**ISSN: 2581-3404 (Online)** **IF: 5.445 (SJIF)**

*International Journal of Innovative Research in Technology and Management, Volume-6, Issue-3, 2022.*

# Computational Fluid Dynamic Thermal Simulation on Double Pipe Heat Exchanger

**Sharad Kumar Jain[1], P K Sharma [2]**

**[1]MTech Research Scholar, Mechanical Engineering Department, NIRT College, Bhopal (M.P.)**

**[2]Principal & Professor, Mechanical Engineering Department, NIRT College, Bhopal (M.P.)**

**Abstract:** *The double tube or tube in the tube heat exchanger consists of a tube which is arranged concentrically in another tube of larger diameter. There are two types of flow in this configuration: parallel flow and counter flow. It can be organized into multiple series and parallel configurations to meet different heat transfer needs. The spiral arrangement stands out because it has found its place in various industrial applications. Since this configuration is widespread, knowledge of the heat transfer coefficient, pressure drop and various flow patterns has been of great importance. this analysis double pipe heat exchangers are divided into three different domains such as two fluid domains hot fluid in the inner tube and cold fluid in the outer pipe and a solid domain as helical baffles on inner tube of hot fluid. Mass flow rate cold fluid was varied from 0.1 kg/s to 0.3 kg/s while the flow rate in the inner tube i.e. hot water was kept constant at 0.1 kg/s.*

**Keywords:** CFD, Helical baffle, ANSYS, Heat exchanger.

## Introduction

The heat exchanger is an equipment that allows heat transference between two fluids at different temperatures. Heat exchangers are extensively used in industry due to their wide variety of construction and applications in heat transference processes for producing conventional energy such as condensers, heaters, boilers or steam generators. They provide an adequate surface for heat transference to occur and their mechanical and thermal characteristics allow high pressure and high temperature processes. Heat exchangers are important, their optimization rises the competitiveness and allows energy saving. The necessity of saving and recovering energy for different processes in industry makes essential the develop of new manufacturing technology for heat exchangers in order to cover a wide range of operation conditions. In recent years, new software for design heat exchangers has been focus in adapting the equipment to the required process and new solutions have been found that make the design time shorter. Tubular Heat Exchangers.Tube heat exchangers mainly consist of circular tubes, although different geometry has been used in other applications. This type of construction offers a high degree of flexibility in construction, since construction parameters such as diameter, length and layout can be easily changed. This type is used for the transfer of heat from liquid to liquid (phase changes such as condensation or evaporation). This type is also divided into tube bundle, double tube and spiral tube heat exchangers.

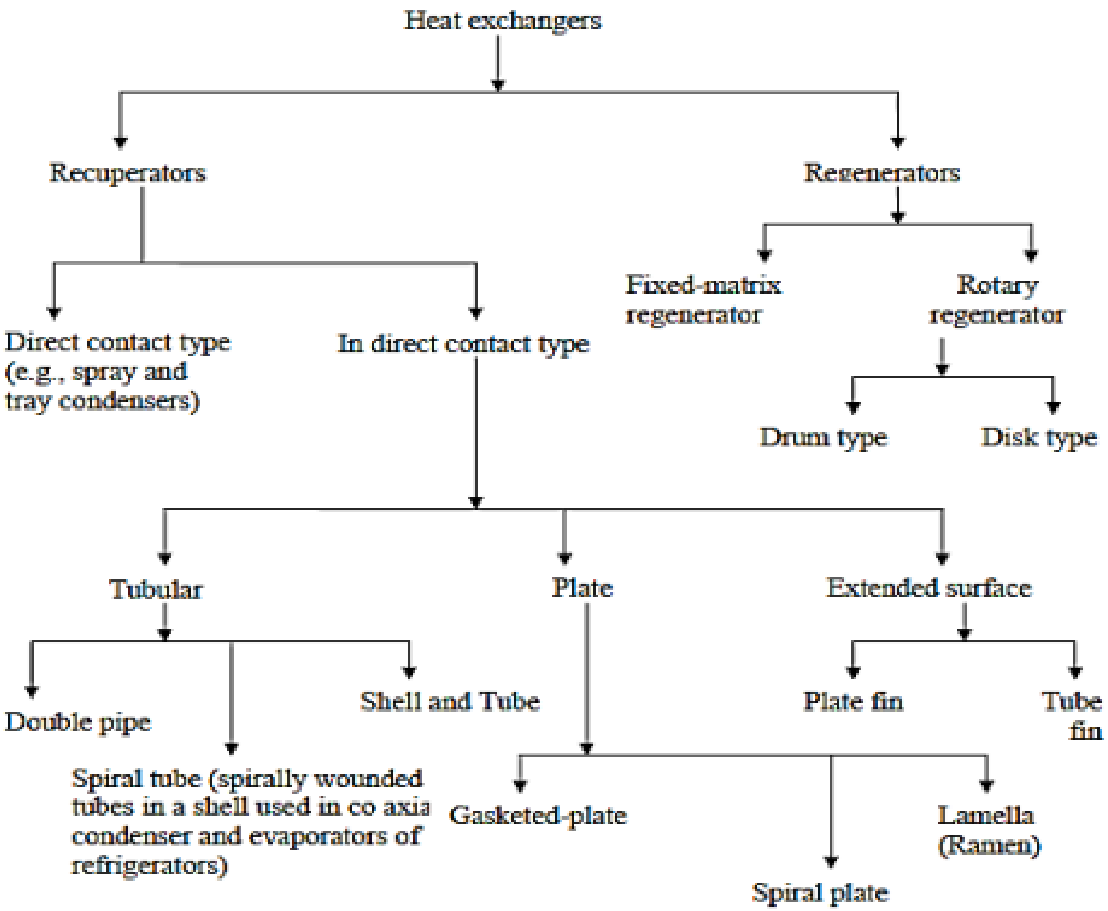


**Fig 1:** Classification of Heat Exchanger.

## II. Objective

There are following objective of the present work.

1. The main objective of the present work to performed three dimensional Computational Fluid dynamics analysis to evaluate the velocity, temperature, overall heat transfer coefficient for double pipe heat exchanger under condition of counter flow.
2. To design the different model of double pipe heat exchanger using Ansys design modular.
3. To perform CFD analysis for heat transfer in the heat exchanger under different operation conditions.
4. To compare the simulated results for different models of double pipe heat exchanger and propose best solution for better heat transfer

## III. Results

A. Computational fluid dynamics analysis for double tube heat exchanger

a. CAD model of double tube heat exchanger without baffle

In the present work a three dimensional CAD model of double tube heat exchanger is created with the help of design modular of ANSYS workbench. The inner diameter of tube is 0.01 m, for hot fluid, inner diameter for cold fluid is 0.016 m with 0.001 mm pipe wall thickness. The length of heat exchanger is 0.1 m. Single helical baffles with spacing of 33 mm pitch from top to bottom on outside of hot fluid pipe as shown in figure no. 2.

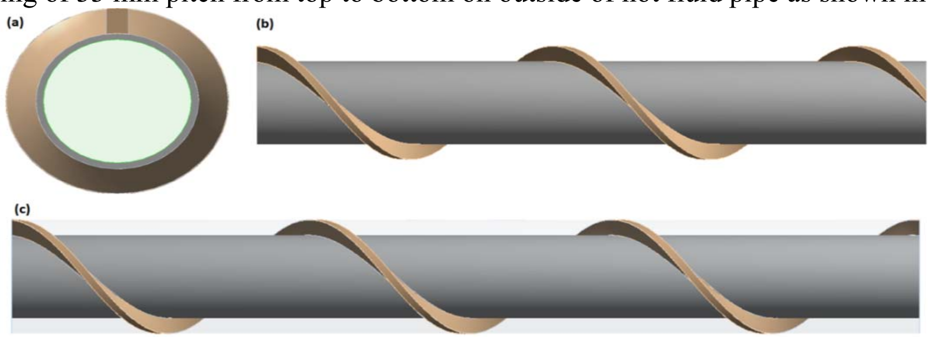


**Fig 2:** CAD model of double pipe heat exchanger without baffle; (a) Face side (b) Baffle (c) Volume of cold flow.

After performing computational fluid dynamics analysis of double pipe heat exchanger at different mass flow rate of hot and cold fluid varied from 0.1 kg/s to 0.3 kg/s while the inlet temperature of hot and cold fluid are 40$^o$C, and 15$^o$C respectively. The variation of temperature along the heat exchanger for hot and cold flow region as shown in below contours diagram.

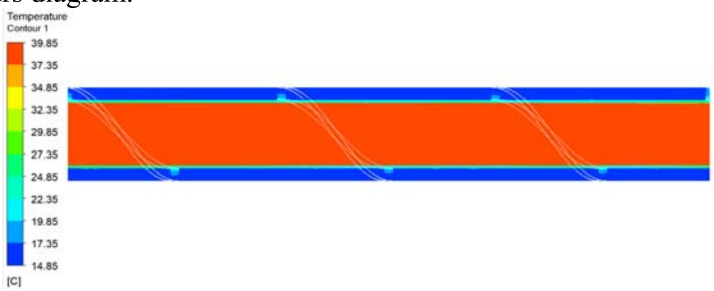


**Fig 3:** Temperature contours of double pipe heat exchanger at mass flow of 0.3 kg/s heat exchanger mid plane

After performing computational fluid dynamics analysis of double pipe heat exchanger at different mass flow rate of hot and cold fluid the velocity streamlines along the heat exchanger for cold flow region as shown in below contours diagram.

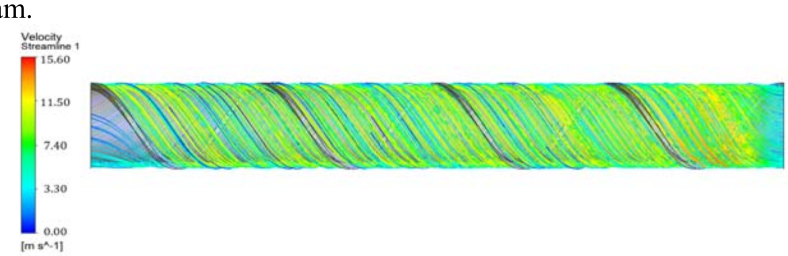


**Fig 4:** Velocity streamlines at mass flow 0.3 kg/s

It has been observed that the maximal velocity of the cold fluid flowing in annulus side is near the inlet at the entrance region because of the sudden reduction in the flow area.

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From the above validation work it has been observed that the compared result of temperature variation in cold fluid is about 1.23% and variation in velocity less than 1% from base paper which shows very good agreement with 1.23% error. After the validation from base model some other designs of double pipe heat exchanger have been used for computational fluid dynamics analysis to enhance the thermal performance of the double pipe heat exchanger.

It has been observed that the helically baffled in the laminar flow provides a better heat transfer characteristics then turbulent flow hence rest of all computational fluid dynamic analysis will performed using laminar flow.

**Comparative result analysis of double pipe heat exchanger**

**Table 1:** Temperature distribution and LMTD for double pipe heat exchanger without baffles.

| . mass flow rate | Temperature of Double pipe HE without baffles | | Temperature Increase in % for cold fluid | Temperature Decrease in % for hot fluid | LMTD | | |
|---|---|---|---|---|---|---|---|
| | Hot outlet | cold outlet | | | $\Delta T_1$ | $\Delta T_2$ | $\Delta T_m$ |
| 0.1 | 38.34 | 16.22 | 7.52 | 4.15 | 23.78 | 23.34 | 23.56 |
| 0.2 | 38.02 | 15.53 | 3.41 | 4.95 | 24.47 | 23.02 | 23.74 |
| 0.3 | 37.88 | 15.32 | 2.09 | 5.3 | 24.68 | 22.88 | 23.77 |

**Table 2:** Result Analysis of double pipe heat exchanger with single baffles

| mass flow rate | Heat transfer by hot fluid $Q_h$ [W] | Heat gain by cold fluid $Q_c$ [W] | Velocity of cold fluid $V_{in}$ [m/sec] | Reynolds No. for cold fluid [Re] | Nusselt No. for Cold fluid [Nu] | Convective Coefficient for Cold fluid[$h_c$] | Over all Heat transfer coefficient [U W/m$^2$.C] |
|---|---|---|---|---|---|---|---|
| 10.1 | 760.76 | 815.1 | 0.011 | 190.836 | 3.544 | 130.446 | 96.425 |
| 20.2 | 2541.44 | 2131.8 | 0.023 | 381.673 | 6.170 | 227.120 | 140.693 |
| 30.3 | 5053.62 | 4965.84 | 0.034 | 572.509 | 8.534 | 314.144 | 169.838 |

## IV. Conclusion

In the present work computational fluid dynamics analyses have been performed for double pipe exchanger used helical baffles with different spacing on the hot fluid pipe. For this analysis double pipe heat exchangers are divided into three different domains such as two fluid domains hot fluid in the inner tube and cold fluid in the outer pipe and a solid domain as helical baffles on inner tube of hot fluid. Mass flow rate cold fluid was varied from 0.1 kg/s to 0.3 kg/s while the flow rate in the inner tube i.e. hot water was kept constant at 0.1 kg/s. the inlet temperature of hot fluid taken as 40$^o$C while Cold fluid inlet temperature taken as 15$^o$C. Mathematical and computational fluid dynamic analyses have been performed and compared the results. for cold fluid are observed at 0.3 kg/sec mass flow rate for double pipe heat exchanger with single helical baffles. It has been also observed that the heat transfer coefficient increasing with the increasing in the mass flow rate of cold fluid. The overall heat transfer coefficients differ significantly by 20.4 % at same mass flow rate, because the considerable difference between heat transfer surface area on the inner and outer side of the tube resulting in a prominent thermal enhancement of the cold fluid. Application.

## References

[1] Osama A. Mohsen, Muhannad A. R. Muhammed "Heat Transfer Enhancement in a Double Pipe Heat Exchanger Using Different Fin Geometries in Turbulent Flow" June 2020.

[2] Hasan Sh. Majdi, Hussein A. Alabdly "Oil fouling in double pipe heat exchanger under liquid liquid dispersion and the influence of copper oxide nanofluid" Heat Transfer-Asian Research • May 2019.\

[3] Mateusz Korpyś, Grzegorz Dzido "intensification in turbulent flow of CuO–water nanofluids in horizontal coil" Chemical Engineering and Processing • June 2020.

[4] M. Sheikholeslami, Rizwan-ul Haq "Heat transfer simulation of heat storage unit with nanoparticles and fins through a heat exchanger" International Journal of Heat and Mass Transfer 135:470-478 • June 2019.

[5] P.C.Mukesh Kumar, M.Chandrasekar "CFD analysis on heat and flow characteristics of double helically coiled tube heat exchanger handling MWCNT/water nanofluids" Heliyon Volume 5, Issue 7, July 2019.

[6] Davood Majidi, Hashem Alighardashi "Experimental studies of heat transfer of air in a double-pipe helical heat exchanger" Applied Thermal Engineering 133:276-282 • March 2018.

[7] Luanfang Duan, Xiang Ling "Flow and heat transfer characteristics of a double-tube structure internal finned tube with blossom shape internal fins" Applied Thermal Engineering 128 • September 2017.

[8] Basim O Hasan, Enas A. Jwair "The effect of heat transfer enhancement on the crystallization fouling in a double pipe heat exchanger" Experimental Thermal and Fluid Science, 86 • April 2017.

[9] Mohamad Omidi, Mousa Farhadi "A comprehensive review on double pipe heat exchangers" Applied Thermal Engineering 110:1075-1090 • January 2017.

[10] J. M. Gorman, Kevin R. Krautbauer "Thermal and Fluid Flow First-Principles Numerical Design of an Enhanced Double Pipe Heat Exchanger" Applied Thermal Engineering 107 • June 2016.