Cfd Analysis of Heat Transfer in Double Pipe Heat Exchanger

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ABSTRACT
In this paper computation fluid dynamics (CFD) is used to study of heat transfer characteristics of a double pipe heat exchanger for parallel flow and counter flow, and the results were then compared. The study showed that there is not much difference in the heat transfer within the error limits performance of the parallel-flow configuration and the counter-flow configuration. Nusselt number at different points along the pipe length was determined from the numerical data. The simulation was carried out for water to water heat transfer characteristics and for same length and same diameter of tube and for same input temperature for cold inlet 300k, for hot inlet 360k. We analyze that in counter flow heat exchanger there is high temperature difference in output streams (hot outlet, cold outlet). Nusselt number for the counter *flow heat exchanger 802 and parallel flow is 144.And Analysis is done in ansys workbench 15.1 and various contour plots and vector plots are presented.*

Keywords : Heat exchanger, heat transfer ehancement, CFD, heat transfer coefficient, pressure drop, Reynolds number.

INTRODUCTION:

A heat exchanger is a gadget that is utilized to exchange warm thermal energy (enthalpy) between two on the other hand more fluids, between a solid or strong surface and a fluid at unmistakable temperatures and in warm contact. In hotness or warmth exchangers, there are typically no outside warmth and work joint efforts. Typical applications incorporate warming (heating) or cooling of a fluid stream of concern and dispersal or development of single-or multi fragment fluid streams. In various applications, the goal might be to recuperate or dismiss heat, or sanitize, distil, fractionate, concentrate, purify, take shape, or control a procedure fluid. In a few warmth exchangers, the fluids exchanging or trading hotness or temperature are in prompt contact. In for the most part heat exchangers, high temperature trade or warmth exchange between fluids occurs through an isolating divider (wall) or into and out of a divider(wall) fleetingly. In various warmth exchangers, the fluids are separated by a warmth exchange surface, and ideally they don't mix or break. Such exchangers are named as immediate exchanger, or basically recover.

In contrast, exchangers in which there is irregular warmth trade between the hot and cold fluids by means of warm vitality stockpiling and discharge through the exchanger surface or framework are alluded to as circuitous exchange type, or on a very basic level regenerators. Such exchangers more often than not have fluid spillage from one fluid stream to the next, because of weight divergences and lattice pivot/valve exchanging. Regular instances of warmth exchangers are vehicle radiators, condensers, shell and-cylinder exchangers, evaporators, cooling towers, and air radiators. If no stage change occurs in any of the fluids in the exchanger, it is all over implied as a reasonable warmth exchanger. There could be inside warm vitality sources in the exchangers, for example, in electric radiators and atomic fuel component.

combustion and chemical response may occur inside the exchanger, for example, in boilers, fired radiators, and fluidized-bed exchangers. Mechanical gadgets might be utilized in certain exchangers, for example, in scratched surface exchangers, fomented vessels, and mixed tank reactors. Warmth move in the isolating mass of a recuperator for the most part happens by conduction.

Classification Of Heat Exchangers According To The Flow Direction:

a) Parallel flow b) Cross flow

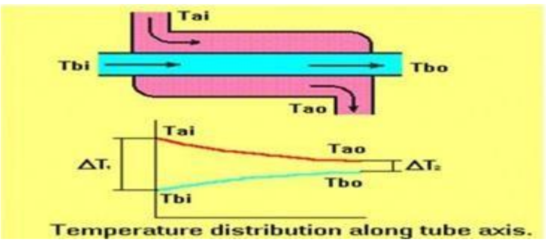

Fig1. Parallel flow

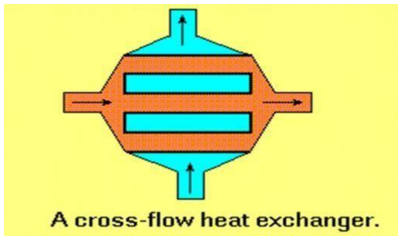

Fig2. Cross flow

. C) Counter flow

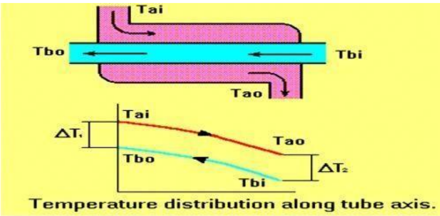

Fig3. Counter flow

In 2017, Rosyida Permatasari et al. in Material choice for shell and cylinder heat exchanger utilizing computational liquid elements considered three distinctive material of cylinder for counter stream heat exchanger and find that copper has best warmth exchange coefficient and less temperature drop along the length of the warmth exchanger. [1]

Masliyah et al. contemplated heat exchange qualities for a laminar constrained convection completely created stream in an inside triangular finned roundabout cylinder with pivotally uniform warmth transition utilizing a limited component method.for a smooth cylinder. Additionally, it was discovered that for greatest warmth exchange there exists an ideal blade number for a given balance design. [2]
Agarwal et al. examined Laminar stream and warmth move sizes in a finned cylinder annulus. Weight drop and warmth exchange qualities of the balances are gotten in the occasionally completely created area by changing geometric and stream parameters. Geometric parameters are annulus sweep proportion (0.3 to 0.5), balance tallness/annular hole (0.33 to 0.67) and blade dividing/annular hole (2 to 5). Stream parameters are Reynolds number (100 to 1000) and Prandtl number (1 to 5). Correlations are made with a plain cylinder annulus having a similar length, heat exchange surface territory, volume stream rate, and Reynolds number. They saw that a prandtl numbers less than2, the utilization of blades may not be defended in light of the fact that the expansion in weight drop is more articulated than the increment in warmth exchange. At a Reynolds number of 1000 and A Prandtl number of 5, the warmth exchange increments by of a factor of 3.1, while the weight drop increments by a factor of 2.3. [3]

Soliman et al. contemplated unfaltering, laminar , constrained convection heat move in the warm passageway district of inside finned tubes for the instance of completely created hydrodynamics. Results were introduced for 16 geometries including the nearby Nusselt number and creating length comparing to every limit condition. These outcomes demonstrates that interior finning impacts the warm improvement complicatedly, which makes it improper to stretch out the smooth cylinder results to inside finned tubes on a water powered distance across premise. [4]

Totala et al. directed investigations in a twofold pipe heat exchanger by giving strings in the internal pipe. They saw that Nusselt number, heat exchange coefficient were expanded for the strung pipe. Be that as it may, the siphoning power required additionally expanded contrasted with the plain cylinder. Khannan et al. considered the warmth exchange through a twofold pipe heat exchanger with annular balances. Three unique designs annular ring , winding pole and rectangular projection were considered outwardly surface of the external cylinder. Trials were finished with shifted mass stream rates. It was seen that heat exchange rate was expanded for a finned cylinder. Blade with annular ring demonstrated preferable execution over other strategy. [5]

METHODOLOGY:

1. Geometry:

Heat exchanger is built in the ANSYS workbench design module. It is a counter-flow heat exchanger. First, the fluid flow (fluent) module from the workbench is selected. The design modeler opens as a new window as the geometry is double clicked.

2. Sketching:

Out of three plane viz, XY -plane, YZ –plane and ZX –plane, the XY plane is selected for the first sketch. A circle of diameter 9.5 is drawn by selecting circle in sketching tab menu. Similarly by selecting again xy plane we draw another sketch with two circle having 9.5 mm and 11 mm, by repeating this process we create sketch no.3 and sketch no.4 having diameter of 28.5mm and 30.5mm respectively.

3. Extrude:

By choosing first sketch in xy plane expel it up to a length of 1600mm.again select another sketch Extrude it up to 1600mm and change activity from add material to include solidified. Essentially expel sketch 3 and sketch 4 upto 1600mm length in z-course and change task add material to include frozen. By extrudeing entire body and by changing activity from add material to include frozen we have four diffrent parts and four bodies**.**

Table 1: Naming of various parts of the body with state type

Part Number	Part Of The Model	State Type
1.	Inner fluid	Fluid
2.	Inner pipe	Solid
3.	Outer fluid	Fluid
4.	Outer pipe	Solid

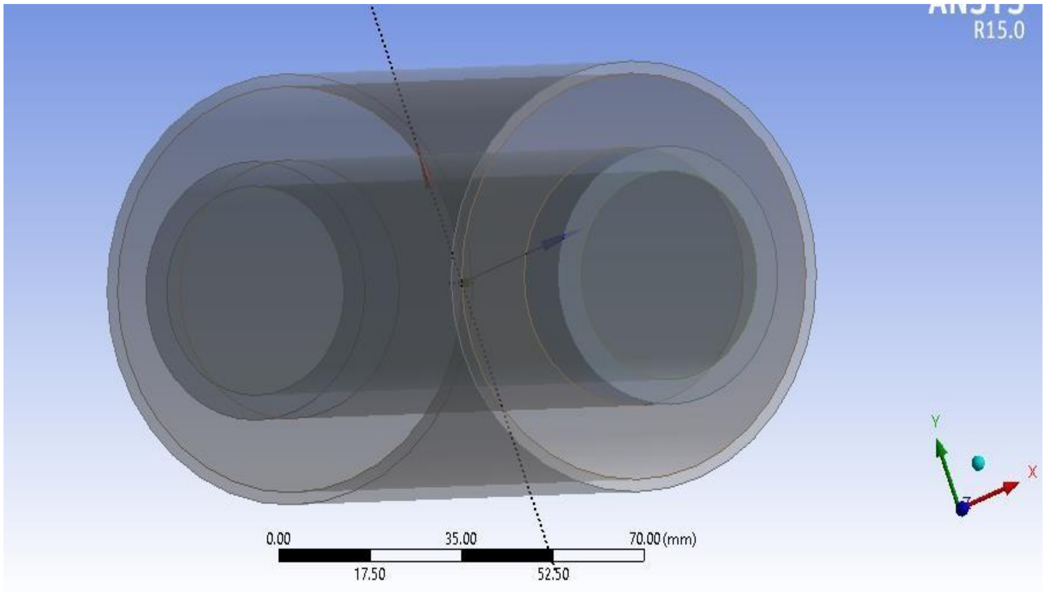

Fig.4 Geometry for meshing

4. Meshing:

At first a generally coarser mesh is created. This mesh contained blended cells (Tetra and Hexahedral cells) having both triangular and quadrilateral faces at the bounderies. Care is taken to utilize organized hexahedral cells however much as could reasonably be expected. It is intended to reduce numerical diffusion however much as could reasonably be expected by organizing the work in a well way, especially close to the divider region. Later on, a fine mesh is created. For this fine mesh, the edges and regions of high temperature and pressure gradients are finally meshed.

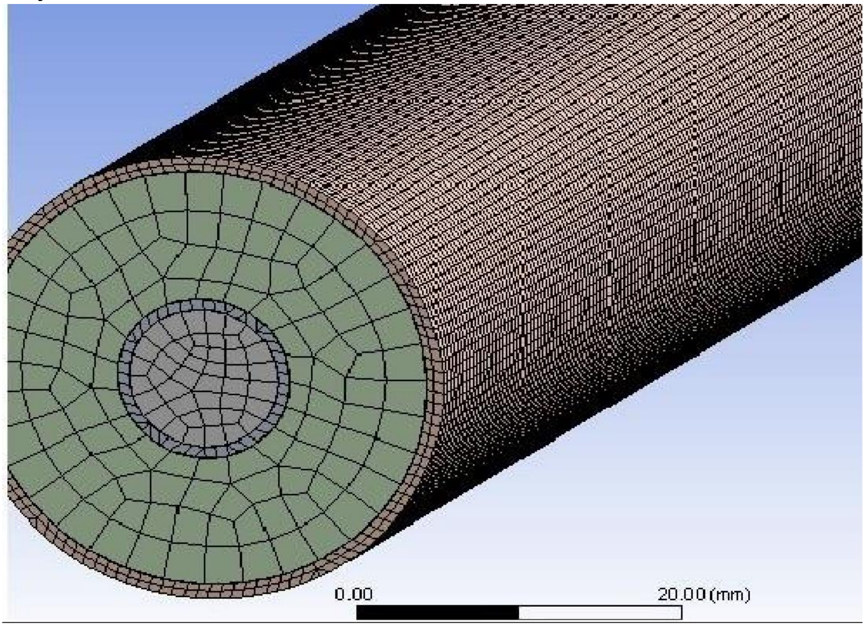

Fig.5 close view of mesh parts.

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Table 2: Details of mesh

Average orthogonal quality	0.747970
Number of element	703592
Number of nodes	1045694
Structure of element	Tetrahedral
Type of meshing element	Unstructured

5. Solution:

Problem Setup:

The mesh is checked and quality is obtained.The analysis type is changed to pressure based type.The velocity formulation is changed to absolute and time to steady state.Gravity is defined as y= -9.81m/s^2.

Models:

Energy is set to on postion. Viscous model is selected as "k-ε" model (2 equation).

Materials:

The create/edit option is clicked to add water-liquid and copper to the list of fluid and solid respectively from the fluent database.

Cell zone condition:

Inner and outer fluid assigned as water and inner and outer solid pipe assigned as material copper

BOUNDARY CONDITIONS:

Table 3: Boundary Condition for parallel and Counter flow Hex

S.no.	Boundary condition type	Mass flow rate magnitude	Turbulent intensity	Hydraulic diameter	Temperature
Hot inlet	Mass flow inlet	0.02 kg/s	4.6%	9.5 mm	360 k
Hot outlet	Pressure outlet	-	4.6%	-	-
Cold inlet	Mass flow inlet	0.02 kg/s	3.6%	17.5 mm	300 k

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Cold outlet	Pressure outlet	-	3.6%	-	-

REFRENCE VALUE:

The inner inlet is selected from the drop down list of "compute form". The values are:

- Area =1 m^2
- Density = 998.2 kg/m^3
- Length =1000 mm
- Temperature =360 k
- Velocity =0.28 m/s
- Viscosity =0.001003 kg/m-s
- Ratio of specific heats =1.4

SOLUTION CONTROL AND INITIALIZATION:

Under relaxation factors the parameters are:

- Pressure =0.3 Pascal
- .Density =1 kg/m^3
- Body forces =1 kg/$m^{2\ 2}$
- Momentum =0.7 kg-m/s
- Turbulent kinetic energy =0.8m^2/s^2

MEASURE OF CONVERGENCE:

Table 4: Residuals:

Variable	Residual
X- Velocity	10^{-6}
Y-Velocity	10^{-6}
Z- Velocity	10^{-6}
Continuity	10^{-6}
Specific dissipation energy	10^{-5}
Turbulent kinetic energy	10^{-5}
Energy	10^{-9}

CONVERGENCE PLOT:

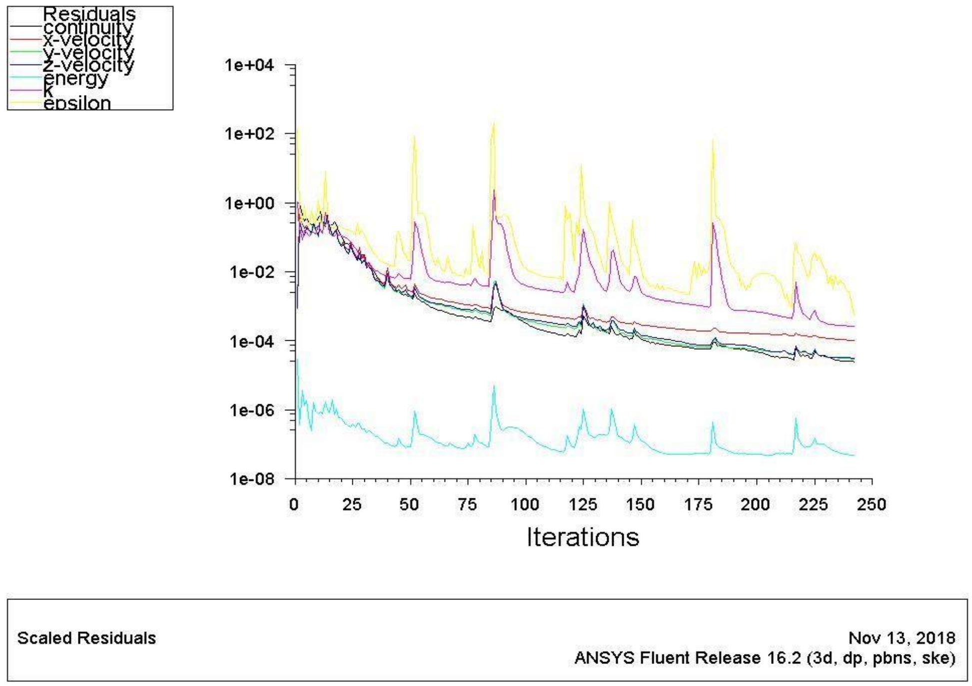

Fig.6 Residue plot for heat exchanger

The convergence of Simulation is required to get the parameters of the shell and tube heat exchanger in outlet. It additionally gives exact estimation of parameters for the requirement of of heat transfer rate. Continuity, X-speed, Y- speed, Z-speed, vitality, k, epsilon are the piece of scaled remaining which need to combine in a particular district. For the congruity, X-speed, Y-speed, Z-speed, k-epsilon ought to be under 10^{-4} and the energy should be less than 10^{-7}. If these all values in same manner then solution will be converged.

RESULTS AND DISCUSSION:

A CFD package (ANSYS FLUENT 15.1) was made for the numerical investigation of heat exchange qualities of a double pipe heat exchanger for parallel flow and counter stream, and the results were then compared.
The study showed that there is not much difference in the heat transfer within the error limits performances of the parallel-flow configuration and the counter-flow configuration. Nusselt number at different points along the points length was determined from the numerical data. The simulation was carried out for water to water heat transfer characteristics. And for same length and same diameter of tube and annulus and for same input temperature for cold inlet 300k, for hot inlet 360k. we analyze that in counter flow heat exchanger there is high temperature difference in output steams (hot outlet, cold outlet). Nusselt number for the counter flow heat exchanger 802 and for parallel flow is 144.

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