CFD Analysis of Double Pipe and Triple Pipe Heat Exchanger

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Abstract: A heat exchanger is a device that is used to transfer thermal energy (enthalpy) between two or more fluids, between a solid surface and a fluid, or between solid particulates and a fluid, at different temperatures and in thermal contact. Heat exchangers are important engineering devices in many process industries since the efficiency and economy of the process largely depend on the performance of the heat exchangers. The present work is directed towards the modeling of double pipe and triple pipe heat exchanger in solid works .CFD analysis is carried out for both double and triple pipe heat exchanger using Ti02 Nano fluids .The LMTD and heat transfer coefficient is calculated for the heat exchangers. The flow trajectories to visualize the resulting flow field .Finally compared the flow simulation results for both double and triple heat exchanger. By observing the results the heat transfer coefficient has been increased 2.5 times by use Tio2 nano fluid in double pipe heat exchanger. By observing the results the heat transfer coefficient has been increased almost 3 times by use Tio2 nano fluid in triple pipe heat exchanger.

***IndexTerms* - CFD analysis double and triple heat exchange Ti02 Nano fluids.**

I. INTRODUCTION

Heat exchangers are important engineering devices in many process industries since the efficiency and economy of the process largely depend on the performance of the heat exchangers. High performance heat exchangers are, therefore very much required. Improvement in the performance may result in the reduction in the size of the heat exchangers of a fixed size can give an increased heat transfer rate.

A heat exchanger is a device that is used to transfer thermal energy (enthalpy) between two alternately more fluids, between a strong or solid surface and a fluid at distinctive temperatures and in thermal contact. In hotness or heat exchangers, there are normally no external heat and work collaborations. Commonplace applications include warming(heating) or cooling of a fluid stream of concern and dissipation or buildup of single-or multi segment fluid streams. In different applications, the destination may be to recover or reject heat, or sterilize, distill, fractionate, concentrate, pasteurize, crystallize, or control a process fluid. In a couple of heat exchangers, the fluids trading or exchanging hotness or temperator are in immediate contact. In mostly heat exchangers, high temperature exchange or heat tranfer between fluids happens through a dividing divider(wall) or into and out of a divider(wall) in a transient way. In numerous heat exchangers, the fluids are differentiated by a heat transfer surface, and in a perfect world they don't blend or break. Such exchangers are named as direct exchanger, or essentially recuperate. In contrast, exchangers in which there is intermittent heat exchange between the hot and cold fluids—via thermal energy storage and release through the exchanger surface or matrix— are referred to as indirect transfer type, or fundamentally regenerators. Such exchangers usually have fluid leakage from one fluid stream to the other, due to pressure divergences and matrix rotation/valve switching. Common examples of heat exchangers are automobile radiators, condensers, shell-and-tube exchangers, evaporators, cooling towers, and air pre heaters. On the off chance that no stage change happens in any of the fluids in the exchanger, it is here and there alluded 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 exchangers. Mechanical devices may be used in some exchangers such as in scraped surface exchangers, agitated vessels, and stirred tank reactors. Heat transfer in the separating wall of a recuperator generally takes place by conduction.

1.1 Classification of Heat Exchangers According to the Flow Direction:

a) Parallel flow
b) Cross flow
c) Counter flow

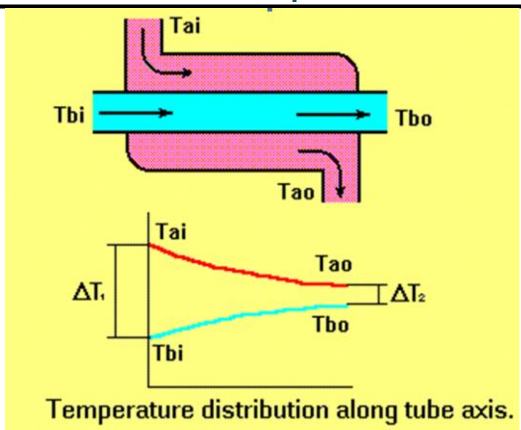


Fig: 1 Parallel flow Heat Exchanger

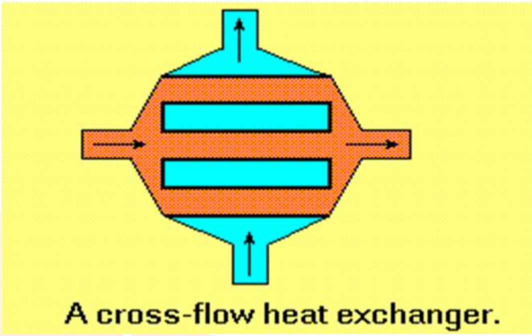


Fig 2: Cross flow Heat Exchanger

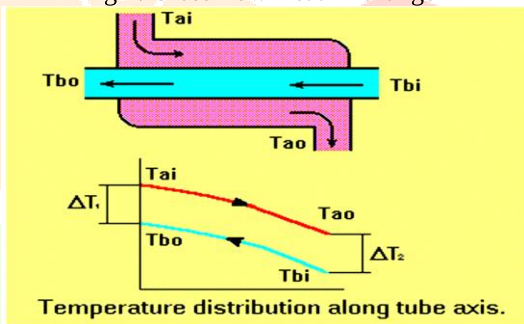


Fig: 3 counter flow heat exchanger
Types of heat exchangers

1.2 Shell and Tube Heat Exchanger
Compact Heat Exchanger
Shell and Tube Heat Exchanger

- Shell and tube heat exchangers consist of a series of tubes. One set of these tubes contains the fluid that must be either heated or cooled. The second fluid runs over the tubes that are being heated or cooled so that it can either provide the heat or absorb the heat required.

1.3 Compact Heat Exchanger

- Compact heat exchangers are a class of heat exchangers that incorporate a large amount of heat transfer surface area per unit volume.

The compact heat exchangers are :
a. Plate heat exchanger
b.Plate fin heat exchanger
c.Spiral heat exchanger
a.Plate heat exchanger
plate heat exchanger is composed of multiple, thin, slightly separated plates that have very large surface areas and fluid flow passages for heat transfer. This stacked-plate arrangement can be more effective, in a given space, than the shell and tube heat exchanger

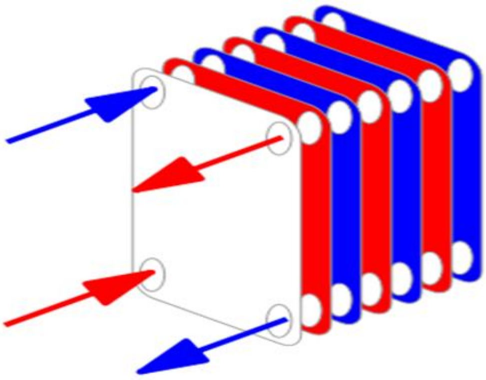


Fig: 4 b.Plate and fin heat exchanger

This type of heat exchanger uses "sandwiched" passages containing fins to increase the effectiveness of the unit

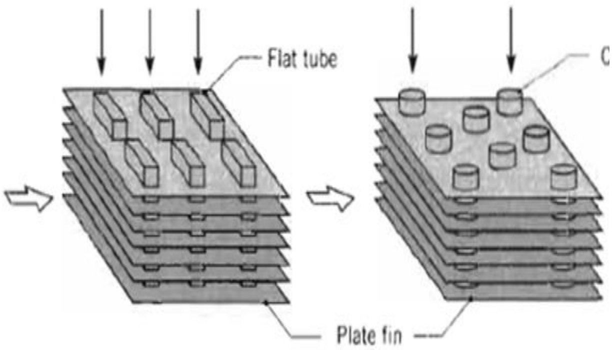
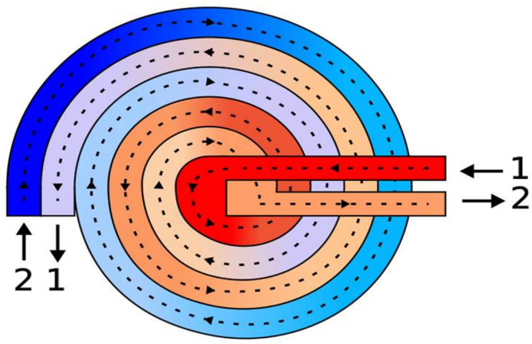


Fig: 5 c.Spiral heat exchanger

A spiral heat exchanger (SHE), may refer to a helical(coiled) tube configuration, more generally, the term refers to a pair of flat surfaces that are coiled to form the two channels in a counter-flow arrangement. Each of the two channels has one long curved path.



1.4 Applications of Heat Exchangers

- Heat exchangers are used in a wide variety of applications such as home heating, refrigeration, air conditioning, petrochemical plants, refineries as well as in natural gas processing.
- In many industrial processes a heat exchanger helps in using the wasted heat from one process to be utilized in another process which saves a lot of money while being efficient at the same time.
- Cooling of hydraulic fluid and oil in engines, transmissions and hydraulic power packs.
- Heat exchangers are used in many industries, including:

  -Waste water treatment
  -Refrigeration
  -Wine and beer making
  -Petroleum refining
- In commercial aircraft heat exchangers are used to take heat from the engine's oil system to heat cold fuel.

1.5 Solid Work

- Solidworks is a mechanical design software which is feature based and parametric solid modeling and takes the advantage of easy to learn windows graphical user interface.
- It is an easy-to-learn tool which makes it possible for mechanical designers to quickly sketch ideas, experiment with features and dimensions, and produce models and detailed drawings.

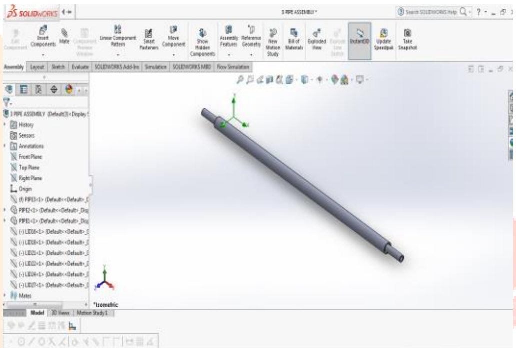
- A Solid Works model consists of parts, assemblies, and drawings.

II. LITERATURE SURVEY

The goal of this chapter is to summarise some of the relevant studies from the extensive literature and material available on heat exchangers. This includes the latest studies on individual components using numerical techniques. The rationale is to put the present work in perspective with the state-of-the-art. For the past decades, several analyses of heat transfer and flow phenomena were carried out in components of heat exchanger tube side, shell side, fins, and baffles using numerical codes. The review is carried out on the literature available on heat exchanger. The complex nature of flow poses a challenge for both the numerical code and for the turbulence models. A review of previous works will highlight some of the drawbacks and challenges of obtaining a numerical solution of the flow. The review will also guide this work in presenting constructive results and conclusions on heat and flow modeling.

Behzadmehr et al., [1] have established numerically the critical Grashof numbers for transition from laminar to turbulent convection and relaminarization of fully developed mixed convection in a vertical pipe with uniform wall heat flux. A study of upward mixed convection of air in a long vertical tube with uniform wall heat flux has been conducted for two very low Reynolds numbers (Re=1000 and Re=1500) over a wide range of Grashof numbers (Gr 108) using a low Reynolds number k– model with proven capabilities of accurately simulating both laminar and turbulent flows. The results in the fully developed region define three critical Grashof numbers for each Reynolds number. The smallest critical value distinguishes the Re–Gr combinations that lead to a pressure decrease over the tube length from those leading to a pressure increase. The middle one corresponds to transition from laminar to turbulent conditions while the largest indicates the conditions for which relaminarization takes place.

III. **Double Pipe Heat Exchangers**



3.1 Triple Pipe Heat Exchangers

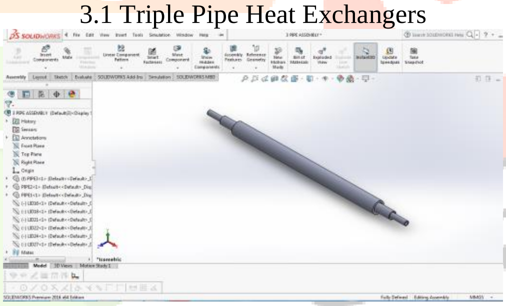
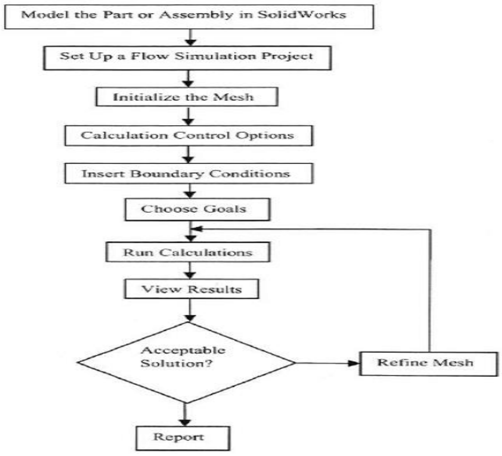


Fig: 6 Flow simulation /CFD analysis

- Solidworks flow simulation intuitive CFD[computational fluid dynamics] tool enables us to simulate liquid and gas flow in real world conditions .
- It uses CFD analysis to enable quick efficient simulation of fluid flow and heat transfer.
- We can easily calculate fluid forces and understand the impact of liquid and gas on product performance.
- We can compare design variations to make better decisions to create products with superior performance.

Steps involved in flow simulation



IV. CFD ANALYSIS OF DOUBLE PIPE HEAT EXCHANGER USING WATER AS FLUID

- Hot water from inner tube
- Cold water from outer tube

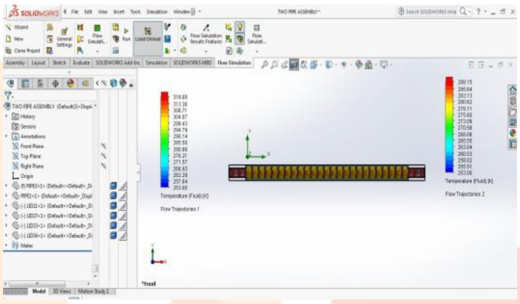


Fig: 7 Flow trajectories of cold and hot fluid

4.1 Cfd Analysis Of Double Pipe Heat Exchanger Using Tio2 Nano Fluid

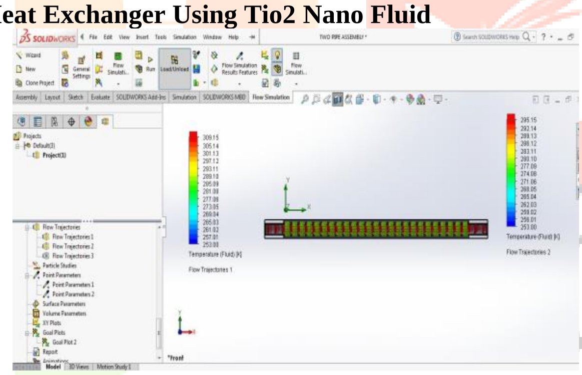


Fig:8 Flow trajectories of hot and cold fluid

4.2 Cfd Analysis Of Triple pipe Heat Exchanger Using Water As Fluid

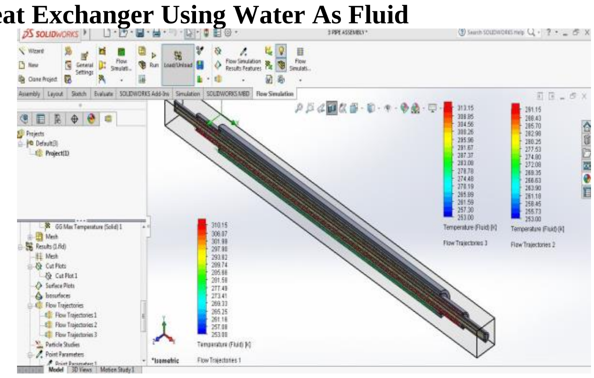


FIG:9 Flow trajectories of three fluids

4.3 Cfd Analysis Of Triple pipe Heat Exchanger Using Ti02 Nano Fluid

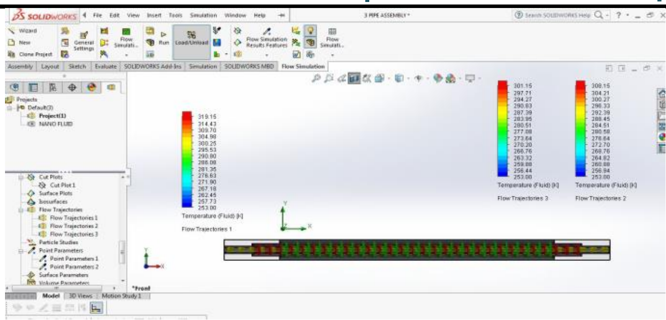


Fig: 10 Flow trajectories of three fluids

4.4 Results and Discussion for Double Pipe Heat Exchanger

S.no	Thi	Tho	Tci	Tco	LMTD(k)	Qav(kw)	h(w/m2k)	Fluid
1	323.15	318.15	278.15	288.15	37.4	5.23	59.85	Water
2	323.15	309.15	278.15	295.15	29.47	11.18	151.74	Tio2 nano

By observing the above results the heat transfer coefficient has been increased 2.5 times by use Tio2 nano fluid in double pipe heat exchanger.

4.5 Results and Discussion for Triple Pipe Heat Exchanger

S.no	Thi	Tho	Tci	Tco	Tni	Tno	LMTDavg(k)	Qav(kw)	h(w/m2k)	Fluid
1	323.15	313.15	278.15	291.15	298.15	310.15	23.72	14.5	122.2	Water
2	323.15	301.15	278.15	308.15	298.15	319.15	11.09	19.4	349.8	Tio2 nano

By observing the above results the heat transfer coefficient has been increased almost 3 times by use Tio2 nano fluid in triple pipe heat exchanger.

V. CONCLUSIONS

- The present work is directed towards the modeling of double pipe and triple pipe heat exchanger in solidworks .CFD analysis is carried out for both double and triple pipe heat exchanger using Ti02 Nano fluids .The LMTD and heat transfer coefficient is calculated for the heat exchangers. The flow trajectories to visualize the resulting flow field .Finally compared the flow simulation results for both double and triple heat exchanger.
- By observing the results the heat transfer coefficient has been increased 2.5 times by use Tio2 nano fluid in double pipe heat exchanger.
- By observing the results the heat transfer coefficient has been increased almost 3 times by use Tio2 nano fluid in triple pipe heat exchanger.

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