drop Characteristics inside a Double Pipe U-Bend Heat Exchanger” Jordan Journal of Mechanical and Industrial Engineering(JJMIE), ISSN 1995-6665, Volume 3, Number 1, Pages 17- 22, March. 2009.
17. Sarmad A. Abdal Hussein et.al “Experimental Investigation of Double Pipe Heat Exchanger by using Semi Circular Disc Baffles” International Journal of Computer Applications (0975 – 8887), Volume 115, pp.13-17, No. 4, April 2015.
18. S. Girish et.al **“**Enhancement Techniques Of Double Pipe Heat Exchanger**”** International Journal of Scientific Development and Research (IJSDR), ISSN: 2455-2631, Volume 2, pp.220-222, Issue 7, July 2017.