ISSN : 2455-9679
Impact Factor : 4.256

ijrtsm

# IJRTSM

INTERNATIONAL JOURNAL OF RECENT TECHNOLOGY SCIENCE & MANAGEMENT

## "COMPUTATIONAL FLUID DYNAMICS THERMAL SIMULATION ON DOUBLE PIPE HEAT EXCHANGER"

***Ram Sagun Kumar* [1], *Neeraj Agrawal* [2]**
[1] *MTech Scholar, IES College of Technology, Bhopal MP*
[2] *Associate Professor, IES College of Technology, Bhopal MP*

## ABSTRACT

***Heat exchangers play an important role in the operation of systems such as the process industry, power plants and heat recovery systems. The main objective of this work is to compare different configurations of helical baffles in the cold fluid side of a double tube heat exchanger. 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°C while Cold fluid inlet temperature taken as 15°C. Mathematical and computational fluid dynamic analyses have been performed and compared the results. There are following conclusive points drawn from this work.***

***Key Words:*** *CFD, helical baffle, ANSYS, heat exchanger*.

## I. INTRODUCTION

The heat exchange between circulating liquids is one of the most important physical processes and a large number of heat exchangers are used in different types of systems, e.g. in the process industry, in the nuclear power plant for compact heat exchangers, in HVAC systems, in the food industry, in cooling, etc. The purpose of building a heat exchanger is to provide an efficient method for transferring heat from one fluid to another by contacting. Heat transfer is based on three principles: conduction, convection and radiation. Heat transfer due to radiation is not taken into account in a heat exchanger, since it is negligible compared to conduction and convection. Conduction occurs when the heat of the high temperature fluid flows through the surrounding solid wall. Conductive heat transfer can be maximized by choosing a minimum wall thickness of a highly conductive material. However, convection plays the main role in the execution of a heat exchanger. Forced convection in a heat exchanger transfers heat through the tube wall from one mobile flow to another. The cooler liquid extracts heat from the warmer liquid as it flows along or above.

### 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.

ISSN : 2455-9679
Impact Factor : 4.256

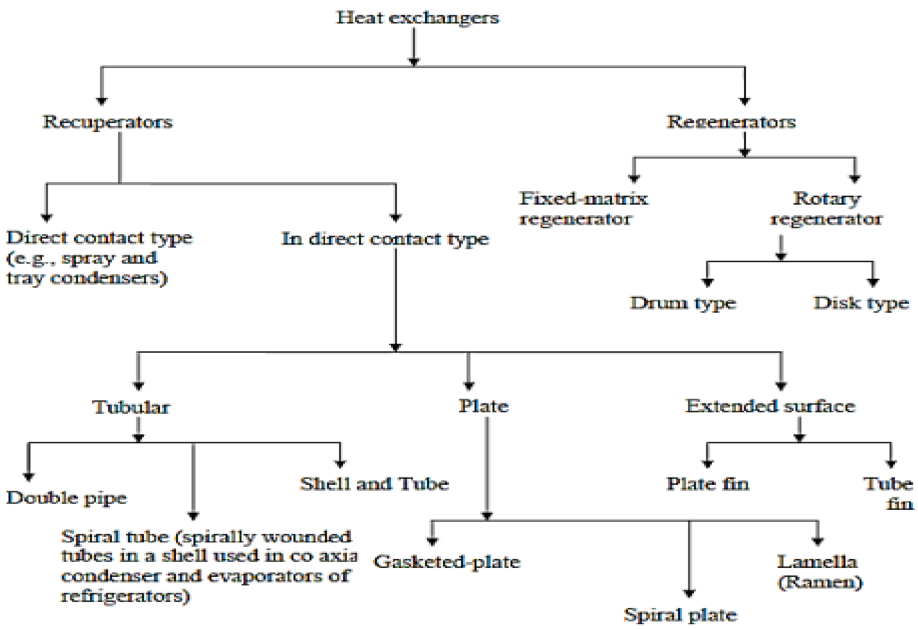


Fig.1 Classification of Heat Exchanger

## 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. BOUNDARY CONDITIONS

1. To determine the temperature distribution need to on energy equation.
2. Turbulent model is K-epsilon realizable, scalable wall function is used.
3. Working fluid water liquid with density of 998.2 $kg/m^3$ and heat exchanger pipe material is stainless steel having thermal conductivity is k =15.2W/mk.
4. Cold inlet having mass flow rate is 0.1, 0.2 and 0.3 kg/sec, temperature 288K.
5. Hot inlet having mass flow rate is 0.1, 0.2 and 0.3 kg/sec, temperature 313K.
6. For the outlet boundary condition the gauge pressure needs to be set as zero because the fluid flowing inside the heat exchanger( hot & cold) is atmospheric.
7. Rest of all surface treated as wall with no slip conditions set for solid walls where the heat flux is set as zero for the outer side wall to make adiabatic condition, while the inner tube walls and baffles is coupled.
8. The second order upwind scheme is used for the momentum energy turbulence and its dissipation rate.
9. The Fluent solver is used for CFD analysis.

### *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

ISSN : 2455-9679
Impact Factor : 4.256

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.

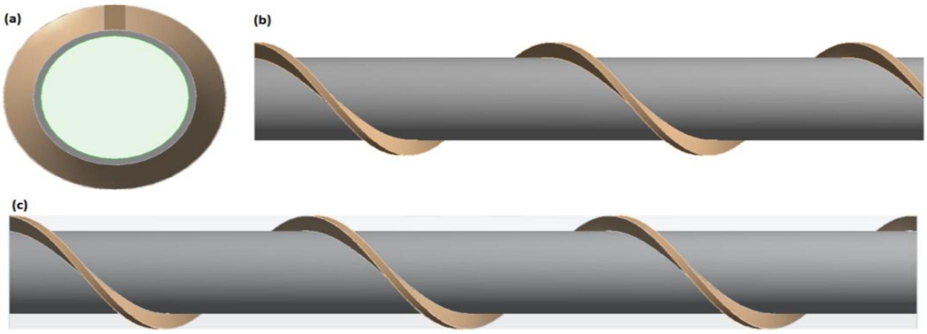


Fig. 2 CAD model of double pipe heat exchanger without baffle; (a) Face side (b) Baffle (c) Volume of cold flow

respect to different circumstances.All the above frameworks have been coordinated with usage of a predefined conditions and prerequisites that helps with obtain the suitable and trustworthy result.

## IV. RESULTS

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.

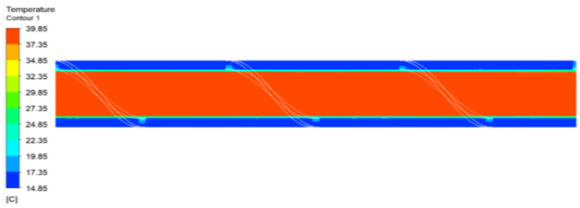


Fig. 3 Temperature contours of double pipe heat exchanger at mass flow of 0.3 kg/s heat exchanger mid plane

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.

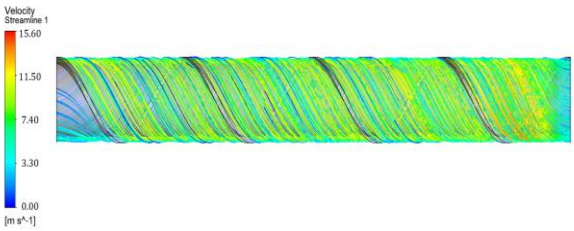


Fig. 4 Velocity streamlines at mass flow 0.3 kg/s

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.

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.

ISSN : 2455-9679
Impact Factor : 4.256

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

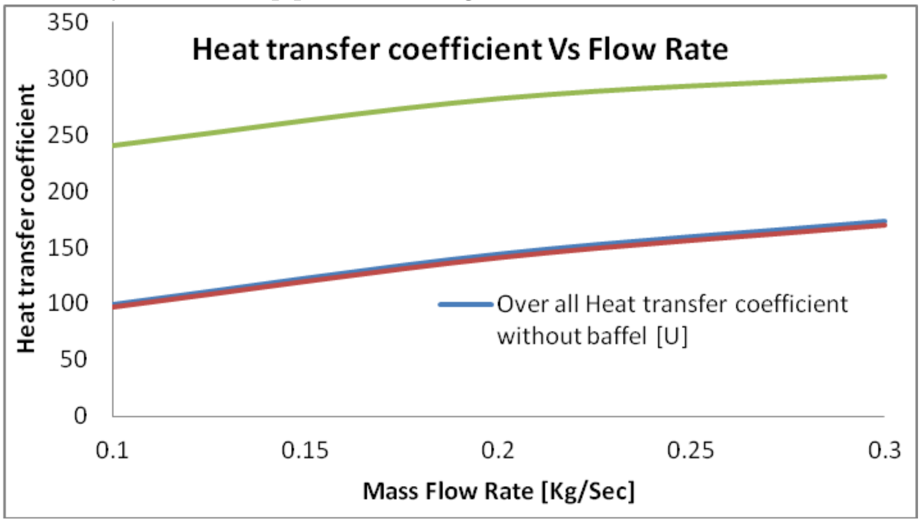


Fig. 5 Heat transfer coefficient Vs Flow Rate

Above figure represents the comparisons of the heat transfer coefficient for cold fluid of double pipe heat exchanger. It can be 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 0.3 kg/sec 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.

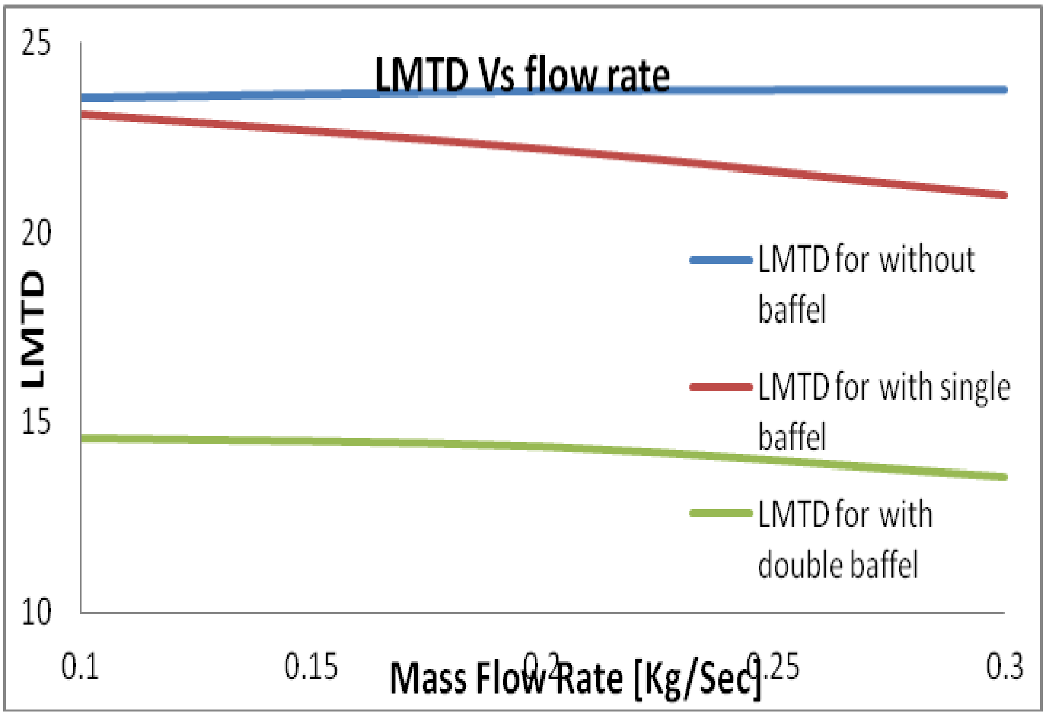


Fig. 6 LMTD Vs flow rate

Logarithmic mean temperature difference is use to determine the rate of heat transfer in heat exchanger. The temperature difference between the two fluid decrease from $\Delta T_1$ at the inlet to $\Delta T_2$ at the outlet. The logarithmic mean temperature difference is decreasing from 23.5°C to 13.59°C with increasing mass flow rate thus resulting increasing in overall heat transfer coefficient.

ISSN : 2455-9679
Impact Factor : 4.256

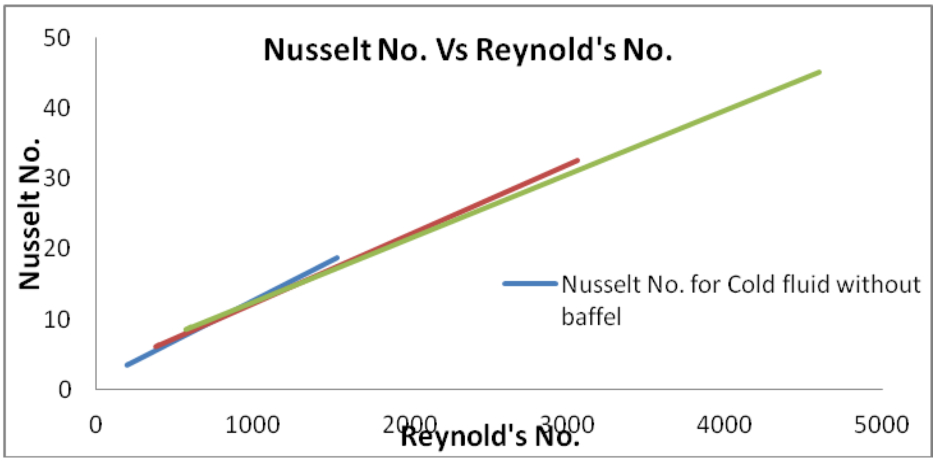


Fig. 7 Nusselt No. VsReynold's No.

It has been observed that the Nu increasing with increasing Reynolds number because of higher fluid velocities when using continuous helical baffles. Thus, the use of the baffles in the outer fluid pipe improves heat transfer due to turbulence. Turbulence enhancement increases the Reynolds number and increase in Nu for the same mass flow rate. It has been also observed that for the same mass flow rate the heat transfer improves with smaller baffle spacing.

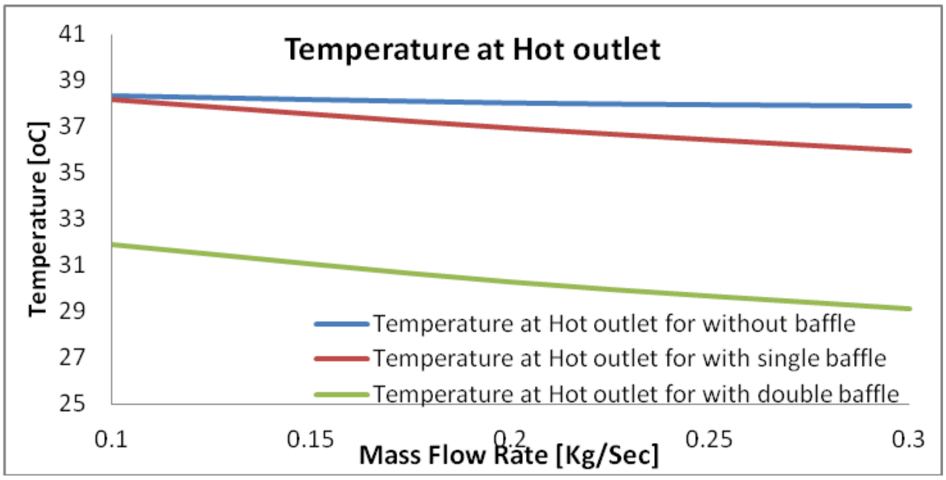


Fig. 8 Temperature at Hot outlet

It has been observed that the temperature of hot fluid is decreasing with increasing mass flow rate of cold fluid, maximum the temperature difference enhance the heat transfer rate. The maximum temperature drop of 10.9 $^{o}$C (27.25%) for hot fluid is observed at .3 kg/sec mass flow rate.

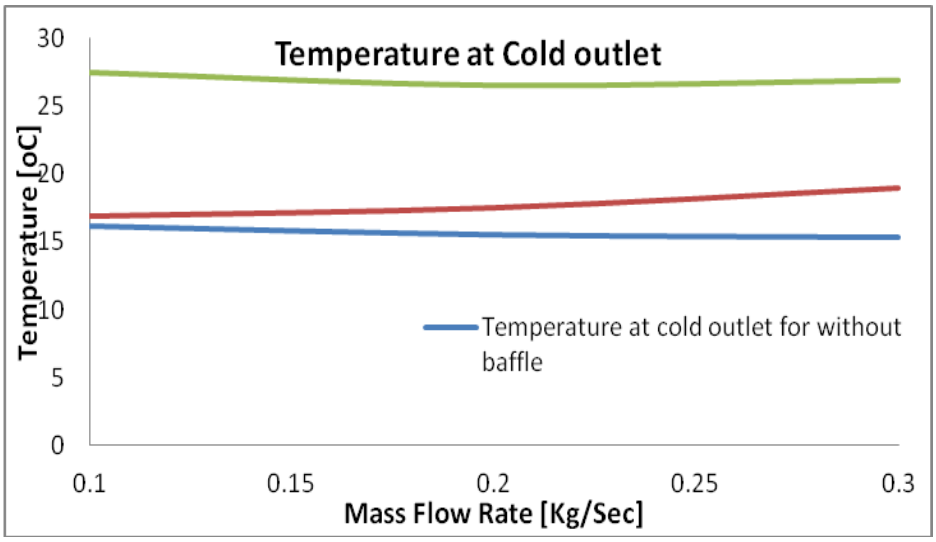


Fig. 9 Temperature at Cold outlet

ISSN : 2455-9679
Impact Factor : 4.256

It has been observed that the temperature of cold fluid is increasing with increasing mass flow rate of cold fluid, maximum the temperature difference enhance the heat transfer rate. The maximum temperature rise of 11.9 $^{o}$C (44.23%) for cold fluid is observed at .3 kg/sec mass flow rate.

## V. RESULTS

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. There are following conclusive points drawn from this work. it can be summarized that the maximum temperature drop of 10.9 $^{o}$C (27.25%) for hot fluid and the maximum temperature rise of 11.9 $^{o}$C (44.23%) for cold fluid are observed at 0.3 kg/sec mass flow rate for double pipe heat exchanger with double 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.

## VI. APPLICATION

Use of spiral heat exchangers in various heat transfer applications:

1) Helical coils are used for heat transfer in chemical reactors because the heat transfer coefficients in the helical coils are larger than in other configurations. This is particularly important when chemical reactions have a high reaction heat and the heat generated (or consumed) must be transferred quickly to maintain the reaction temperature. They are often used in the oil industry for various applications.
2) The coils have a compact configuration and can therefore be easily used in heat transfer applications with limited space, e.g. B. ship cooling systems, central cooling, lubricating oil cooling, steam generation in marine and industrial applications.
3) Coiled spiral heat exchangers are often used in the food and beverage industry, for example in the processing and preheating of food, in the pasteurization of liquid food and in storage at the desired temperatures.
4) Helical spiral heat exchangers are often used as condensers in HVAC systems due to the higher heat transfer rate and compact structure.
5) Spiral wound tubes are often used in the cryogenic industry to liquefy gases.
6) Used in hydrocarbon processing, $CO_2$ recovery and liquid hydrocarbon cooling and also in the polymer industry for cooling purposes.

## 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.

ISSN : 2455-9679
Impact Factor : 4.256

[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 (EXP THERM FLUID SCI) 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.