CFD ANALYSIS OF TRIPLE CONCENTRIC HEAT EXCHANGER

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Abstract
This study is focus on experimental and CFD analysis of triple concentric heat exchanger. Three fluids are used in three different pipes at different inlet temperature. The rib is implement in triple concentric pipe heat exchanger and seen the effect of this setup. After performing experimental result the CFD analysis is perform and compare both results.
Keyword: Triple concentric Heat Exchanger, Parallel flow, ANSYS, CFD analysis

1. Introduction

The need to understand the transfer of heat between various systems pertaining to the industrial as well as residential applications is an important process which has motivated the research community to improve in the design and performance of heat exchanger devices in recent years. The technology of heating and cooling of systems is one of the most basic areas of mechanical engineering. Wherever steam is used, or wherever hot or cold fluids are required we will find a heat exchanger. They are used to heat and cool homes, offices, markets, shopping malls, cars, trucks, trailers, aero planes, and other transportation systems. They are used to process foods, paper, petroleum, and in many other industrial processes. They are found in superconductors, fusion power labs, space crafts, and advanced computer systems. The list of applications, in both low and high tech industries, is practically endless. In heat exchangers, there are usually no external heat and work interactions.

1.1 Classification of heat exchangers

Heat exchangers are classified according to:-

- Transfer process
- Number of fluids
- Degree of surface contact
- Design features
- Flow arrangements
- Heat transfer mechanisms

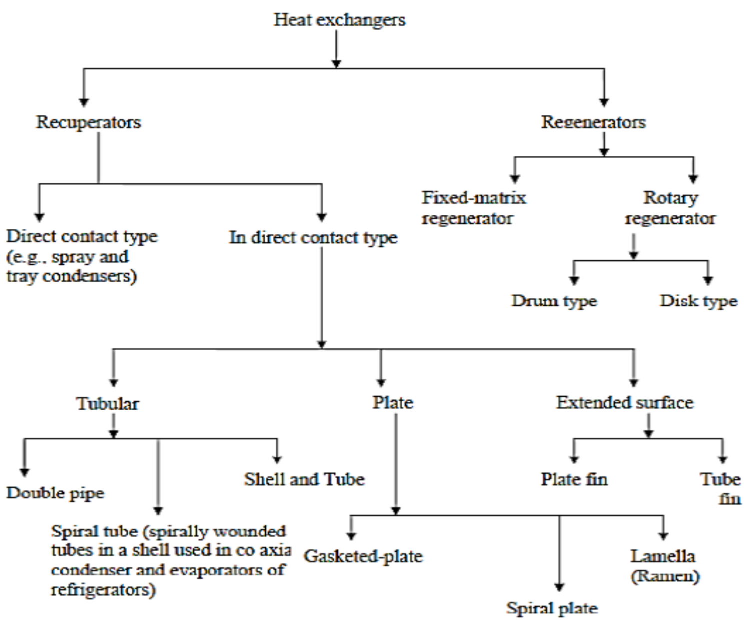

Figure 1classifications of heat exchangers

2. LITERATURE SURVEY

[1] G.A. Quadir et al. observed that the crossover purpose occurs between hot and traditional water for insulated also as non-insulated conditions under N–H–C arrangement. The crossover purpose is seen once rate of hot water is same or slightly but that of different 2 flu-ids flow rates. The crossover purpose appears early on the length of heat exchange r once the outer annulus is exposed to close having higher temperature than that of the fluid in outer annulus. The heat transferred from hot water to fluid in outer annulus is higher in N–H–C arrangement whereas it's almost same for each the flu-ids in C–H–N arrangement.

[2] Patel Dharmik A et al.

- For triple concentric tube heat exchanger factors which affect the performance ought to be relation in sizes or radius of inner tube, inner annulus and outer annulus, mass flow rate, material of tube.
- With the increase in inner tube diameter heat transfer rates of hot fluid, inner cold fluid and outer cold fluid increased, heat transfer coefficient of hot fluid was increased and heat transfer coefficient of inner cold fluid was decreased. Heat transfer coefficient of outer cold fluid remains constant.
- Overall heat transfer coefficient based on inner diameter of inner annulus and effectiveness was increased with the increase in inner tube diameter.
- With the increase in inner annulus diameter heat transfer rate of hot fluid and inner cold fluid increased up to 26 mm after that it decreased due to decrease in temperature difference and flow became laminar. Heat transfer coefficient of hot fluid decreased whereas heat transfer coefficient of outer cold fluid was increased.
- Overall heat transfer coefficient based on inner diameter of inner annulus was also improved. Effectiveness of triple concentric tube heat exchanger was increased up to 26 mm and after that it was decreased.

[3] Mr. Ganesh V. Wafelkar et al. Following conclusions were observed during these experimentation:

1. It is found that for the equivalent Reynolds number efficiency of triple tube heat exchanger is 60% more than double tube heat exchanger.
2. From the experimental data we found that Nusselt number is 1.25 times of predicted Nusselt number.
3. Increasing effectiveness from 0.27 to 0.5 with respect to varying mass flow rate of cold water at same range of 'Re' varies from 1500 to 4500 .
4. Friction factor on hot fluid side is decreases as 'Re' increases and hence pumping power is reduced.

Hence from the above discussion we conclude that triple tube HEX is suitable for all industrial as well as automotive vehicles (it depends on temperature range).

[4] Dilpak Saurabh P et al. Subsequent conclusions can be drawn from our current study.

1) Study of the experimentation was complete and the procedure of experimentation was briefed here.
2) Experimentation was carried out for both flow arrangements, but here we mainly focused on two conditions, Vn=Vh=Vc = 35l/min and Vh=20l/min; Vn=Vc=35l/min.
3) The flow analyzed was co present parallel flow with N-H-C arrangement (Normal water in the inmost tube, Hot in the intermediate and Cold at the outermost tube)
4) When the flow rate is decreased in the hot tube there is decrease in the temperature rise of the normal and cold fluids
5) Results are presented in graphical as well as tabular form
6) Tolerating small difference, CFD results are close to the experimental results.

[5] Pierre Peigné et al. the TCTHE-NI is a static element which permits coupling a RSWPS with a MVHR unit in command to distribute heat power in the complete house and attain a better thermal comfort while ensuring occupants safety, indoor air quality and improving the combustion efficiency of the wood-burning appliance. This combined system is installed in two monitored low energy houses with a living area of 100 m² since September 2010 and first results presented and discussed evaluate its possibility and performance as well as inhabitant's satisfaction. In addition, a comparison between energy consumption of apartments equipped with the proposed system and another without will be carrying out including control of the system. This will be the subject of another article. Finally, since experimental and numerical results are during a sensible agreement, following step can consist to implement the mathematical model of the TCTHE-NI within a dynamic thermal simulation code for buildings.

[6] Achour Touatit et al. The technical-economic calculation is required for the design of economic hydrogen engine. The computer program developed in FORTRAN language provides us the optimal diameter corresponding to the minimum total cost of the heat exchanger (production and pumping costs to overcome pressure drops) for the same transferred thermal power. The obtained temperature fields help us to choose the desired temperatures. The effectiveness of the heat exchanger increases proportionally with the central tube radius. The developed model are often a superb tool to optimize the efficiency of triple concentric tube heat exchangers, and so the consumption of energy and matter. We have one optimum diameter, unlike previous studies, where they had two different optimal diameters, the first corresponds to the maximal heat exchanger efficiency and the last one to the minimal energy consumption required overcoming the pressure drop in the heat exchanger.

[7] Maulik Pancholi et al. Triple concentric tube heat exchanger performs better in counter flow arrangement then in parallel flow arrangements. C-H-N arrangement ha higher heat exchange rate then N-H-C arrangement. For higher mass flow rate, heat transfer rate is higher. Overall steady state counter flow arrangement for C-H-N arrangement with insulation with higher RE number is the best possible flow configuration for the triple concentric tube heat exchanger.

[8] Dilpak Saurabh P et al. The errors we get in CFD analysis with respect to analytical calculations are 6.7%. The errors in experimental investigation with respect to analytical calculations are 5.45%. These errors are tolerable as the assumptions considered are not practically achievable. From the present study, we can conclude that CFD results and the Experimental results were very much in agreement with the analytical calculations and our design is a success. Thus, use of CFD is very helpful in fabrication of heat transfer related equipment.

3. Objective

- To study the effect of rib design in triple concentric heat exchanger and determine the temperature at outlet.
- To carry out the process in analytical as well as experimental forms
- To compare the results and validate the values of CFD and experimental results
- To carryout the complete simulation process on Ansys 19.0

4. Methodology

- Collecting information and data related to the Heat Exchanger.
- Establish the correct setup of concentric pipe heat exchanger and determine outlet temperature by using thermocouple.
- After that parametric model of the Heat Exchanger is generated using ANSYS Design Modeler.
- Model obtained is analyzed using ANSYS 19 (FLUENT).
- Manual calculations are done.
- Finally, we compare the results obtained from ANSYS.

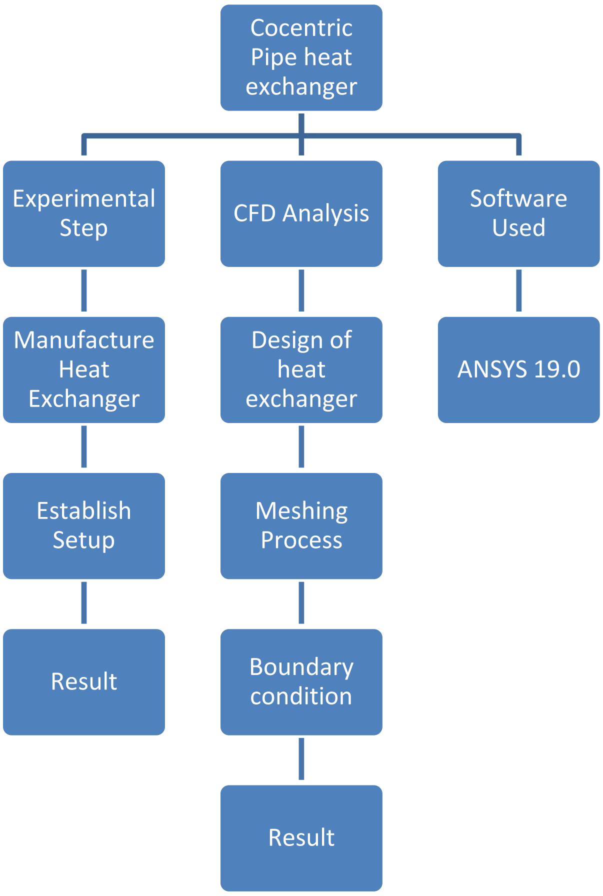

Figure 2 Flow Diagram of processs

4.1 Design of heat exchanger

The three concentric pipe heat exchanger, the exit temperatures of all the fluids flowing through the heat exchanger are to be known. For this, the finite element method is used. In the triple pipe heat exchanger three types of fluids i.e. hot water, cold water and normal tap water flowing in three pipes of the heat exchanger.

Table 1 Parameter of Heat Exchanger Model

S.NO.	Outer diameter	Thickness	Length
1	0.0508m	1.5mm	4m
2	0.0762m	1.5mm	4m
3	0.1016m	1.5mm	4m

4.1.1 Experimental process

Triple pipe heat exchanger is shown in figure, it consist three pipe which name is inside pipe, middle pipe and outer most pipe and three different temperature fluid is flow the fluid temperature is shown in table 3.

Three thermocouples are used in outlet of heat exchanger and measure outlet temperature of water and note down the readings.

Figure 3 Inlet of heat exchanger

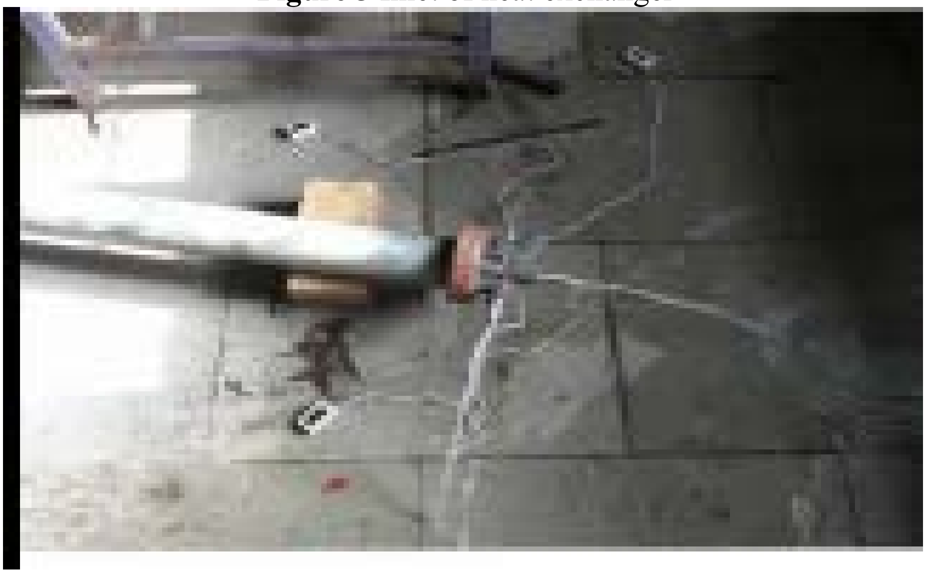

Figure 4 Outlet of heat exchanger

Figure 5 Measuring water temperature by using Thermocouple

4.1.2 Meshing

The total numbers of Node generated are 771356 & Total No. of Elements is 1765014 for Heat Exchanger Rib.

Table 2 Nodes and element of heat exchanger

Number of Nodes	771356
Number of element	1765014

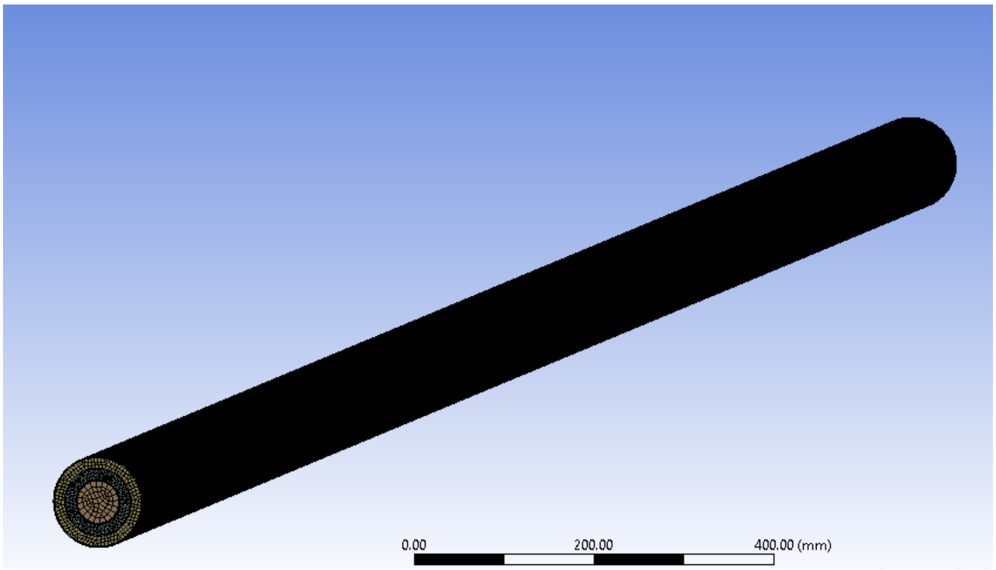

Figure 6 Meshing of heat exchangers

4.2 Boundary condition

The three fluids having the same volume flow rates as, $V_h = V_c = V_n = 35$ l/min under co-current parallel flow arrangement of the insulated heat exchanger. The inlet temperatures of the hot water, cold water, and normal water are 51.22 ^{0}C, 10.93 ^{0}C, and 27.47 ^{0}C respectively. The developed computer program is used to predict the temperature distributions of the three fluids along the length of the heat exchanger. All simulations were performed using ANSYS FLUENT that can simulate a two type of model of a Heat Exchanger.

Table 7 Inlet boundary condition

S.NO	Condition	Inlet temperature (°C)	Inlet velocity (l/min)
1	Cold	10.93	35
2	Hot	51.22	35
3	Normal	27.47	35

After applying the proper boundary condition the simulation is run. And the results were recorded.

5. Result

After performing CFD analysis the result are obtained as a term of temperature difference outlet to inlet section. The temperature is measure by using probe definition at different point of cold, hot and normal section.

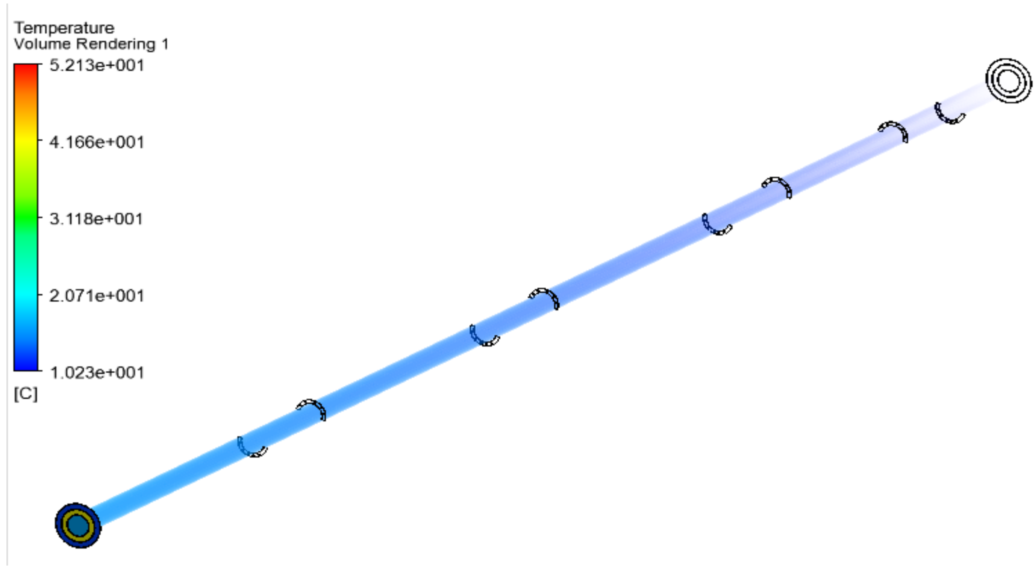

Figure 8 Temperature in cold section

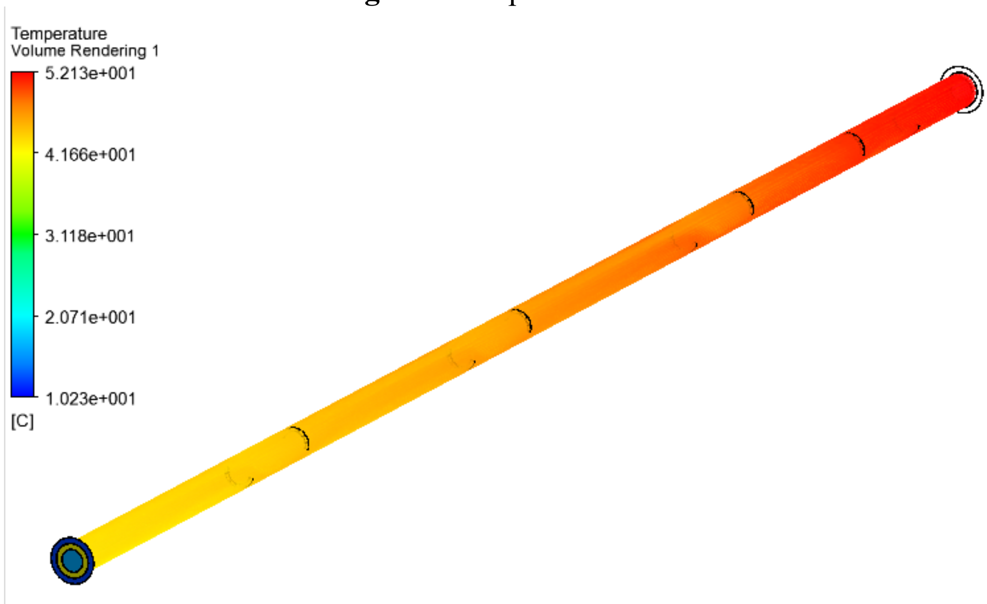

Figure 9 Temperature in Hot section

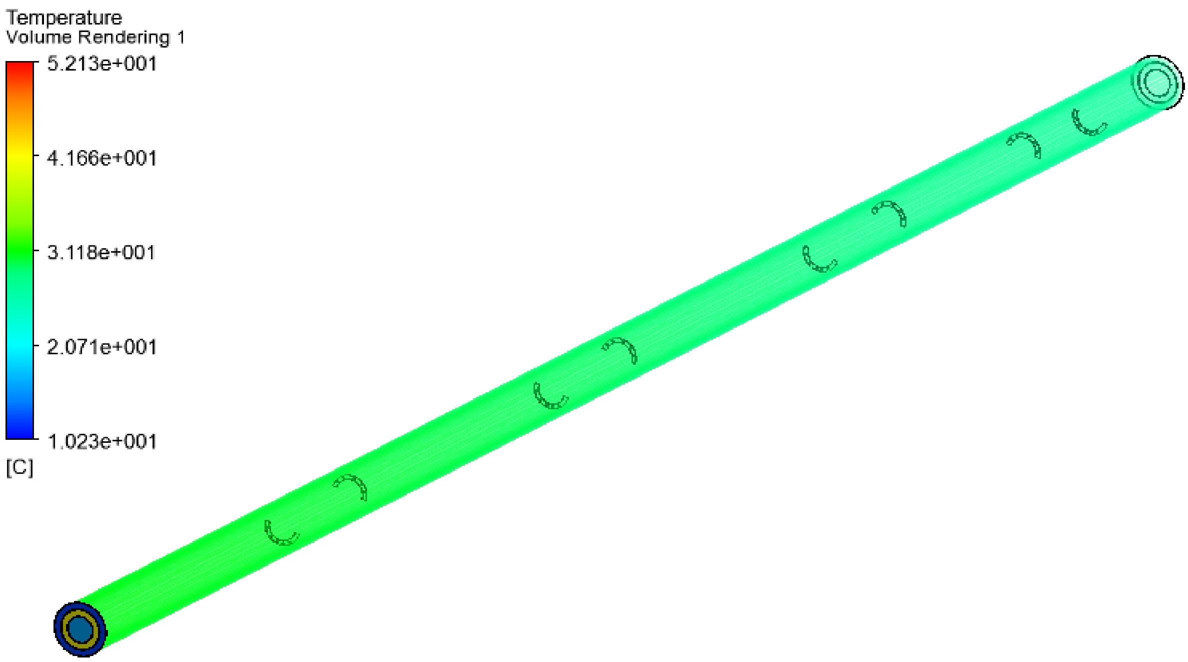

Figure 10 Temperature in Normal section

6. Validation of work

CFD and experimental result is compare, and it is obtained that the outlet temperature is both the research (CFD and experimental) are approximately same.

Table 4 Inlet and outlet temperature

	Inlet (C)	Outlet CFD (K)	Outlet Experiment (K)
Cold	10.93	22.5	20.3
Hot	51.22	31.5	29.2
Normal	27.47	30.6	33.0

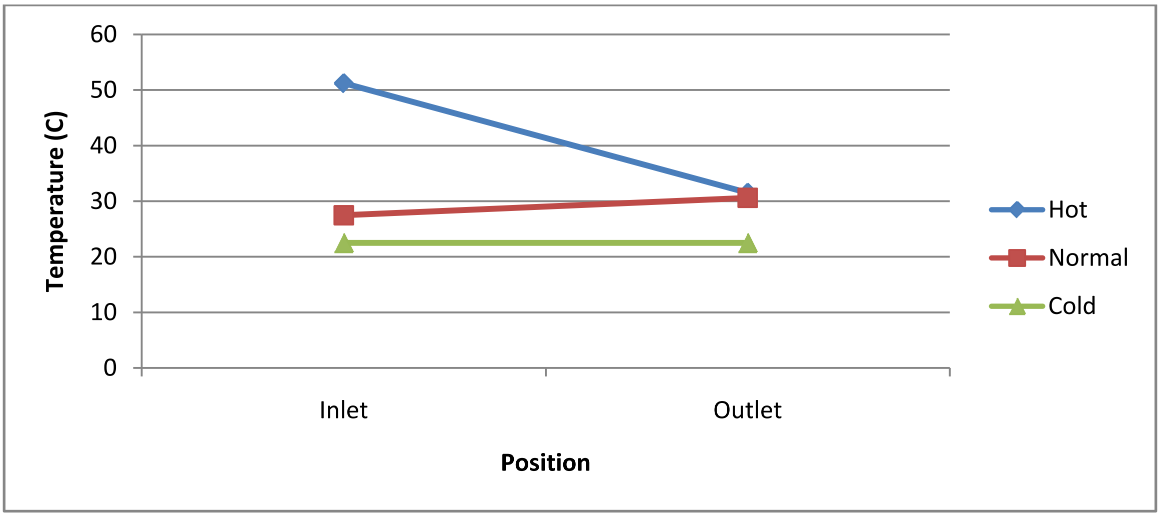

Figure 11 Inlet/Outlet temperature graph of CFD analysis

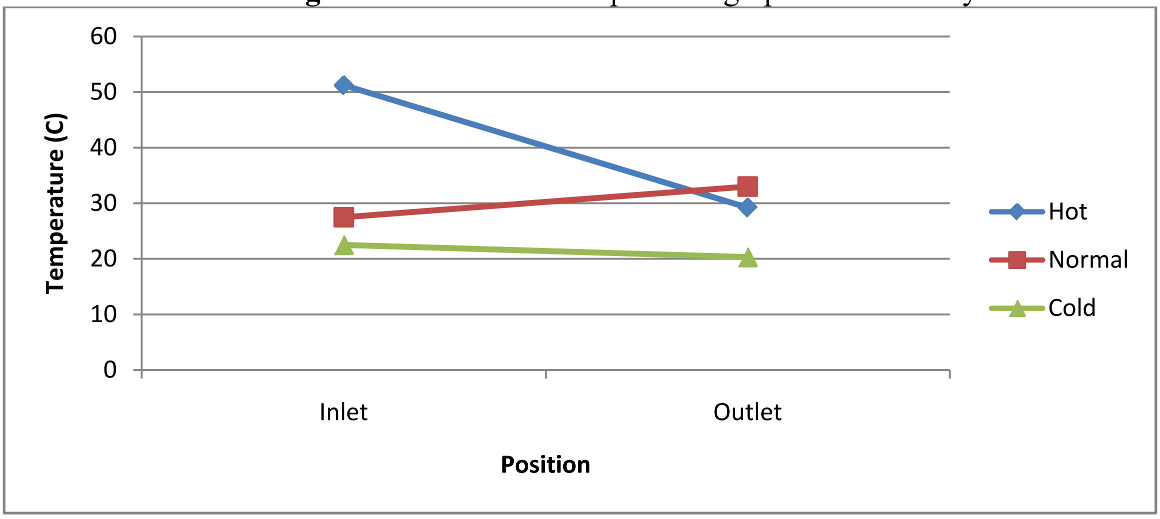

Figure 12 Inlet/Outlet temperature graph of CFD analysis

7. Conclusion

1. It is conclude that the following temperature range is obtained in outlet of pipe.
2. The flow analysed was co current parallel flow with C-H-N arrangement (Normal water in the outermost tube, Hot in the intermediate and Cold at the inner most tube)
3. When the flow rate is decreased in the hot tube there is decrease in the temperature rise of the normal and cold fluids
4. The temperature range of normal water, hot water temperature and cold water temperature of CFD analysis and experimental analysis is almost same.

8. References

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