# Performance Improvement of Double Tube Heat Exchanger Using CFD

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***Abstract*- In a heat exchanger with two tubes, one tube is carefully made to fit inside the tube with the largest diameter. But in this arrangement, there are two flows going in different directions: parallel and counter flow. Multiple series and parallel arrangements can be made to meet different heat transfer needs. The straight arrangement stands out because it has been used in many industrial settings. Since then, this configuration has become common, and it has been very important to understand the pressure drop, heat transfer coefficient, and various types of flow forms. This analysis was done on double-tube heat exchangers. Double tube HE is split into five different domains, like cold and hot fluid in the outer and inner tubes, and helical baffle fins on the inner pipe of the hot fluid. The mass flow rate varied from 0.15 kg/s to 0.35 kg/s for cold fluid. The mass flow rate of hot fluid (water liquid) in the inner tube, on the other hand, stayed the same at 0.2 kg/s the flow was increasing. Theoretical and CFD calculations were analyzed, and the results for cold fluid were seen at a mass flow rate of 0.35 kg/s. Furthermore, it was noted that the heat transfer coefficient increased with the flow rate of the cold fluid and based on result the overall heat transfer coefficients for heat exchanger is differ significantly by 21.7% at similar mass flow rates. The modification in heat transfer surface area on the outer and inner sides of the tube led to an exceptional thermal development of the cold fluid Presentation.**

***Keyworks- Heat exchanger, CFD, Helical baffle, ANSYS fluent, double tube***

## I. Introduction

The use of a heat exchanger allows for the transmission of heat between two fluids that are at various temperatures. Due to their extensive variety of manufacturing and applications in thermal transferal methods for producing conventional energy, such as evaporators, condensers, heaters, boilers, or steam generators Heat exchangers are widely employed in industry applications [1]. They offer a surface that is conducive to heat transfer, and processes requiring high pressures and temperatures are made possible by their mechanical and thermal properties. The performance and energy savings of heat exchanger devices can be greatly increased by improving their thermal and mechanical properties [2]. The development of innovative engineering technology for heat exchangers is needed in order to meet a wide variety of operating circumstances due to the importance of saving and recovering energy for various types of industrial operations [3]. In recent years, new modelling software for heat exchangers has been emphasised in order to adapt the tools to the necessary development and new findings have been established that shorten project times. While other applications have used alternative geometries, tube heat exchangers typically use spherical tubes [4-5]. Because structure elements like width, length, and layout may easily be changed, this sort of assembly offers a high level of manufacturing flexibility. This classification is used to describe the transmission of heat from one liquid to another (phase changes such as condensation or evaporation) [6]. Additionally, this category is divided into spiral, double, and tube bundle heat exchangers.

In general, increased heat transfer surfaces can be utilised for the aforementioned goals, which include making heat exchangers smaller in size or can say more compact in order to lower their total volume, and their cost. By increasing heat transfer surfaces either the amount of pumping power necessary for a specific heat transfer operation is reduced and increased the heat transfer coefficient value of the heat exchanger as a whole [7]. A higher UA value can be used as an advantage to decreases the mean temperature difference and for fixed fluid inlet temperatures obtained increased heat exchanger rate, using this we can savings of operating costs and increases the thermodynamic process efficiency.

Either way, the higher UA value can be used to obtain an increased heat exchanger rate. [8] This study focuses exclusively on improving fluid-side heat transfer by employing unconventional surface shapes and a variety of materials.

There are two main types of enhancement processes: 1. Passive enhancement, and 2. Active enhancement. [9-10] Presented that the passive enhancement does not require use of external power source for its functioning, and such enhancement can be simply achieved by the use of special geometries and some fluid additives. The passive enhancement has been commonly employed in wide range of enhancement devise. In case of active enhancement, some external source, like electromagnetic field and surface vibration, is required for its operation. The current research objective deals with passive type fluid side enhancement technique using special surface geometries and two different materials, i.e. Copper and Aluminium.

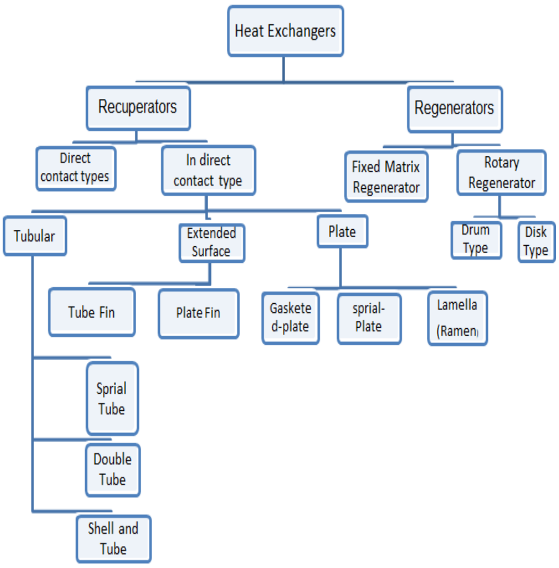


Fig. 1. Heat Exchanger classification

## II. Objective

There are subsequent objective of the research work.

- This study's main goal is to apply 3D Computational Fluid Dynamics (CFD) analysis to determine the stream velocity, static temperature, and overall heat transfer coefficient for double tube heat exchangers in counter-flow conditions.
- Using Ansys design modular, offer various models of heat exchanger having double pipe
- Conduct a heat transport analysis using CFD in the heat exchanger under various conditions.
- To compare the simulated results of various heat exchangers (double pipe) models and provide the optimum solution for greater heat transfer in the heat exchanger.

## III. Results

The CFD model (ANSYS Fluent 16) was initially used to verify the performance of double tube heat exchangers. The analysis setup based on five cell zone condition, inner, outer tubes and baffles solid material with copper while inner fluid (water liquid ) flow at hot temperature and outer cold fluid (water liquid) ,this analysis done in double precision for more accuracy. In this research work of heat exchanger having double pipe a three dimensional (3D) CAD model is generated in perfect and accuracy dimension using SOLID WORK and ANSYS workbench. The inside diameter of hot and cold fluid are 10 mm and 16 mm respectively, with wall pipe thickness 1 mm. the total length of the tube is 200 mm. Rectangular single helical baffles with weigh and length 1 and 6 mm, pitch spacing 33 mm on the wall of outside portion of inner hot fluid tube which is shown in figure 2.

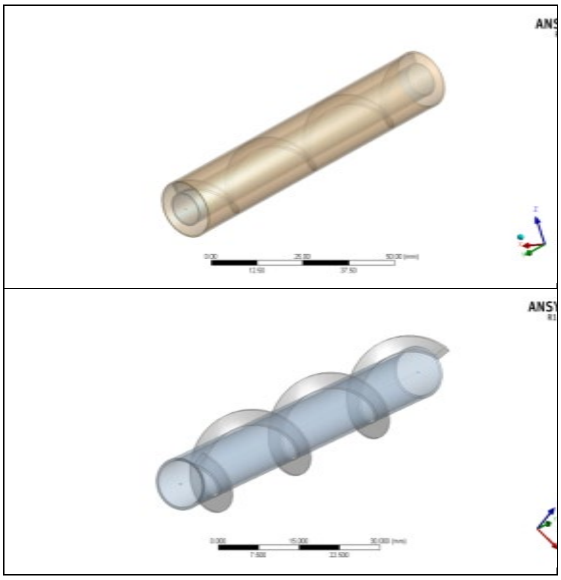

Fig. 2. Geometry Design of double tube heat exchanger Isometric side view

Meshing is a crucial step in the process of computer-aided engineering simulation. The mesh should mesh on the necessary surface and edges since it has an impact on the precision, convergence, and speed of the solution result. If the geometry contains a large number of elements, the results will be more accurate and the surface will be highly apparent. Figure 3 depicts the meshed model of a heat exchanger having double pipe created with the help of the double precision and two processes approach in the ANSYS fluent.

The number of elements used in this meshing for different domain., is shown in Table I, In this process, face meshing, inflation, and edge sizing of meshing is done to update the setup stage for analysing the process.

Table I NUMBER OF ELEMENTS AND NODES OF MESHING OF DIFFERENT MODELS

| Domain | Elements | Nodes |
|---|---|---|
| ***Inlet Tube*** | 12292 | 24664 |
| ***Outlet Tube*** | 31005 | 60427 |
| ***Baffles*** | 7095 | 1733 |
| ***Cold Fluid*** | 34302 | 60398 |
| ***Hot Fluid*** | 69933 | 103444 |

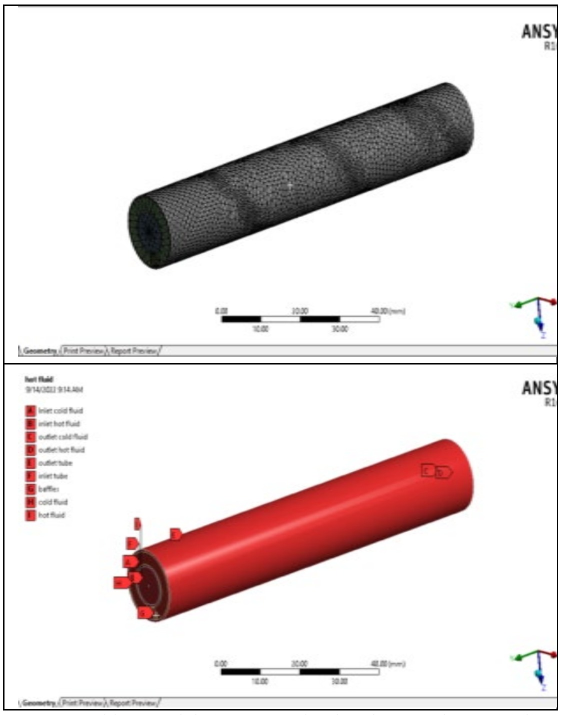

**Fig. 3**. Meshing model, (a) Isometric view heat exchanger), (b) Name selections on Model

After carrying out CFD analysis for the intake temperatures of cold fluid and hot fluid which are 20 °C and 45 °C of the heat exchanger at various mass flow rates of hot and cold fluid ranging from 0.15 - 0.35 kg/s. For hot and cold flow regions the variation of static temperature over the whole length of the heat exchanger is depicted in figure 4 and for cold flow regions the stream velocity along the heat exchanger is depicted in figure 5.

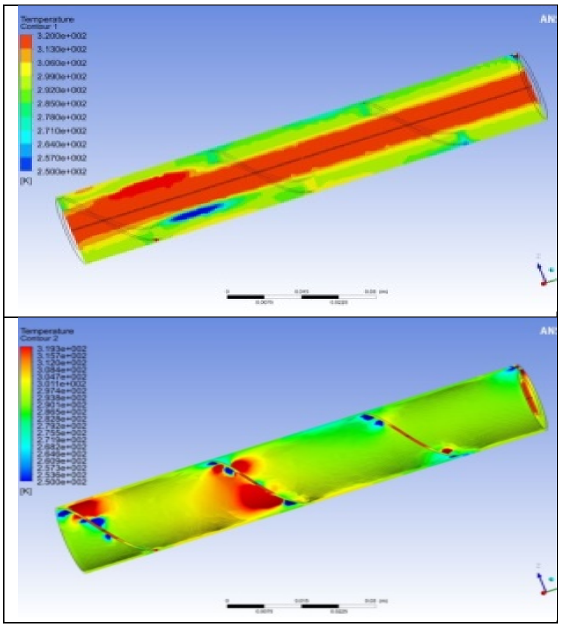

**Fig. 4** Temperature contours of DTHEX heat exchanger having double tube at mass flow of 0.15 kg/s (mid plane view and 3D view)

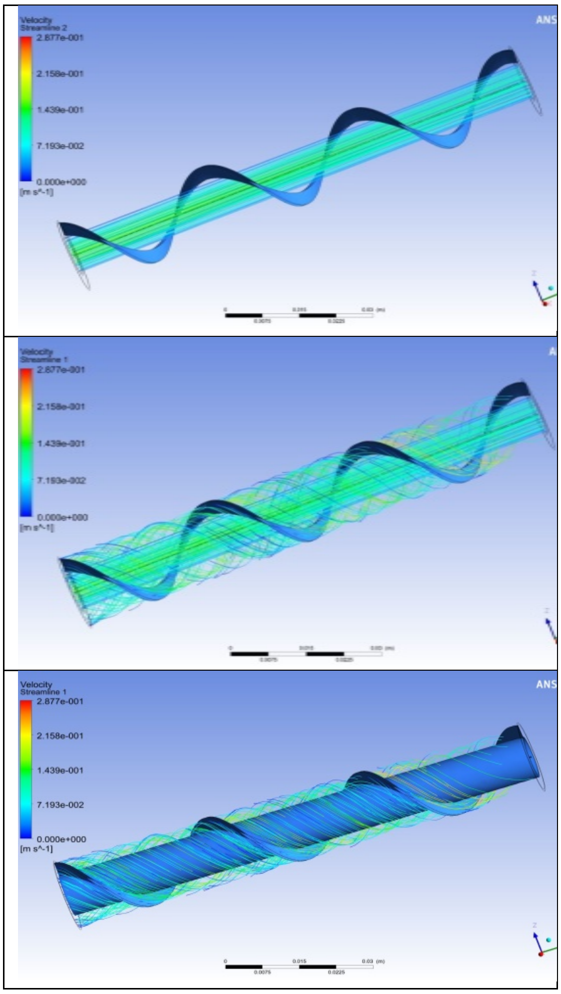

**Fig. 5** Stream velocity at mass flow 0.35 kg/s

It has been noticed that due the quick sudden drop in the flow zone, the highest stream velocity of the cold fluid streaming is observed in annulus side and at near inlet entrance regain side.

Based on above validation analysis results, it has been noticed that the comparison of temperature deviation in cold fluid domain result of was about 1.37 % and the deviation in the velocity factor is less than 0.75% from essential research articles which confirmations great arrangement with 1.17% error. Afterward the validation from essential design several further models of heat exchanger with double pipe have been used for CFD study to improve the thermal effectiveness of the different heat exchanger.

The results showed that the helical single baffle in laminar movement offers an enhanced heat transfer characteristics particularities in turbulent movement. Therefore in other cases all CFD analysis will implement using laminar flow.

### A. *Comparison analysis result of double tube HE*

**TABLE II** TEMPERATURE DISTRIBUTION AND LMTD FOR DOUBLE TUBE HE WITHOUT BAFFLES

| | | | | |
|---|---|---|---|---|
| **LMTD** | **$\Delta T_m$** | 26.9 | 26.76 | 26.65 |
| | **$\Delta T$** | 26.68 | 26.04 | 25.76 |
| | **$\Delta T_1$** | 27.12 | 27.49 | 27.56 |
| ***Temperature Decrease in % for hot fluid*** | | 7.377 | 8.80 | 9.42 |
| ***Temperature Increase in % for cold fluid*** | | 12.2 | 5.30 | 3.20 |
| ***Pipe HE without baffles*** | ***Cold outlet*** | 22.44 | 21.06 | 20.64 |
| | ***Hot outlet*** | 41.68 | 41.04 | 40.76 |
| **Mass Flow Rate** | | 0.150 | 0.250 | 0.350 |

**TABLE III** ANALYSIS RESULT OF DOUBLE TUBE HEX WITH HELICAL SINGLE BAFFLES

| | | | |
|---|---|---|---|
| **Over all Heat transfer coefficient [U W/m2.C]** | 192.85 | 281.386 | 339.676 |
| **Convective Coefficient for Cold fluid[hc]** | 260.892 | 454.24 | 628.288 |
| **Nusselt No. for Cold fluid [Nu]** | 7.088 | 12.34 | 17.068 |
| **Reynolds No. for cold fluid [Re]** | 381.672 | 763.346 | 1145.018 |
| **Velocity of cold fluid** | 0.022 | 0.046 | 0.068 |
| **Heat gain by cold fluid** | 1630.2 | 4263.6 | 9931.68 |
| **Heat transfer by hot fluid** | 1521.52 | 5082.88 | 10107.24 |

## IV. CONCLUSION

It was discovered from the current research study using CFD analysis that helical single baffles with different pitch arrangements on the hot fluid tube domain might be used in double tube heat exchangers. The double tube heat exchanger was divided into five distinct domains for greater accuracy and analysis results, including three solid domains such as outer tube, inner tube, and helical single baffle on inner tube of hot fluid. The mass flow rate in the heat exchanger of the cold fluid varied from 0.15 kg/s to 0.35 kg/s, but the flow rate of the hot water via the inner pipe remained unchanged at 0.2 kg/s. At the inlet the temperature of the hot was 45 ºC, whereas the cold fluid at the inlet was 20 ºC. For a heat exchanger having double tube with a single helical baffle, theoretical and CFD calculations were analysed, and the results for cold fluid were seen at a mass flow rate of 0.35 kg/s. Furthermore, it was noted that the heat transfer coefficient increased with the flow rate of the cold fluid and based on result the overall heat transfer coefficients for heat exchanger is differ significantly by 21.7% at similar mass flow rates. The modification in heat transfer surface area on the outer and inner sides of the tube led to an exceptional thermal development of the cold fluid Presentation.

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