# CFD Simulation on Computational Fluid Dynamic Analysis of Tube Heatexchanger Having Discontinuous Helical Baffles

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***Abstract - Heat exchanger is an apparatus to carry heat from one channel to another. Due to the significance of heat exchanger in different field there is a pressure to enhance heat transfer rate on researcher. Requirement of excessive heat transfer from small area generate the concept of close pack heat exchanger. For different applications compact heat exchanger were employ to transfer heat at a much faster rate than the conventional heat exchanger. To expand the fulfillment of heat exchanger researchers had optimized the different process parameters on which the operation of heat transfer depends. To enhance the turbulence interior the heat exchanger dissimilar category of baffles were used, with the help of baffles turbulence were created inner side the heat exchanger. To improve the heat transfer here in this work perforated irregular helical baffles are used to growing the heat transfer. Here in this effort square, circular and triangular perforated intermittent helical baffles were operating to increase the heat transfer rate. It also determine the effect of changing Reynolds number on heat transfer, to evaluate the effect of altered Reynolds number here it considered four altered Reynolds number that is 6000, 8000, 10000 and 12000. It also calculates the significance of Darcy friction factor for discrete perforated interrupted helical baffles at different Reynolds number. After doing the CFD analysis and mathematical calculation it is establish that the baffles having square perforation shows supreme heat transfer as compared to the other categories of perforation. For calculating the effect of dissimilar perforation shape on heat transfer thermal performance of heat exchanger were also calculated in this work.***

***Keyword: heat exchanger, helical baffles, perforation, thermal enhancement, flow rate.***

## I. INTRODUCTION

### Heat exchanger

Heat exchanger is a mechanism that is typically used to happen the resolve of an equipment to switch heat among two procedure streams.The fluids may be detached by using a solid wall to prevent mixing or they may be in direct contact. They are commonly used in space heating, refrigeration, chemical plants, petrochemical plants, petroleum refineries, natural-gas processing, and sewage treatment. Example of heat exchanger is shown in an internal combustion engine where fluids flows through radiator coils and air flows over the coils, which cool the coolant and heats the coming air. Another instance is the heat sink which is a inert heat exchanger that convey the heat generated by an electronic or a mechanical equipment to a fluid norm, air or a liquid fluid.

### 1.2 Types of heat exchanger

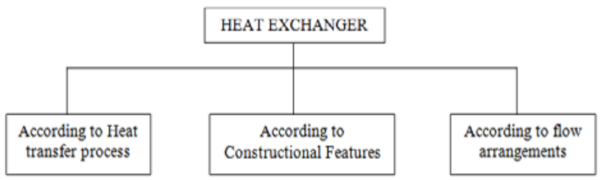


***Fig.1.1 Schematic diagram showing the types of heat exchanger***

### 1.2.1 According to Heat transfer process

### 1.2.1.1 Direct contact type heat exchanger

Here in this exchanger two immiscible fluids are mixed with each other to exchange heat between two fluids.

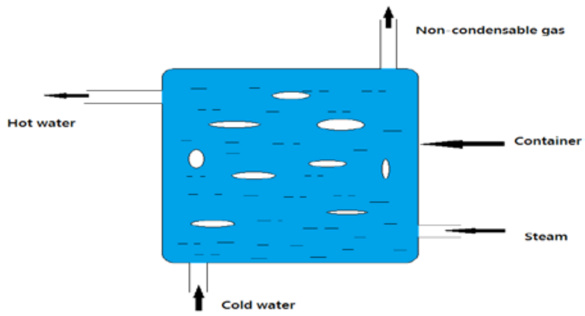


***Fig. 1.2 Schematic diagrams showing direct contact heat exchanger***

The two streams must also be at the same pressure in a direct contactor, which could result in additional fees. The benefits in utilizing a direct contactor include the dearth of surfaces to corrode or foul, or otherwise degrade the warmth transfer performance.Cooling tower, jet condenser, de-super heaters, open feed water heater are the example of this sort of heat exchanger

### 1.2.1.2 Transfer type heat exchanger

In transfer kind or recuperate sort of heat exchanger two fluids flow concomitantly through two tube seprated by walls. A recuperator is a distinctive motive counter flow power regaining heat exchanger situated within the supply and deplete air streams of an air coping system, or within the exhaust gases of a industrial process in order to recover the waste heat.

### 1.2.1.3 Regenerator type heat exchanger

In Regenerator type heat exchanger the cold fluid glide and warm fluid flow instead on same surface. In the course of the recent fluid switch the surface wall of warmth exchanger get heated and when the cold fluid flows through it, wall heat get transferred to the cold fluid and heat exchanges in direction that the temperature of cold fluid get increase. The common instance of these kind of heat exchangers is pre-heater for blast furnace, steam power plant and so on.

### 1.2.2 On the Basis of Constructional Features

### 1.2.2.1 Tubular Heat Exchanger

Tubular heat exchangers are the category of heat exchange device in which two different fluids having changed temperatures are separate by the two concentric tubes. It is mostly used in many engineering application like power plant.

### 1.2.2.2 Shell and Tube type Heat Exchanger

Shell and tube cluster of warmth exchanger consists of shell and large variety of parallel tubes. The warmth transfer takes places when one fluid flows through the tube and another fluid flows outside the tube that is privileged the shell of the exchanger. These varieties of device having giant surface area. Through baffles heat transfer rate of warmth exchanger get improved or it increases the turbulence inside the warmth exchanger.

### 1.2.2.3 Finned tube Heat Exchanger

In order to improve the heat transfer rate, fins are provided on the outer surface of the heat exchangers. Those are used in gas to liquid heat exchanger and fins are placed on the gas side. These are used in gas turbine, aero plane, warmness pumps, automobiles etc.

### 1.2.2.4 Compact heat exchanger

A compact heat exchanger to be characterized as heat exchanger which has area density (β) greater than $700m^2/m^3$ for gas or higher than $300m^2/m^3$ when working in liquid or two phase streams. For example car radiators which has an area density in order to 1100 $m^2/m^3$. Compact heat exchanger are cross flow type where two fluid flows perpendicular to each other.

### 1.2.3 According to flow arrangement

There are three primary classifications of warmth exchangers on the premise of flow. In parallel-flow heat exchangers, the two form of fluids enter the money changer at the identical finish, and travel in parallel to one another to the opposite finish. In counter-flow heat money changers the fluids enter the exchanger from completely different ends. The counter current style is that the utmost effective, it will transfer the foremost heat from medium per unit mass due the common activity on any unit size is higher. See countercurrent exchange. In an exceedingly cross-flow device, the fluids travel equally at right angles to one another through the money changer. For potency, heat exchangers are created to maximize the extent of the wall between the two fluids, whereas reducing resistance to fluid flow within the money changer. The exchanger's act may also be littered with the addition of fins, that increase extent and should waterway fluid flow or induce commotion. The driving temperature across the warmth transfer surface varies with position, however associate appropriate mean temperature are often well-defined. In most straightforward systems this is often the "log mean temperature difference" (LMTD).

### 1.2.3.1 Parallel Flow

A double tubes device may be running in parallel flow mode as shown within the diagram. equally a shell and tube device area unit running in near parallel flow whereas having two fluids enter at one aspect and exit at the opposite aspect. With same direction flow the temperature distinction between the two fluids is massive at the coming into finish, however it develops tiny at the exit finish because the two fluid temperatures near one another.

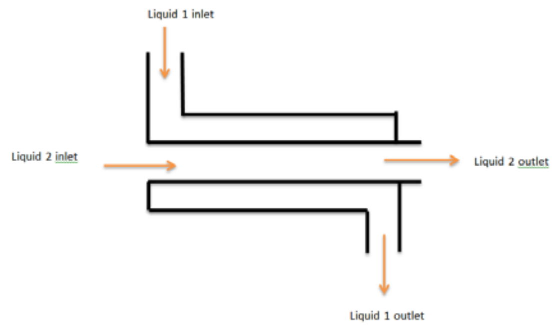


***Fig. 1.3Schematic diagram of a double pipe parallel flow heat exchanger***

The general live of heat transfer driving pressure, the log mean temperature distinction is larger for counter flow, then the warmth money dealer surface region demand could also be larger than for a counter associate with the flow device with the identical recess and outlet temperatures for the recent and the cold fluid.

#### 1.2.3.2 Counter Flow

A counter flow device is that the only pattern of flow of the three. It ends up in all-time low needed device area as a result of the log mean temperature drop is that the perfect for a counter flow device. A counter flow device has the recent fluid getting into at one finish and cold fluid at the choice stop. Kind of flow most typically type liquid-liquid device, as a result of it's for higher effective compare to alternative.

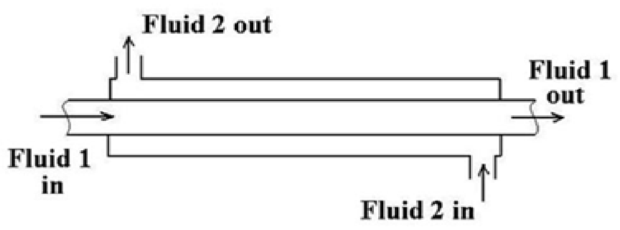


*Fig. 1.4 Schematic diagram of a double pipe counter flow heat exchanger [23]*

#### 1.2.3.3 Cross flow

An automobile radiator associate cooling system evaporator coil are samples of cross flow heat exchangers. In every instances heat transfer is taking location among a liquid flowing interior a tube or tubes and air flowing on the so much facet the tubes. With a vehicle radiator, the new water among the tubes is being cooled by air flowing via the radiator between the tubes. With associate cooling system evaporator coil, air flowing past the evaporator coils are cooled by implies that of the cold refrigerant flowing within the tubes of the coil. Cross float heat exchangers are typically used for heat switch between petroleum and a liquid as in those examples.

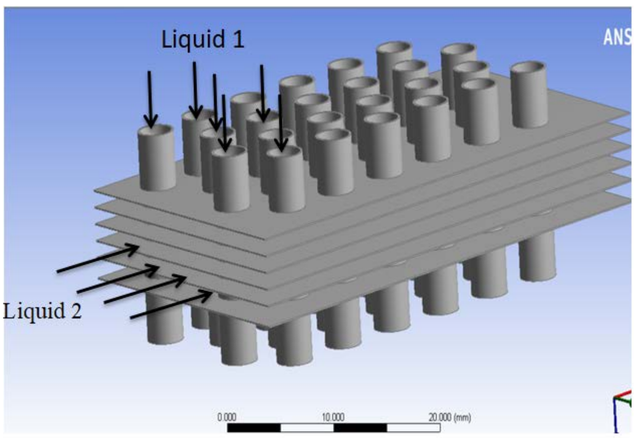


*Fig. 1.5 Schematic diagram of cross flow heat exchanger*

## II. LITERATURE REVIEW

### 2.1 Introduction

In later on the far side year, the changes in computing energy have extended the interest of engineers and researchers to simulate their troubles with procedure and numerical techniques. Plenty of procedure apparatuses and techniques are created within the foremost recent a protracted time to interrupt down liquid float, combustion, and specific techniques of heat alternate. Usage of warmth exchangers in widespread type of uses attracts within the professionals and researchers to paintings on this discipline.

**Camilleriet. al [1]**This paper presents a computationally economical flow network model to predict the flow distribution in compact multi-channel parallel flow heat exchangers. Compact U-type and Z-type heat exchangers with nine parallel channels were used as legal action thereon the model was valid to at intervals 4-8% in terms of non-dimensional flow distribution magnitude relation, the globe magnitude relation AR could be a crucial overall performance parameter which will indicate the degree of flow mal-distribution. Whereas flow mal-distribution was found to be heavily influenced by the friction issue and therefore the style of the manifolds. The impact of the recess jet rate is diminished by commutation the recess pipe by a diffuser that step by step slows the recess flow before getting into the manifold and reduces unexpected entry losses. As an alternative a spreading material is applied at the manifold recess to dissipate the mechanical energy of the flow at the expense of a rise in device pressure.

**Hajabdollahi et.al [2]**A plate fin device was optimally designed by choosing effectiveness and total annual price as two synchronal fitness functions mistreatment particle swarm optimization algorithmic program. owing to the variation of temperature and pressure within the money handler passages, the non-uniform properties are occurred throughout the warmth money handler to generalize the optimization results, the on top of procedure was performed for varied hot aspect recess temperatures. The case of SEG compared with UN-SEG. Moreover, % of variation in TAC inflated by increase of effectiveness and a device with higher hot aspect recess temperature had higher variation in TAC within the case of SEG compared with UNSEG. What is more, % of variation in effectiveness was more or less constant by variation of TAC and its price was higher for the upper hot aspect recess temperature. Finally, device required the lower fin pitch and fin height whereas the upper cold and hot stream lengths within the case of SEG compared with UN-SEG for the mounted price of effectiveness.

**Brandner et.al [3]**The facility transferred per unit volume is especially a operate of the gap between heat supply and warmth sink the smaller this distance, the higher the warmth transfer. Another parameter governing for the warmth transfer is that the lateral characteristic dimension of the warmth transfer structure; within the case of micro channels, this is often the hydraulic diameter. Decreasing this characteristic dimension into the vary of many 10s of micrometers results in terribly high values for the warmth transfer rate, the warmth transfer in microstructure heat exchangers is increased by decreasing the hydraulic diameter of micro channels, if the look relies on stacked foils comprising micro channels. Or else, it is increased by dynamic the look from micro channels to additional advanced geometries. As associate example, two completely different layouts of small column arrays were compared with reference to their heat transfer capabilities at a given mass flow. A primary example of the economic production application of associate electrically battery-powered small device was conferred. within the future, additional improvement of small heat exchangers are going to be continued by systematic studies of the dependence of warmth transfer properties on geometric structure dimensions and surface properties, to call simply the foremost vital parameters..

**Kim et.al [4]**The thermal performance and uniformity of frost growth between the front- and rear-sides of tiny channel heat cash dealers was investigated as a perform of the depth of the heat money changer, the pitch of the fins, and so the pitch of the channels. Throughout the defrosting cycle, compared with natural convection, forced convection defrosting resulted among the unit long less water between the fins, leading to improved thermal performance. Device resulted in further uniform frost growth between the front- and rear-sides, And an enlarged heat transfer rate per unit volume. Heat exchangers with a bigger fin pitch showed less reduction within the heat transfer rate throughout the center stages of the experiment owing to additional uniform frost growth with slower frost growth at the front-side. Heat exchangers with an enlarged channel pitch had a bigger initial heat transfer rate thanks to the larger fin surface area; but, the frost growth was less uniform and, as a result, the warmth transfer rate bated considerably within the latter stages of the experiment. Additional uniform frost growth between the front- and rear-sides of the warmth money dealers resulted within the improved thermal performance of the warmth exchanger.

## III. METHODOLOGY AND MATERIAL USED

### 3.1 Introduction

Here in this chapter is considered step that are taken to fulfill the objective of the work and also contains the material used for the different purposes.

### 3.2 Steps to be followed

1. Study of heat exchanger and there types.
2. Literature survey and problem identification.
3. Development of solid model of heat exchanger on the basis of geometry given in the base paper.
4. Development of CFD model of the heat exchanger for numerical analysis.
5. Validation of the numerical analysis with the experimental analysis performed in the base paper.
6. Finding the effect of different shape of perforation on the heat transfer inside the heat exchanger.
7. Finding the effect of transformation in velocity on the heat transfer.
8. Calculating the value of nusselt number and friction factor for altered geometry at different velocity.
9. Comparison of different types of baffles for heat transfer.
10. Report preparation.

### 3.3 Material Used

Here in this work water is used as a hot fluid, which is flowing in the inner tube, whereas air is used as a cold fluid which is flowing in the outer tube. Here in this work inner tube is prepared of copper whereas outer tube is of Plexiglas. The properties of different material used .

## IV. RESULT AND DISCUSSION

Water to air heat exchanger can be selected on the basis of different application. It can be utilized for residential heating and dehumidification. Swirl flow device are one of the similar way for heat transfer enhancement which becomes popular due to low price. To find out the effect of different Reynolds number (Re) on heat transfer hear it considered four different Re of cold fluid that is 6000, 8000, 10000, 12000. To enhance the heat transfer from water to air baffles were placed in the outer surface of inner tube. Due to the baffles turbulence and contact time were increased which helps in increasing the heat transfer. In this work it considered three different shapes of perforated helical baffles that are triangular, square and circular perforated helical baffles to enhance heat transfer rate. Here it calculate the value of nusselt number for different Re and also calculate the value of friction factor for different nusselt number. To measure the heat transfer increasing due to baffles hear it also calculate the value of thermal performance for different perforated baffles. To complete the objective numerical model of the heat exchanger is develop in the below section.

## V. CONCLUSION

From the analysis following conclusion were drawn

1. From the numerical investigation of discontinuous helical perforated baffles, it is determine that the heat transfer.
2. The value of Nu number and Re number of cold fluid flowing in the outer pipe.
3. The value of Nu number heat exchanger having discontinuous helical baffles with square perforation as compared to the heat exchanger with circular and triangular perforation.

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