ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Issue 4, April 2017

CFD ANALYSIS OF DOUBLE HELICAL PIPE PARALLEL & COUNTER FLOW HEAT EXCHANGER

A.RAKESH
rakesh.ashapog@gmail.com

Assistant Professor, Dept of MECH, Aurora Scientific and Technology Research Academy, Bandlaguda, Hyderabad, Telangana, India.

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 distinctive 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.

A helical coil heat exchanger has a wide range of application in industries over the straight and shell type heat exchangers because of its greater heat transfer area, mass transfer coefficient and higher heat transfer capability, etc. The relevance of helical coil heat exchanger has been identified in industrial application like turbine power plants, automobile, aerospace, etc. because of above mentioned factors.

Double helical pipe is modeled by using solid works 2016 software & CFD analysis has been done for varying inlet condition keeping the heat flux of outer wall constant. Steel was used as the base metal for both inner and outer pipe and simulation has been done using ANSYS 14.5. The software ANSYS 14.5 work bench was used to plot the temperature contour, velocity contour and total heat dissipation rate taking cold fluid at constant velocity in the outer tube and hot fluid with varying velocity in the inner one. Water was taken as the working fluid for both inner and outer tube.

Introduction to Heat Exchanger:

A heat exchanger is a device used to transfer heat between one or more fluids. The fluids may be separated by a solid wall to prevent mixing or they may be in direct contact. They are widely used in space heating, refrigeration, air conditioning, power stations, chemical plants, petrochemical plants, petroleum refineries, natural-gas processing, and sewage treatment. The classic example of a heat exchanger is found in an internal combustion engine in which a circulating fluid known as engine coolant flows through radiator coils andair flows past the coils, which cools the coolant and heats the incoming air.

Heat exchangers are one of the mostly used equipment in the process industries. Heat exchangers are used to transfer heat between two process streams. One can realize their usage that any process which involve cooling, heating, condensation, boiling or evaporation will require a heat exchanger for these purpose. Process fluids, usually are heated or cooled before the process or undergo a phase change.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Issue 4, April 2017

Different heat exchangers are named according to their application

Literature Survey:

[1]H. S. Patel ** R. N. Makadia [1] "A Review on Performance Evaluation and CFD Analysis of Double Pipe Heat Exchanger" Double pipe heat exchanger is one of simplest type of heat exchanger, generally used for the purpose of sensible heating or cooling. In this paper it describes the different techniques which may help to enhance the heat transfer rate. Heat exchangers are modified in space of annular, also using Nano particle in water and compared with the conventional heat exchanger. Double pipe heat exchanger is practically investigated and results are validated with Ansys CFX software. Results shows that heat transfer rate of modified heat exchanger are higher than the conventional heat exchanger.

[2]Antony luki.A , Ganesan.M "Flow Analysis and Characteristics Comparison of Double Pipe Heat Exchanger Using Enhanced Tubes" In this investigation, augmented surface has been achieved with dimples strategically located in a pattern along the tube of a concentric tube heat exchanger with the increased area on the tube side. Augmented surfaces to increasing the heat transfer coefficient with a consequent increase in the friction factor. In this analysis to modify the inner tube of double pipe heat exchanger using dimpled tube.

Classification of heat exchangers

Concentric Tube Heat Exchangers:

Design A Simple And Classic Design

With its simple design and ability to operate under high pressures, the concentric tube heat exchanger is a valued resource in many industries for a range of purposes, from food preparation to material processing. In this type of heat exchanger, a pipe is placed inside another pipe, with cold fluid traveling through the inner tube and warm fluid traveling through the space between the inner tube and outer tube.

These fluids can flow parallel to one another or they can run in counterflow. While flowing through the system, heat from the warm fluid is transferred through the inner tube to the cold fluid.

As different design schemes are developed, the designers and manufacturers behind the heat exchanger will turn to you the simulation engineer to run their simulations. This can, of course, be a rather time-consuming process, as the design can go

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Issue 4, April 2017

through numerous minor modifications before the optimal configuration is achieved.

With the Application Builder, you can now take the physics and functionality behind your model and make it available in an easy-to-use simulation app. Once you have customized the app's layout to meet specific design needs, it can be shared with your colleagues and customers, who can then run their own simulations. Extending the scope of simulation capabilities not only establishes a more integrated workflow, but it also enables you to take on more simulation projects.

Theory Of Design And Analysis Design Considerations

In designing heat exchangers, a number of factors that need to be considered are:

1. Resistance to heat transfer should be minimized
2. Contingencies should be anticipated via safety margins; for example, allowance for fouling during operation.
3. The equipment should be sturdy.
4. Cost and material requirements should be kept low.

Materials Used For concentric tube Heat Exchangers:

A variety of materials are used in the design of concentric tube heat exchangers, including carbon steel, stainless steel, copper, bronze, brass, titanium and various alloys. Generally, the outer shell is made of a durable, high strength metal, such as carbon steel or stainless steel. Inner tubes require an effective combination of durability, corrosion resistance and thermal conductivity. Regular materials used in their construction are copper, stainless steel, and copper/nickel alloy. Other metals are used in device fittings, end bonnets and heads.

Project Aim:

The design of a helical coil tube in tube heat exchanger has been facing problems because of the lack of experimental data available regarding the behavior of the fluid in helical coils and also in case of the required data for heat transfer, unlike the Shell & Tube Heat exchanger. So to the best of our effort, numerical analysis was carried out to determine the heat transfer characteristics for a double-pipe helical heat exchanger by varying the different parameters like different temperatures and diameters of pipe and coil and also to determine the fluid flow pattern in helical coiled heat exchanger. The objective of the project is to obtain a better and more quantitative insight into the heat transfer process that occurs when a fluid flows in a helically coiled tube. The study also covered the different types of fluid flow range extending from laminar flow through transition to turbulent flow. The materials for the study were decided and fluid taken was water and the material for the pipe was taken to be steel for its better conducting properties

Boundary conditions:

Cold Inlet velocity: 2 m/s
Hot inlet velocity: 1.8 m/s
Cold inlet temperature: 303 k
Hot inlet temperature: 353 k
Cold outlet: pressure outlet
Hot outlet: pressure outlet
Hot & cold fluid: water
Inner & outer Pipe material: steel

Geometry And Design

One inner tube inside an outer tube in which the product flows through the inner tube and services

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Issue 4, April 2017

through the annular space.

Advantages Of Concentric Tube Heat Exchanger:

- Low maintenance cost due to absent of gaskets
- High working temperatures and pressures
- Easy to enlarge due to modular design
- Easy inspection and disassembly
- Processing of particulated or fibre product
- High security in aseptic processes
- Easy construction
- Easy to adjust the flow manner
- Flexible to clean
- Slurries can easily pass as it is a long extend.

Benefits Of Corrugation

- Increasing of turbulent flow
- Higher heat transfer coefficients
- Lower exchange area
- Homogeneous thermal treatment

Applications:

Low and medium viscosity products with large and medium sized particles, fibres, strips and mixed phase liquids for food, beverages or industrial applications such as

- Fruit pulps
- Boiled fruits
- Frozen juice cells
- Fish by products
- Minced meat
- Limed fleshing
- Yoghurt containing pieces

Classification of Heat Exchangers According To the construction

Tubular heat exchangers:

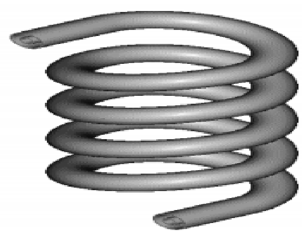
Tubular heat exchangers are built of mainly of circular tubes there are some other geometry has also been used in different applications. This design can be modified by length, diameter and physical arrangement. This type is used for liquid-to-liquid (phase changing like condensing or evaporation) heat transfer. Again this type is classified into shell and tube, double pipe and spiral tube heat exchangers.

Double pipe heat exchanger:

The double pipe or the tube in tube type heat exchanger consists of one pipe placed concentrically inside another pipe having a greater diameter. The flow in this configuration cane be of two types: parallel flow and counter-flow. It can be arranged in a lot of series and parallel configurations to meet the different heat transfer requirements. Double coil heat exchanger is widely used; knowledge about the heat transfer coefficient, pressure drop, and different flow patterns has been of much importance. The curvature in the tubes creates a secondary flow, which is normal to the primary axial direction of flow. This secondary flow increases the heat transfer between the wall and the flowing fluid. And they offer a greater heat transfer area within a small space, with greater heat transfer coefficients. The two basic boundary conditions that are faced in the applications are constant temperature and the constant heat flux of the wall. [5] proposed a system about Efficient Sensor Network for Vehicle Security. Today vehicle theft rate is very high, greater challenges are coming from thieves thus tracking/ alarming systems are

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Issue 4, April 2017

being deployed with an increasingly popularity .As per as security is concerned today most of the vehicles are running on the LPG so it is necessary to monitor any leakage or level of LPG in order to provide safety to passenger. Also in this fast running world everybody is in hurry so it is required to provide fully automated maintenance system to make the journey of the passenger safe, comfortable and economical. To make the system more intelligent and advanced it is required to introduce some important developments that can help to promote not only the luxurious but also safety drive to the owner. The system "Efficient Sensor Network for Vehicle Security", introduces a new trend in automobile industry.



Double pipe helical coil

Close-up of double pipe coil

Advantages & Disadvantages:

Advantages of coils:

1) Helical coils give better heat transfer characteristics, since they have lower wall resistance & higher process side coefficient.

2) The whole surface area of the curved pipe is exposed to the moving fluid, which eliminates the dead-zones that are a common drawback in the shell and tube type heat exchanger.

3) A helical coil offers a larger surface area in a relatively smaller reactor volume and a lesser floor area.

4) The spring-like coil of the helical coil heat exchanger eliminates thermal expansion and thermal shock problems, which helps in high pressure operations.

5) Fouling is comparatively less in helical coil type than shell and tube type because of greater turbulence created inside the curved pipes.

Disadvantages of coils:

1) For highly reactive fluids or highly corrosive fluid coils cannot be used, instead jackets are used.

2) Cleaning of vessels with coils is more difficult than the cleaning of shells and jackets.

3) Coils play a major role in selection of agitation system. Sometimes the densely packed coils can create unmixed regions by interfering with fluid flow.

4) The design of the helical tube in tube type heat exchanger is also a bit complex and challenging.

Applications:

Use of helical coil heat exchangers in different heat transfer applications:

1) Helical coils are used for transferring heat in chemical reactors because the heat transfer coefficients are greater in helical coils as compared to other configurations. This is especially important

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Issue 4, April 2017

when chemical reactions have high heats of reaction are carried out and the heat generated (or consumed) has to be transferred rapidly to maintain the temperature of the reaction. They are used widely in petroleum industries for different applications.

2) The helical coils have a compact configuration, and because of that they can be readily used in heat transfer application with space limitations, for example, marine cooling systems, central cooling, cooling of lubrication oil, steam generations in marine and industrial applications.

3) The helical coiled heat exchangers are used widely in food and beverage industries, like in food processing and pre-heating, pasteurization of liquid food items, and for storing them at desired temperatures.

4) Helical coil heat exchangers are often used as condensers in used in HVACs due to their greater heat transfer rate and compact structure.

5) Helical coiled tubes are used extensively in cryogenic industry for the liquefaction of gases.

6) Used in hydro carbon processing, recovery of CO_2, cooling of liquid hydrocarbons, also used in polymer industries for cooling purposes.

Materials Used For Heat Exchangers:

A variety of materials are used in the design of tube heat exchangers, including carbon steel, stainless steel, copper, bronze, brass, titanium and various alloys. Generally, the outer shell is made of a durable, high strength metal, such as carbon steel or stainless steel. Inner tubes require an effective combination of durability, corrosion resistance and thermal conductivity. Regular materials used in their construction are copper, stainless steel, and copper/nickel alloy. Other metals are used in device fittings, end bonnets and heads.

Introductions to Solid Works:

Solid works mechanical design automation software is a feature-based, parametric solid modeling design tool which advantage of the easy to learn windows TM graphical user interface. We can create fully associate 3-D solid models with or without while utilizing automatic or user defined relations to capture design intent.

Parameters refer to constraints whose values determine the shape or geometry of the model or assembly. Parameters can be either numeric parameters, such as line lengths or circle diameters, or geometric parameters, such as tangent, parallel, concentric, horizontal or vertical, etc. Numeric parameters can be associated with each other through the use of relations, which allow them to capture design intent.

Modeling of double helical pipe heat exchanger:

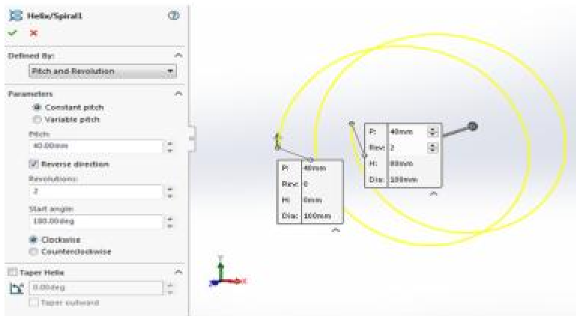
Make sketch for helix

Make helix by giving pitch and revolution

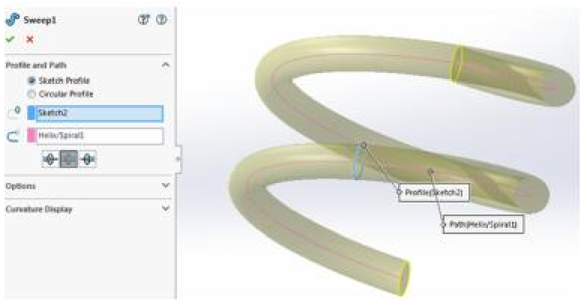
Pitch: 40mm

Revolution: 2

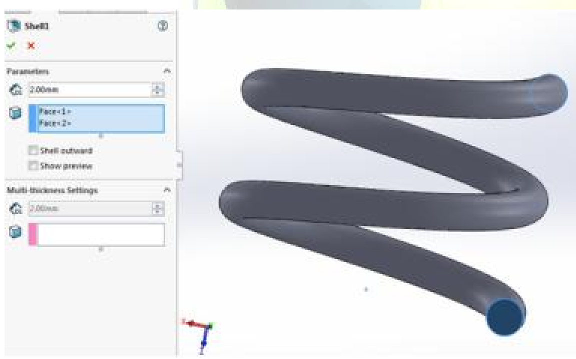
ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Issue 4, April 2017



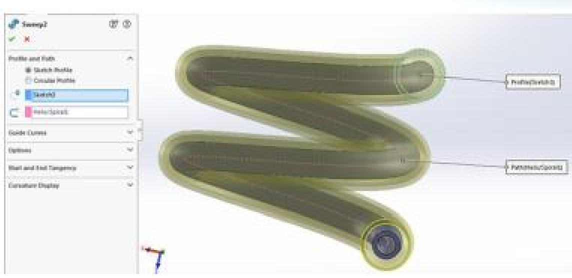
Use sweep feature command and generate inner pipe

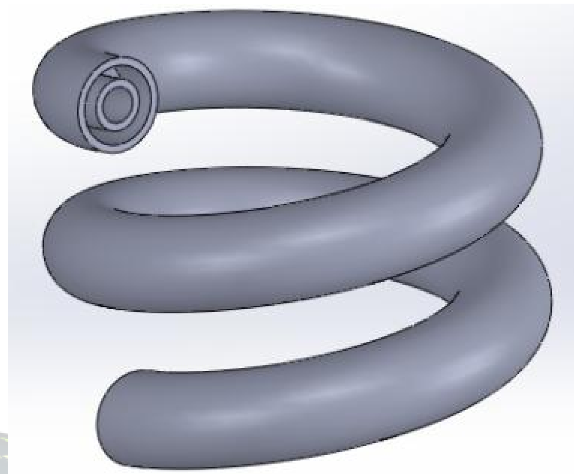


Use shell command and give thickness to pipe



Use sweep feature command and generate outer pipe.





Double helical pipe 3d model

INTRODUCTION TO SIMULATION

ANSYS 14.5

Introduction

ANSYS 14.5 delivers innovative, dramatic simulation technology advances in every major Physics discipline, along with improvements in computing speed and enhancements to enabling technologies such as geometry handling, meshing and post-processing. These advancements alone represent a major step ahead on the path forward in Simulation Driven Product Development. But ANSYS has reached even further by delivering all this technology in an innovative simulation framework ,ANSYS Workbench14.5The ANSYS Workbench environment is the glue that binds the simulation process; this has not changed with version.14.5 In the original ANSYS Workbench, the user interacted with the analysis as a whole using The platform's project page: launching the various applications and tracking the resulting files employed in the process of creating an analysis. Tight integration between the component applications yielded unprecedented ease

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Issue 4, April 2017

of use for setup and solution of even complex multiphysics simulations.

Fig ansys simulation

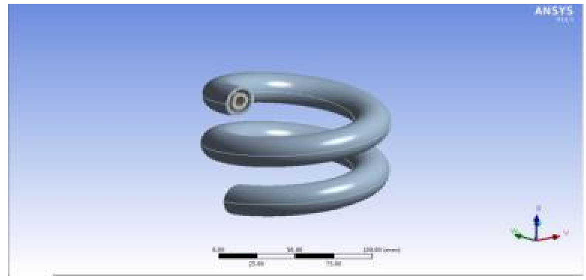
In ANSYS 14.5, while the core applications may seem familiar, they are bound together via the innovative project page that introduces the concept of the project . This expands on the project page concept. Rather than offer a simple list of files, the project schematic presents a comprehensive view of the entire analysis project in flowchart form in which explicit data relationships are readily apparent. Building and interacting with these flowcharts is straightforward. A toolbox contains a selection of systems that form the building blocks of the project.

CFD ANALYSIS

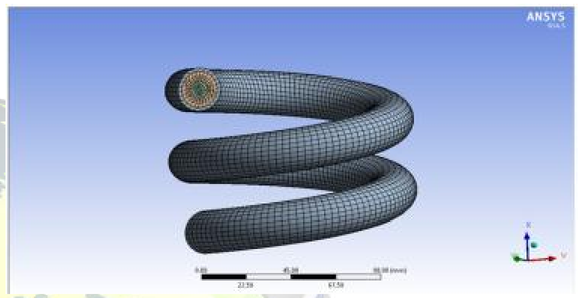
Computational fluid dynamics (CFD) study of the system starts with the construction of desired geometry and mesh for modeling the dominion. Generally, geometry is simplified for the CFD studies. Meshing is the discretization of the domain into small volumes where the equations are solved by the help of iterative methods. Modeling starts with the describing of the boundary and initial conditions for the dominion and leads to modeling of the entire system. Finally, it is followed by the analysis of the results, conclusions and discussions.

Model:

Convert the 3d model file to iges file and transfer it in ansys work bench.



Mesh



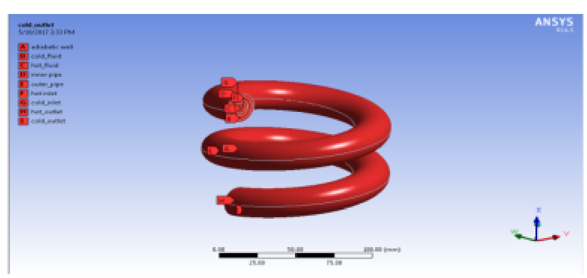
Mesh report table

Domain	Nodes	Elements
cold_fluid	21164	14250
hot_fluid	30843	25868
inner_pipe	30024	20384
outer_pipe	10272	5112
All Domains	92303	65614

CFD analysis for parallel flow heat exchanger:

Name selection:

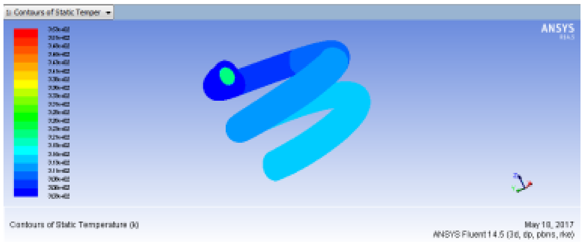
Assign the names for walls, inlets, outlets, and fluids, the different surfaces of the solid are named as per required inlets and outlets for inner and outer fluids. The outer wall is named as adiabatic wall.



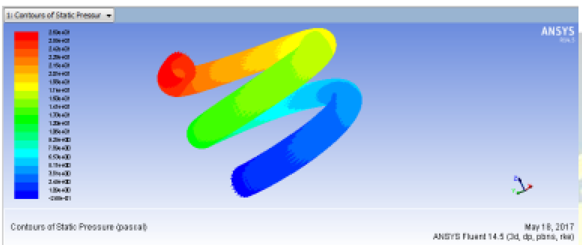
ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Issue 4, April 2017

Outer pipe - Cold fluid:

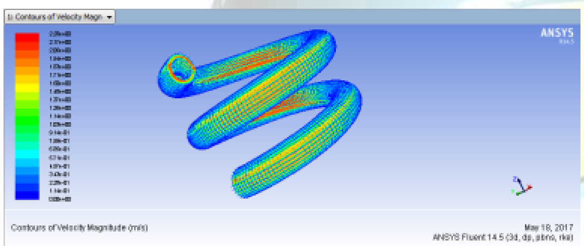
Temperature



Pressure

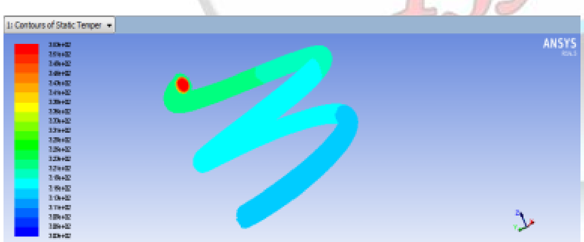


Velocity:

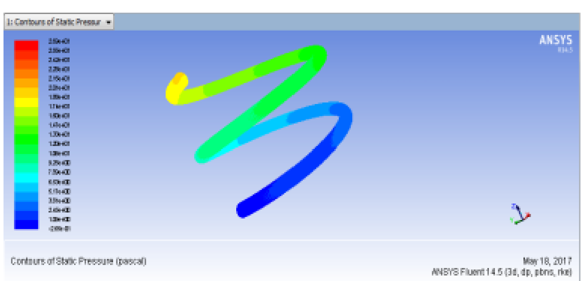


Inner pipe - Hot fluid:

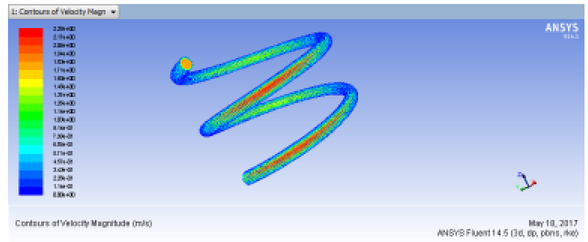
Temperature



Pressure

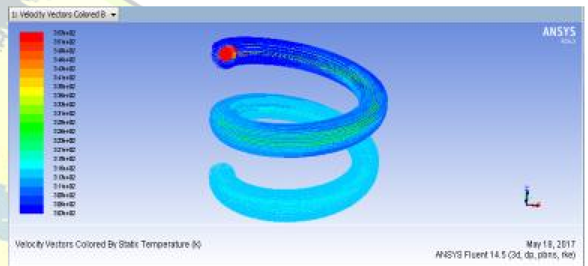


Velocity

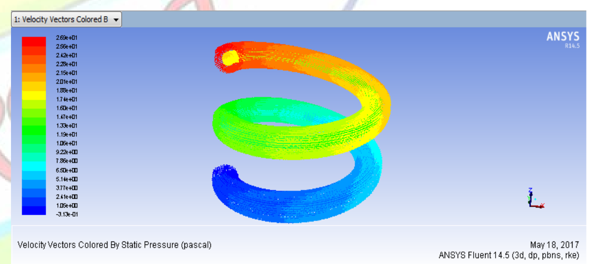


Helical double pipe:

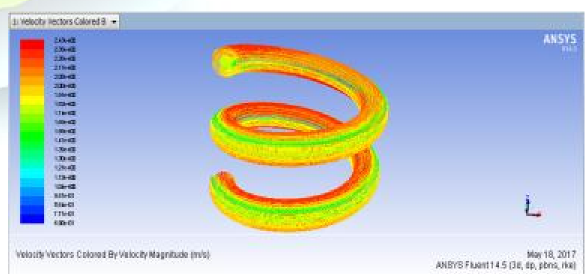
Temperature



Pressure



Velocity:



Result:

Temperature:

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Issue 4, April 2017

Average of Facet Values Static Temperature	(k)
cold_inlet	303
cold_outlet	314.64822
hot_inlet	353
hot_outlet	315.90012
Net	322.58621

Velocity:

Average of Facet Values Static Pressure	(pascal)
cold_inlet	25.596905
cold_outlet	0
hot_inlet	18.613289
hot_outlet	0
Net	10.923223

Pressure:

Average of Facet Values Velocity Magnitude	(m/s)
cold_inlet	2
cold_outlet	1.9868661
hot_inlet	1.8
hot_outlet	1.8766528
Net	1.910135

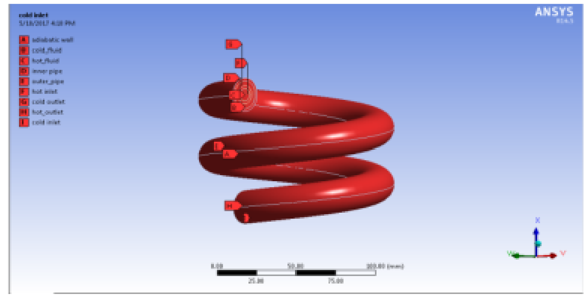
CFD analysis for counter flow heat exchanger:

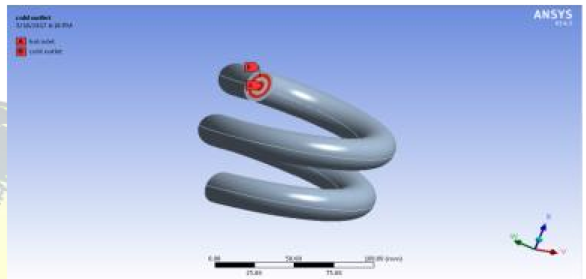
Every step will be same as parallel flow heat exchanger except name selection.

Boundary conditions will be same as parallel flow heat exchanger.

Name selection:

Assign the names for walls, inlets, outlets, and fluids, the different surfaces of the solid are named as per required inlets and outlets for inner and outer fluids for counter flow heat exchanger. The outer wall is named as adiabatic wall.

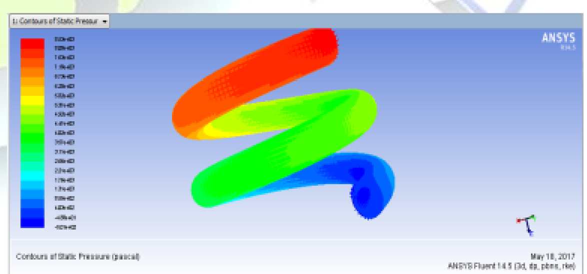




Outer pipe - Cold fluid:

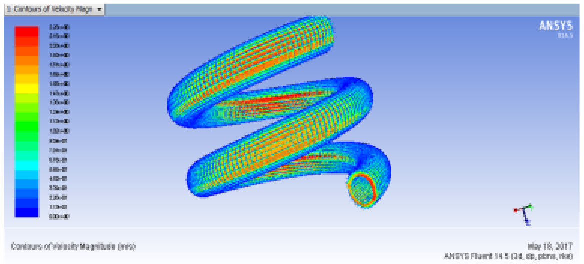
Temperature

Pressure



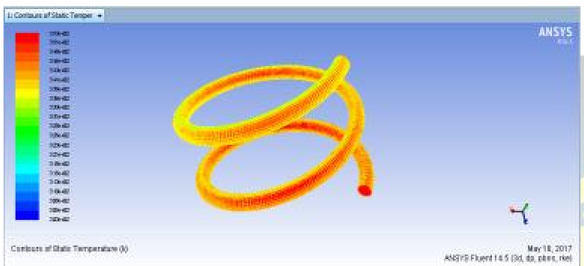
Velocity

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Issue 4, April 2017

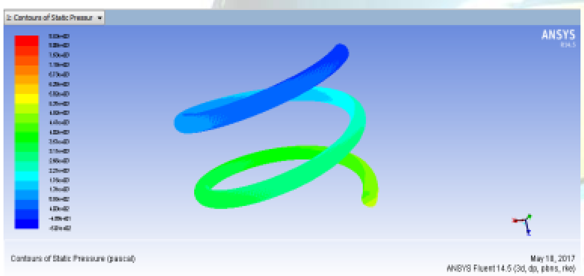


Inner pipe - Hot fluid:

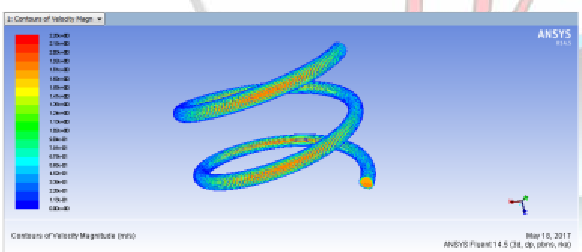
Temperature



Pressure

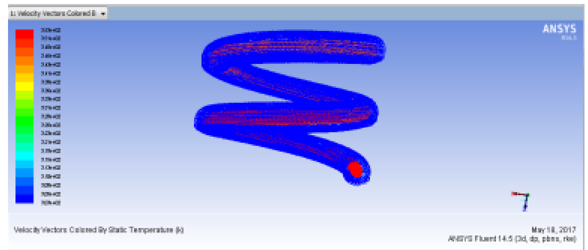


Velocity

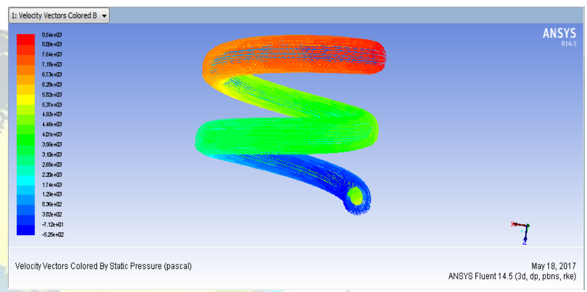


Helical double pipe:

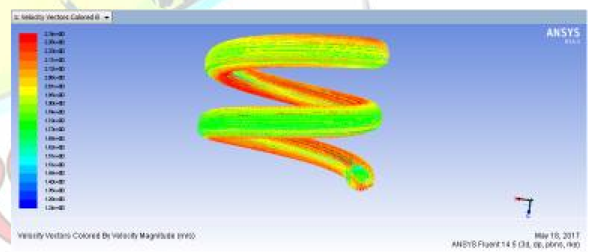
Temperature



Pressure



Velocity



Results:

Temperature

```
 Average of Facet Values
      Static Temperature                  (k)
------------------------- --------------------
              cold_inlet                  303
             cold_outlet            304.96439
               hot_inlet                  353
              hot_outlet            346.83389
         ---------------- --------------------
                     Net            328.65085
```

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Issue 4, April 2017

Pressure

```
Average of Facet Values
        Static Pressure                 (pascal)
------------------------ --------------------
             cold_inlet                7722.0859
            cold_outlet                        0
              hot_inlet                4798.1826
             hot_outlet                        0
       ---------------- --------------------
                    Net                3075.9207
```

Velocity

```
Average of Facet Values
     Velocity Magnitude                    (m/s)
------------------------ --------------------
             cold_inlet                        2
            cold_outlet                2.0216193
              hot_inlet                      1.8
             hot_outlet                1.8452095
       ---------------- --------------------
                    Net                1.9097366
```

Conclusions:

- Modeling and analysis of helical double pipe heat exchangers is done
- Modeling of helical double pipe heat exchanger is done in solid works 2016 software using various commands.
- Model is transfer to ansys 14.5 work bench by converting it into iges file.
- CFD analysis is carried out in Ansys fluent for both parallel and counter flow of hot and cold fluid.
- Name selection is done as inlet, out let , fluid solid , walls are assign and mesh the helical double pipe heat exchanger.
- Water is used as hot and cold fluid and steel is used as material for both inner and outer pipe
- The boundary conditions are assign for parallel and counter flow type heat exchanger at inlet and outlet of pipes , outer wall of outer cold pipe is made as adiabatic..
- Temperatures, pressure and velocity of hot and cold fluid at outlet are found out as result of CFD analysis.
- Temperature, pressure, velocity counters all over the inner and outer pipe is shown.
- Hence the study of temperature ,pressure and velocity because of parallel and counter flow in helical double pipe heat exchanger is done in this project.

References:

1. Experimental and CFD study of a single phase cone-shaped helical coiled heat exchanger: an empirical correlation. By Daniel Flórez-Orrego, ECOSJune 26-29, 2012.

2. Helically Coiled Heat Exchangers by J.S.Jayakumar.

3. Numerical And Experimental Studies of a Double pipe Helical Heat Exchanger by Timothy John Rennie, Dept. of Bio-resource Engg. McGill University, Montreal August 2004.

4. Experimental and CFD estimation of heat transfer in helically coiled heat exchangers by J.S. Jayakumar, S.M. Mahajani, J.C. Mandal, P.K. Vijayan, and Rohidas Bhoi, 2008, Chemical Engg Research and Design 221-232.

5. Christo Ananth, I.Uma Sankari, A.Vidhya, M.Vickneshwari, P.Karthiga, "Efficient Sensor Network for Vehicle Security", International Journal of Advanced Scientific and Technical Research (IJST), Volume 2, Issue 4, March-April 2014,pp – 871-877

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Issue 4, April 2017

6. Structural and Thermal Analysis of Heat Exchanger with Tubes of Elliptical Shape by Nawras H. Mostafa Qusay R. Al-Hagag, IASJ, 2012,Vol-8 Issue-3.

7. Numerical analysis of forced convection heat transfer through helical channels Dr. K. E. Reby Roy, IJEST, July-2012 vol-4.

8. Minton P.E., Designing Spiral Tube Heat Exchangers, Chemical Engineering, May 1970, p. 145.

9. Noble, M.A., Kamlani, J.S., and McKetta, J.J., Heat Transfer in Spiral Coils, Petroleum Engineer, April 1952, p. 723.

10. Heat Transfer Analysis of Helical Coil Heat Exchanger with Circular and Square Coiled Pattern by Ashok B. Korane, P.S. Purandare, K.V. Mali, IJESR, June 2012, vol-2, issue-6.

AUTHOR PROFILE

A.RAKESH $_{\text{M.Tech}}$ is currently working as a Assistant Professor in Mechanical engineering Department in Aurora scientific and technology research academy. He received his Master's degree in Thermal Engineering from Jaya Prakash Narayan College of Engineering. He received his Bachelor's degrees in Mechanical engineering from Jaya Prakash Narayan College of Engineering. His areas of interest are applied thermal-fluid dynamics, Heat Transfer, Automotive Engineering, and Material Science.