

DESIGN AND ANALYSIS OF SHELL TUBE HEAT EXCHANGER

Submitted in partial completion of the requirements
for the award of
Bachelor of Engineering Degree in Mechanical Engineering
by

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DEPARTMENT OF MECHANICAL ENGINEERING
SCHOOL OF MECHANICAL ENGINEERING

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC | 12B Status by UGC | Approved by AICTE

**Jeppiaar Nagar, Rajiv Gandhi Salai,
Chennai - 600 119**

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DEPARTMENT OF MECHANICAL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of
Vineeth raj (37150215), Vasanthakumar (37150203) who carried out the
project entitled "**DESIGN AND ANALYSE OF SHELL TUBE HEAT
EXCHANGER**", under our supervision from November 2020 to April 2021

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DECLARATION

We **Vineeth raj(37150215)**, **Vasanthakumar (37150203)** hereby declare that the project Retort entitled “**DESIGN AND ANALYSE OF SHELL TUBE HEAT EXCHANGER**” done by me under the guidance of **Dr.S.P.Venkatesan M.E.,Ph.D.**, is submitted in partial completion of requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.

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ABSTRACT

A Heat exchanger is a equipment used for transferring the heat from one medium to another. There is widespread range of appliance of heat exchanger in the field of industrial applications and cryogenics for its enhanced features and compact arrangement. We have analysed the shell tube heat exchanger by using CFTD on the primary objective of improving the heat transfer effectiveness. A large variety of fluids can be suitable for a spiral heat exchanger solution e.g. fouling liquids containing solids and fibres, waste water, slurries, mixtures with inert gases, cooling and heat recovery, vapour/liquid condenser and vacuum condenser with inert gases. Low fouling rate of the heat exchanger, reduces the need of cleaning and therefore the out of service will be decreased.

TABLE OF CONTENT

	TITLE	PAGE NO
	ABSTRACT	5
	LIST OF FIGURES	7
1	INTRODUCTION	1
	1.1 BASIC PRINCIPLES OF DESIGN	1
	1.2 GENERALIZED DESIGN PROCEDURE OF HEAT EXCHANGER	2
	1.3 COMPONENTS OF SHELL AND TUBE HEAT EXCHANGER	5
	1.3.1. TUBES	5
	1.3.2. TUBE SHEETS	5
	1.3.3. SHELL AND SHELL NOZZLES	6
	1.3.4. TUBE SIDE CHANNEL AND NOZZLES	6
	1.3.5. CHANNEL COVERS	7
	1.3.6. PASS DIVIDER	7
	1.3.7. BAFFLES	7
	1.4 PROJECT BACKGROUND	8
	1.4.1 PROJECT OBJECTIVES	9
	1.4.2 PROBLEM STATEMENT	9
	1.4.3 PROJECT SCOPES	10
	1.4.4 USES AND APPLICATIONS	10
	1.5 TYPES OF HEAT EXCHANGER	11
	1.5.1 TUBULAR HEAT EXCHANGER	12
	1.5.2 DOUBLE PIPE HEAT EXCHANGER	12
	1.5.3 SHELL AND TUBE HEAT EXCHANGER	13
	1.5.4 SPIRAL TUBE HEAT EXCHANGER	13
	1.5.5 SPECIAL CHARACTERISTICS OF SPIRAL TUBE HEAT EXCHANGER	16
	1.5.6 HIGH RATE HEAT TRANSFER	17
	1.6 THE ENERGY EQUATION	17

	1.6.1 LEAKAGE RISK IS NULL	18
	1.6.2 HIGH VACUUM APPLICATIONS	18
	1.6.3 GEOMETRICAL MODELLING	18
	1.6.4 EXPERIMENTAL METHOD OF SPIRAL TUBE HEAT EXCHANGER	19
	1.6.5 OVERALL ANALYSIS	20
	1.7 ANSYS WORKBENCH 16.0	21
	1.7.1 GEOMETRY	22
	1.7.2 MESH	22
	1.7.3 SETUP AND SOLUTION	22
2	LITERATURE REVIEW	26
3	METHODOLOGY	28
4	DESIGN CALCULATION	29
5	RESULT	34
6	CONCLUSION	38

LIST OF FIGURES

FIGURE	NAME OF THE FIGURE	PAGE NO
1. 1	PROCEDURE OF HEAT EXCHANGER	4
1.2	BAFFLES	8
1.3	INNER VIEW OF SHELL AND TUBE HEAT EXCHANGER	9
1.4	DOUBLE PIPE HEAT EXCHANGER	13
1.5	SPIRAL TUBE HEAT EXCHANGER	15
1.6	CONSTRUCTION OF SPIRAL HEAT EXCHANGER	15
1.7	ANSYS OF SPIRAL HEAT EXCHANGER	23
1.8	DESIGN OF SOLIDWORKS PART 1	24
1.9	DESIGN OF SOLIDWORKS PART 2	24
1.10	DESIGN OF SOLIDWORKS PART 3	25
1.11	DESIGN OF SOLIDWORKS PART 4	25

CHAPTER 1

1.INTRODUCTION

Heat exchangers are used to assigning heat energy between two or more media and widely used to chemical industries, food industries, and so on. The shell tube heat exchanger is widely known heat exchanger, it is suited for the analysis of conserving the energy in heat exchange process. Shell tube heat exchanger are playing a vital role in boilers, oil coolers, condensers, pre-heaters and they are also used in the refrigeration and air conditioning industries. The sturdy and average subjective shape of heat exchangers make them well matched for high pressure systems. The most common configuration of shell tube heat exchangers, the thermal analysis and design of such exchangers are included in the study of mechanical, thermal, chemical engineering academics for their prospectus and research activity. The tube heat exchangers are used extensively throughout the industry process and such basic understanding their design, construction and vulnerability is to practicing the engineer the ideal design of a shell tube heat exchanger includes the reflexion of many design which can be summarized as follows.

1.1 BASIC PRINCIPLES OF DESIGN

By First, the heat exchanger must meet the process requirements. That is, the effect must change the desire in thermal condition of the process stream within the allowable pressure drops, and it must continue to do this until the next scheduled shutdown of the plant for maintenance.

Second, the exchanger must endure the service condition of the plant environment. This includes the mechanical stresses of fixing, start up, shutdown, normal operation, emergencies, and preservation, and the thermal stresses induced by the temperature differences. It must also withstand weathering by the process and service stream, this is ordinarily a matter of choice of resources of construction, but Mechanical structure does have some effect. Desirably, the exchanger should also counter fouling, but there is not

much the designer may do with confidence in this except keep the velocities as high as pressure.

Third, the exchanger must be easy to clean, which usually implies choosing a configuration that allows the cleaning tube side, as may be indicated and replacement of tubes and any other components that may be vulnerable to corrosion, erosion, or vibration. This requirement may also limit on positioning the exchanger and in providing clear space around it.

Fourth, the exchanger must be cost as little as is consistent with the above requirement; in the present context, this makes reference to first cost or installed cost, since working cost or cost of lost production due to exchanger, unavailability have been considered by implication in the earlier and more important criteria.

Finally, there may be restrictions on choosing the exchanger diameter, length, weight and/or tube specification due to site requirements, lifting and servicing capabilities, or inventory consideration.

1.2 GENERALIZED DESIGN PROCEDURE OF HEAT EXCHANGER.

Process conditions (stream compositions, flow rates, temperatures, pressures) must be specified. Required physical properties over the temperature and pressure range of interest must be provided.

A starting estimate of the size of the exchanger is made, using a heat transfer coefficient appropriate to the fluids, the process, and the equipment. A first design is chosen, complete details is necessary to carry out the design calculations.

The design chosen is now to be evaluated or rated, as to its ability to meet the process specifications to both heat duty and pressure drop. Based on this result a new arrangement is chosen if necessary and the above step is repeated.

If the first design was insufficient to meet the required heat load, it is necessary to increase the size of the exchanger, the remaining specified or feasible limits of pressure drop, tube length, shell diameter, etc.

This will process on multiple exchanger configurations. If the first design meets heat load requirements or does not use all the allowable pressure drop, a less expensive exchanger can enough to fulfil process requirements.

The final design should meet process requirements at lowest cost. The lowest cost maintenance should include costs and credit for ability to meet long-term process changes as well as installed (capital) cost.

Exchangers should not be focused entirely on budget basis, which frequently results in future failure.

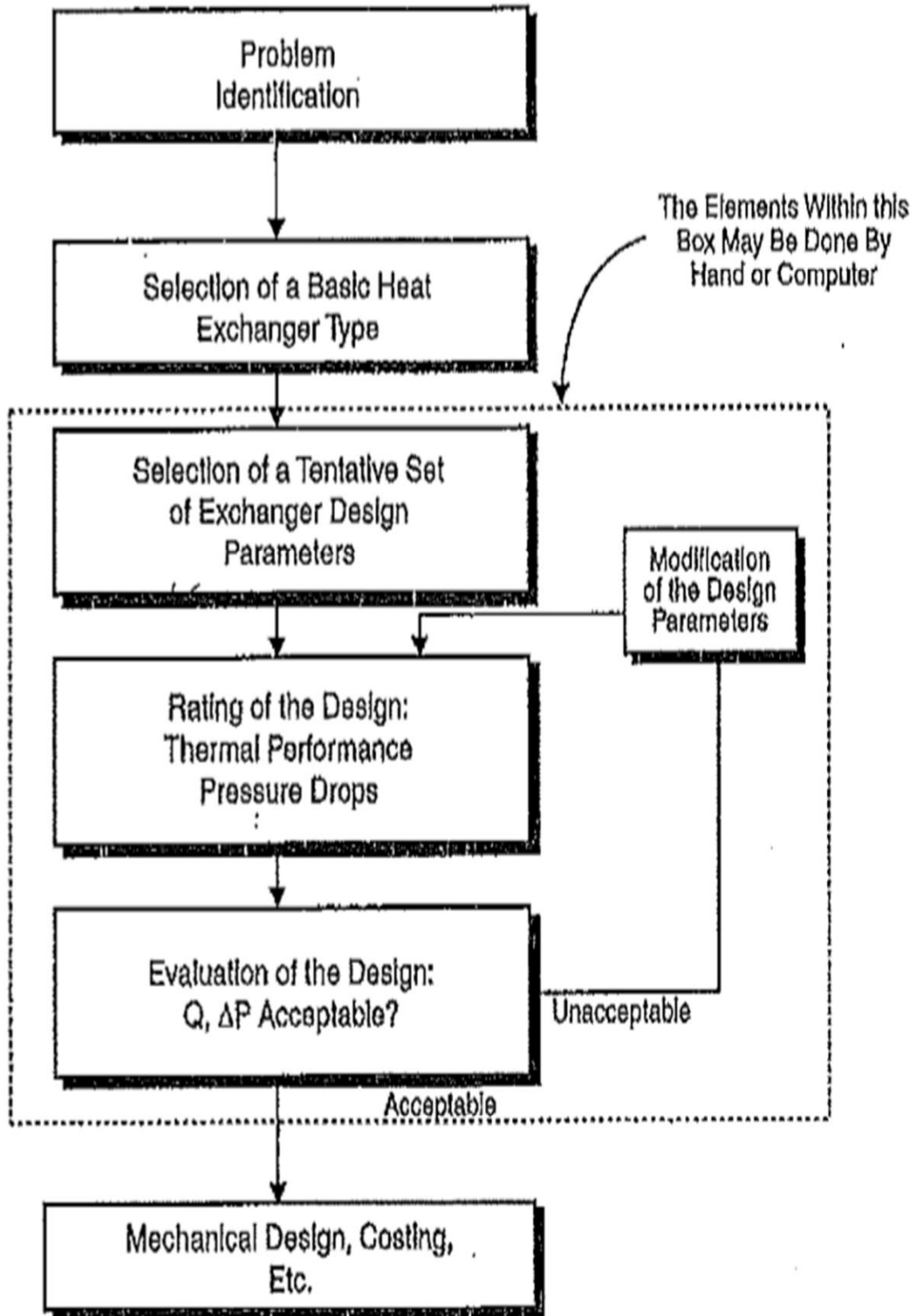


Fig 1.1: Procedure of heat exchanger

1.3 COMPONENT OF SHELL AND TUBE HEAT EXCHANGER

Shell tube heat exchangers in different construction modifications are probably the most widespread and commonly used in basic heat exchanger configuration in the industries.

The reasons for this general acceptance are several. The shell tube heat exchanger provides a comparably large ratio of heat transfer area to volume and weight.

It provides this surface in a form which is relatively easy to construct in a wide range of sizes and which is mechanically enough to withstand normal shop fabrication stresses, shipping and normal operating conditions.

There are many modifications of the basic configuration, which can be used to solve special problems. The shell and tube exchanger can be easily cleaned, and those components most subject to failure gaskets and tubes can be replaced.

Finally, good process exist to expertise the shop facilities for the successful design and construction of shell tube exchangers.

1.3.1 Tubes

The tubes are the common component of the shell tube exchanger, providing the heat transfer between one fluid flowing inside and the other fluid flowing across the outside of the tubes.

The tubes are seamless or welded and most commonly made of copper or steel alloys. Other alloys of nickel, titanium, or aluminium may be required for specific applications.

1.3.2 Tube Sheets

The tubes are placed into holes and there either expanded into grooves cut into the holes or welded to the tube sheet, it's protrudes from the surface.

The tube sheet is a single round plate of metal that has been well drilled and grooved to take the tubes in the desired pattern, the gaskets, the spacer rods and the bolt circle fastened to the shell.

However, where mixing between the two fluids (in the event of leaks where the tube is sealed into the tube sheet) must be avoided.

1.3.3 Shell and Shell-Side Nozzle

It is simply the container for the shell side fluid, and the nozzles are the inlet and exit ports.

The shell normally has a circular cross section and is commonly made by rolling a metal plate of the appropriate dimensions into a cylinder and welding the longitudinal joint "rolled shells". Small diameter shells can be made by cutting pipe of the desired diameter to the correct length "pipe shells).

The roundness of the shell is important in fixing the maximum diameter of the baffles that can be insert and therefore the effect of shell-to-baffle leakage. Pipe shells are more nearly round than rolled shells unless particular care is taken in rolling,

In order to decrease the out of roundness, small shells are purposely expanded over a mandrel in extreme cases, the shell is cast and then bored out on a boring mill.

1.3.4 Tube-side Channel and Nozzle

The tube side of channels and nozzles simply control the flow of the tube side fluid into and out of the tubes of the exchanger.

Since the tube-side fluid is generally the more corrosive, these channels and nozzles will often be made out of alloy materials compatible with the tubes and tube sheets, of course. They may be clad instead of solid alloy.

1.3.5 Channel Covers

The channel covers are round with plates that bolt to the channel flanged and can be removed for tube inspection without disturbing the tube-side piping.

In smaller type heat exchangers, bonnets with flanged nozzles or threaded connections for the tube side piping are usually used instead of channel covers.

1.3.6 Pass Divider

A divider is needed in one channel or bonnet for an exchanger having two tube side passes, and they kind of needed both channels or bonnets for an exchanger having more than two passes.

If the channels or bonnets are cast, the dividers are integrally cast and they faced to give a smooth bearing surface on the gasket between the divider and the tube sheet. If the channels are bundled from plate or built up from pipe, the dividers are welded in place.

The arrangement of the dividers in multiple-pass exchangers is somewhat arbitrary, the usual intent being to provide nearly the same number of tubes in each pass, to minimize the number of tubes lost from the tube count, to minimize the pressure difference across any one pass divider to provide adequate bearing surface for the gasket and to minimize fabrication complexity and cost

1.3.7 Baffles

Baffles serve two functions Most primarily they support the tubes in the assembly and operation and prevent vibration of the tubes caused by flow induced eddies, and secondly, they guide the shell side flow front and forth across the tube field, high the velocity and the heat transfer coefficient.

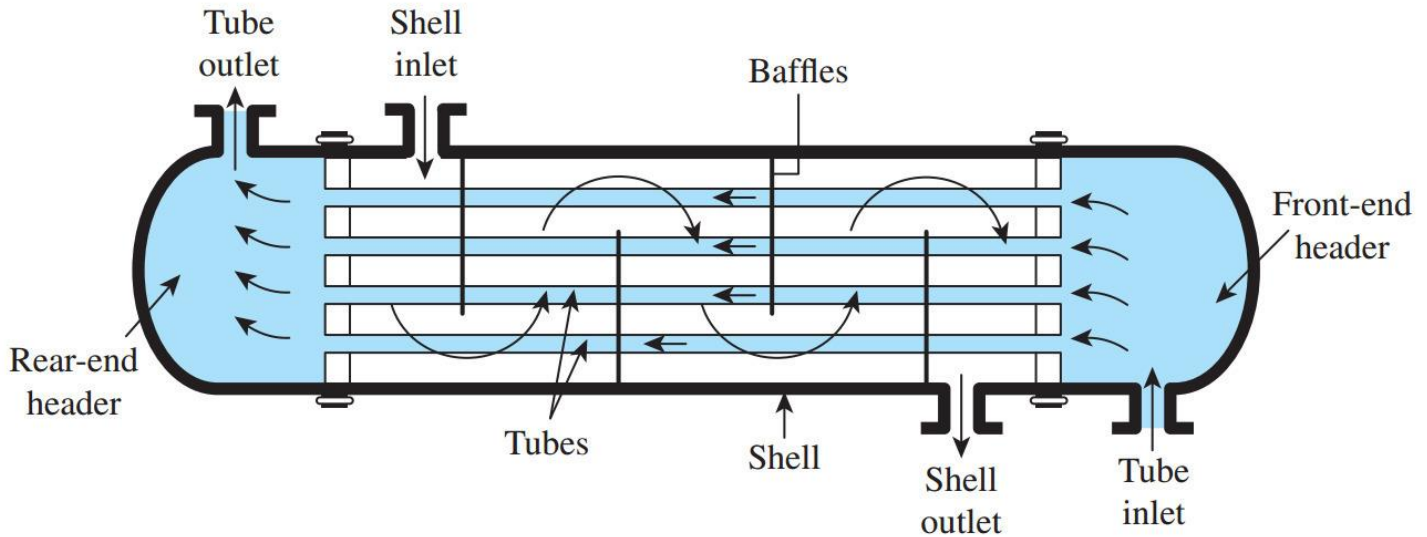


Fig 1.2- Baffles

1.4 PROJECT BACKGROUND

Heat exchanger is a modern tool used for efficient heat transfer from one phase to another, whether the media are separated by a solid wall so they never mix, or the media are in direct contact. They are known widely using in space heating, refrigeration, air conditioning, power plants, chemical plants, petrochemical plants, and natural gas processing. One most common example of a heat exchanger is the car radiator, in which a hot engine fluid, like antifreeze, transfers heat to air flowing through the radiator. Many criteria have to be taken before making any decision. The important parameters of heat exchangers are collected and put a major thought on it. In this project, the software needed to collect all the parameters to put in. From there, the software runs and the main point is to create a new windows program that is similar to another existed software of calculating heat transfer in market. The major thing is to obtain a desired output this program. Thus, the ideal shell tube heat exchanger is produced at the end.

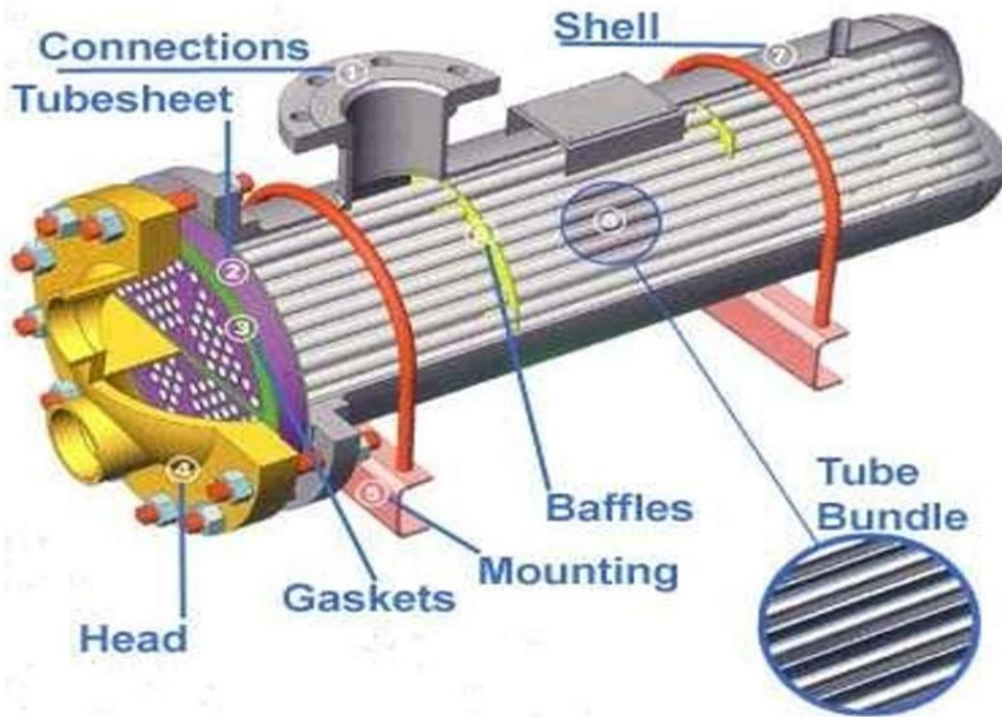


Fig 1.3: Inner view of shell tube heat exchanger

1.4.1 Project Objectives

The objectives of this project are:

- i) To build a shell tube heat exchanger using a suitable software.
- ii) To obtain the heat exchanger's specification.
- iii) To build a small shell tube heat exchanger and check the program.

1.4.2 Problem Statement

The shell tube heat exchanger is one of a kind type of heat exchanger that is used in industry. It contains a large number of tubes rolled in a shell with the axis parallel to that shell. Heat is transferred when one fluid flows inside the tubes and other fluid flows outside the tubes through the shell. shell tube heat exchanger is not suitable for aircraft and

automotive purposes because the size is relatively large and also weighty. In this project, the main focus is in designing a small shell and tube heat exchanger which is available and easy, this experiment can be done in the laboratory. There is a formula to utilize in defining the desired outputs. We can use the LMTD (Log Mean Temperature Difference) or ϵ -NTU (effectiveness-Number of Transfer Units). The method used in developing the formula is using ϵ -NTU which is introduced in 1955 by Kays and London. This method is more easily simplified heat exchanger analysis than LMTD. In this work, the problem stated are to check if the design is worked and is it possibly compatible with the software.

1.4.3 Project scopes

This project is mainly scoping on how to build a new program by using certain software that is available in market. To build a program is to calculate the various outputs of shell tube heat exchanger by applying a formula. The Visual Basic is a software which can be used and it will be utilized to create a new program of calculator. Designing a shell tube heat exchanger by analyse will then runs in total of five flow opening percentage. The shell tube heat exchanger will be tested to get the result and distinguish which flow rate is economical.

1.4.4 Uses and Application of Heat Exchanger

Heat exchangers are used to transfer heat from one media to another. It is mostly used in space heating such as in the home, refrigeration and even in air conditioning. It is used in the radiator using an antifreeze engine cooling fluid. Heat exchangers are classified according to their flow arrangements where there the parallel flow, and the counter flow. Aside from this, heat exchangers also have different types depending on their uses and how that heat is exchanged.

But the fact is that there are heat exchangers even in the circulation system of fishes and whales. The veins of these animals are interconnected such that one side is carrying cold

blood and the other has cold blood. As a result, these species can prevent heat loss especially when they are swimming in cold water. In some whales, the heat exchanger can be found in their tongues. When it comes to the material making industry, heat exchangers are used both for cooling and heating. Heat exchangers in large scale industrial processes are usually custom made to suit the process, depending on the type of fluid used, the phase, temperature, pressure, chemical composition and other thermodynamic properties. (Kakac, S. 2002)

Heat exchangers can transfer the heat stream, which can be seen in many industries. In this case, heat exchangers circulate the output heat to put it as input by heating a different stream in the process. The fact that it really saves a lot of money because when the output heat no longer needed then it can be recycled rather than to come from an external source as heat is basically recycled. When used in industries and in the home, it can serve to lower energy costs as it helps recover wasted heat and recycle it for heating in another process. Typically, most heat exchangers use fluid to store heat and heat transfer can take the form of either absorption or dissipation.

For instance, heat exchangers are used as oil coolers, transmission and engine coolers, boiler coolers, waste water heat recovery, condensers and evaporators in refrigeration systems. In residential homes, heat exchangers are used for floor heating, pool heating, snow and ice melting, domestic water heater, central, solar and geothermal heating. The heat exchangers have different designs which depend on the purpose it is suited for. Braze heat exchangers, a collection of plates which are brazed together, are used for systems like swimming pools, floor heating, snow and ice melting. The shell coil heat exchanger can be easily fitted in the limited areas due to its design as it can be installed vertically. The highly industrial process, the shell tube heat exchanger are the perfect solution for the problem.

1.5 TYPE OF HEAT EXCHANGERS

In industries, there are lots of heat exchanger that can be visually available. The types of heat exchanger can be classified in three important constructions which are tubular type, plate type and extended surface type.

1.5.1 Tubular Heat Exchangers

The tubular types are consisting of roller tubes. One fluid flow inside the tubes and the other flows on the outside of the tubes. The parameters can be changed depending upon of the heat exchanger like the tube diameter, the number of pitches, tube arrangement, number of tubes and length of the tube can be altered. There are three types of heat exchangers lies under this category are double pipe type, shell tube type and spiral tube type. The tubular heat exchangers can be changed for high pressure relative to the environment and pressure difference between the fluids. These exchangers are used for liquid to liquid and liquid to vapor state. when the temperature or pressure is very high or fouling on one fluid side, it will used gas to liquid and gas to gas heat transfer applications.

1.5.2 Double-Pipe Heat Exchanger

According to Sadic Kakac, a double-pipe heat exchanger carries of two types of diameter, smaller and larger diameter pipe, the smaller pipe fitted concentrically into the larger one in order to give direction to the flow from one medium to another. One set of these tubes involves the fluid that has to be cooled or heated. The second fluid runs over to the tubes being cooled temperature or heated in order to provide heat or absorb the heat temperature. It can be made up of several types of tubes such as longitudinally plain, longitudinally finned, and more. If the application features requires an constant wall temperature, the fluids may flow in a parallel direction or it may travel in another direction. This is easy to clean and conveniently easy to disassemble and assemble the parts. The double-pipe heat exchanger is one of the easiest and usually, it is used for small applications because it is so expensive on a cost per unit area basis. The below figure shows...



Fig 1.4- Double pipe heat exchanger

1.5.3 Shell Tube Heat Exchanger

This exchanger is built of a bundle of circular tubes mounted in a large cylindrical shell with the tube axis parallel to the shell to transfer the heat between the two fluids. The fluid flows from inside the tubes and other fluid flows across and along the tubes. But for baffled type heat exchanger the shell side stream flows across between pairs of baffles and then flows parallel to the tubes as it flows from one baffle stage to the next. This carries of exchanger consists of tubes, shells, front end head, rear end head, baffles and tube sheets. The different type of shell tube heat exchangers depends on different application. Usually in chemical industry and process application, it is used as power condensers, preheaters in power plants and also steam generators in nuclear power plants. The most known term of shell tube heat exchanger are fixed tube sheet design, U-tube design and floating-head type. This heat exchanger is easy to clean, it is also low in cost. But among all tube bundle types, the U-tube is the least expensive because it only requires one tube sheet. Technically, because of its construction in U shape, the cleaning is hard to done in the sharp bend. Only the few types of tube passes only can be achieved.

1.5.4 Spiral-Tube Heat Exchanger

A spiral heat exchanger is a helical tube configuration or coiled tube configuration. It consists of spirally round coils placed in a shell or designed as co-axial condensers and co-axial evaporators that are used in refrigeration systems. The heat transfer coefficient rate is significantly higher in a spiral tube than in a straight tube. The main disadvantage is cleaning the heat exchanger impossible, the spiral tubes are suitable for thermal expansion and clean fluids.

The major advantage of this spiral heat exchanger is space and a compact spiral design can lower costs, while an oversized one can have less pressure drop, higher thermal efficiency, less pumping energy, and lower energy costs.

Spiral heat exchangers are frequently used when heating fluids that have solids and therefore often foul the inside of the heat exchanger. Spiral heat exchangers have types of flow configuration. First, the spiral flow and cross flow has one fluid in each.

The spiral flow passages are welded at each side and one carries the cool fluid and the other carries the hot fluid, this type of flow is good for handling low density gases which pass through the cross flow.

This can be used for liquid to liquid applications if one fluid has a much greater flow rate than the other. A second type is the distributed vapor and spiral flow.

The coolant moves in a spiral and exits through the top. The hot gases that enter the inlet and will leave as condensate out of the bottom outlet.

The third type is the counter the current fluids will flow in opposite directions and are used for liquid to liquid applications. The spiral heat exchanger is good for 8 sterilization.

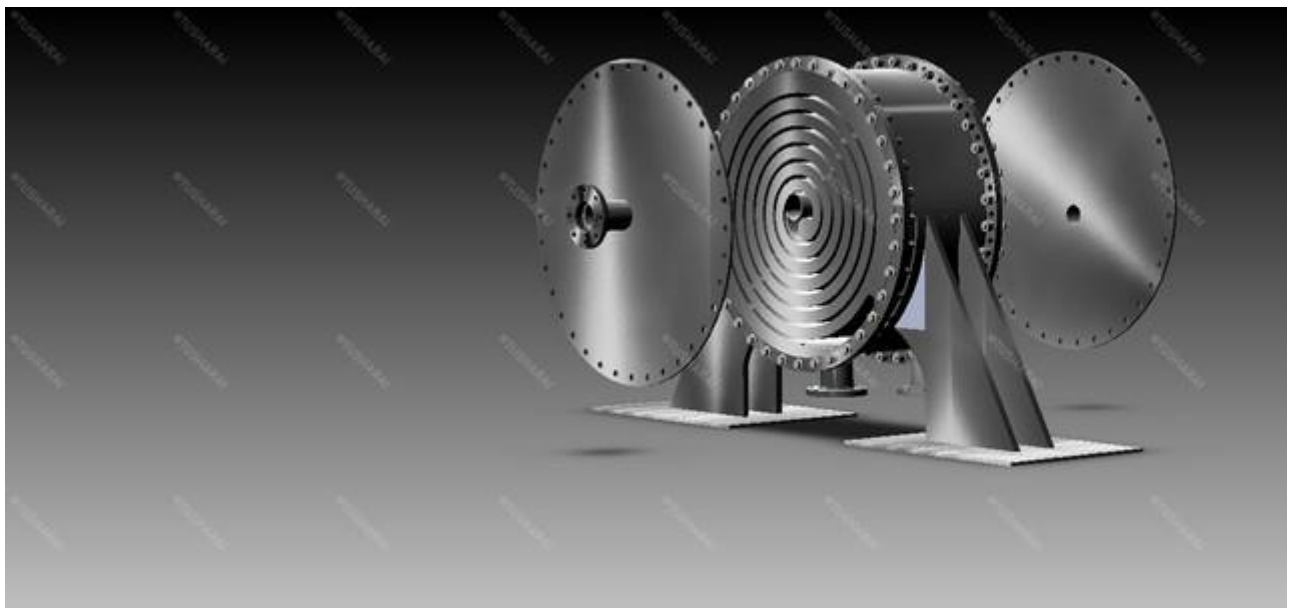


Fig1.5- spiral tube heat exchanger

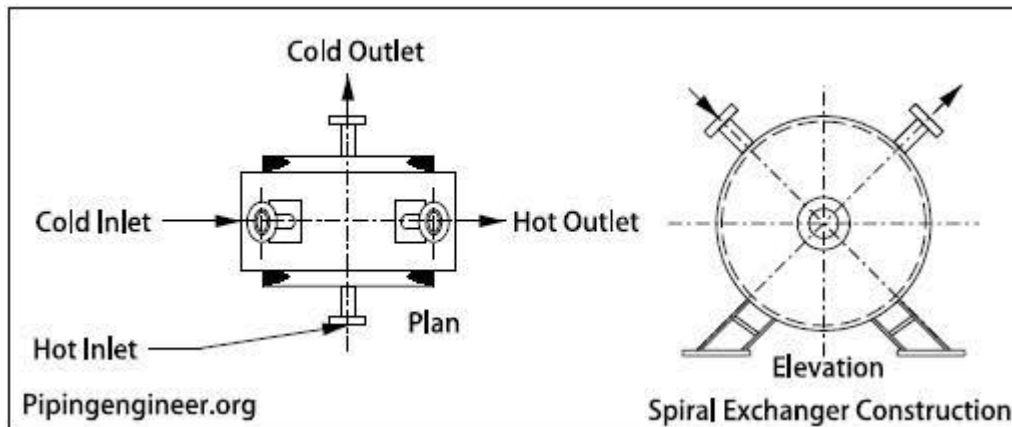


Fig 1.6- construction of spiral heat exchanger

The spiral heat exchanger also called as SHE has compact double coil heat exchanger along spiral tubing. The spiral heat exchanger is also known as one among the heat transfer system with more efficiency. Among the no of issues it has there is one that is internal leakage defects due to the mixing of the cold and hot fluids and leakages from gasket due to an imbalance in the temperature and pressure.

The spiral shell and tube heat exchanger aim is to numerically it can analyse the parameters that affect the (SHE) performance with the help of the CFD numerical. Solutions the final thing the spiral heat exchanger is it will come up with better alternatives to further improve its overall efficiency.

Once it simulated results have been compiled, then it shall be compared with those results from the real existing data, along with the improved efficiency it will be derived from its observation that the results are better. From this paper, the effect of a number of variable parameters are analysed. In this the parameters are inlet and outlet pressure due to the hot and cold fluids.

It has numerical solutions that aims to find its best combination of the parameters this gives to the better performance while we are comparing it with the other ones or the existing ones.

As based on the results we have been achieved by our data we note that the drop in pressure reduces when there is an increase in pressure at unit of (Kpa).

At the same time there is a decrease in the hot input pressure at a unit of (Kpa) based on its range of data it obtained. At last it concludes that the pressure drops becomes better than before state in the hotter fluid region the pressure drops at a 50% rate, so the change in the physical design is recommended to establish a better results.

1.5.5 Special Characteristics of Spiral Tube Heat Exchanger

The spiral tube heat exchanger, has a single flow channel and pure current flow, produces a flow path that has high shear rates and also high turbulence. In a fluid velocities it can be normally be in laminar flow while comparing with other types of heat transfer equipment, the spiral tube heat exchanger is in a fully developed turbulent flow.

In this heat exchanger the continuously curving flow channel produces an intense scrubbing effect that prevents it fouling deposits from forming. Instead, the fouling starts to build to anywhere in the channel, the local cross-sectional area for the flow will be gradually reduced at that position, the consequence for this is, the local velocity will be higher than in the rest of the channel.

Shear rate between the solid fouling and liquid will increase in proportion to its velocity squared and it will cause a scrubbing effect that tends to remove the fouling, the phenomenon is often referred as self-cleaning effect. The overall resulting heat transfer coefficient is higher while comparing with normal shell and tube heat exchangers. In multiple channel heat exchanger such as an T&S, partial plugging of its one tube will, due to the law of least resistance, it lead to higher flow in the other tubes.

The tube that is plugged will see a smaller flow that may not be sufficient to scrub it clean enough. A snowballing effect will result as more tubes become plugged, and the rapid decrease in effective heat transfer area.

1.5.6 High Heat Transfer Rate

In this liquid duties, at first one liquid enters the spiral heat exchanger in the centre and spirals to the peripheral connection welded to the shell. The other fluid enters the via a peripheral connection and exits through a connection at the centre. This flow is practically 100% counter-current flow, which allows a higher degree of heat recovery. The curvature and studs of the single channel help to promote thus turbulence and heat transfer, which gives the spiral heat exchanger to twice the heat transfer coefficient compared to the T&S.

1.6 THE ENERGY EQUATION

In this spiral tube and heat exchanger, the hot fluid it contains flows at a counter clock wise direction from the (core) to the outer region to the central region. at the same time the cold fluid flows at a direction of clockwise from its outer region to its central region. In this heat exchanger there is a partition used to prevent its flow to mix up with the cold flow temperature distributions. In this model its central region of the hot and cold fluid channel is considered to be the half turn of the channel (innermost)half turn.

Additional to this central part between the two fluid hot and cold fluid the flow is assumed to be insulated, while its outermost half turns of the walls are assumed to be insulated. so, either the cold flow or the hot flow can be divided into three different heat transfer regions (for example intermittent turns, outermost half turns and innermost turns).

1.6.1 Leakage is Null

In this single flow channel of the spiral tube heat exchanger it eliminates the leakage and bypassing streams those are common in shell and tube heat exchanger such as(shell-to-baffle)or(tube-to-baffle) leakage. In this the units single flow passage also eliminates flow plugging caused by the mal-distribution an exit/entrance tribulations, this allows for easy handling of viscous materials.

Since it has no sharp turns or corners in it's flow channel, eddying and stagnant areas are either eliminated or reduced. This has added the benefit of reducing potential problems commonly caused due to the erosion. The spiral gauge thick gauge material minimizes possible erosion and corrosion effects.

1.6.2 High Vacuum Applications

The single flow channel & reduced fouling results in achieving very low pressure drops in vacuum operations which is not possible by normal shell and tube heat exchanger since they have minimum pressure drop restrictions. Efficient handling of highly viscous fluids such as greases, oils, thick slurries, fluid containing solids, fibrous materials, fruit pulps, etc.

It is also possible with compact heat exchanger size, maintenance and minimum fouling. A standard shell and tube heat exchanger tends to choke and foul due to smaller tube passages for fluids and requires frequent cleaning adding up to maintenance cost and time.

1.6.3 Geometrical Modelling

Spiral coiled heat exchanger is found having good heat transfer rate and occupy very less space. In present research working the number of turns of spiral coiled heat exchanger have been taken as the distance between two consecutive turns called as pitch. The distance between the centre to the last turn of the spiral coiled heat exchanger. The distance from the centre to the first turn of the spiral coiled heat exchanger is taken at a unit of mm.

1.6.4 Experimental Method of Spiral Tube heat exchanger

The spiral tube and heat exchanger has excellent heat transfer capacity because of its far compact and high heat transfer efficiency. spiral-tube heat exchangers consists of one or more than spirally wound coils which are circular in pattern, connected to the header from which fluid is flowed.

In this spiral heat exchanger it consists of a spiral coil which is installed in a shell another fluid is circulated around outside of the tube, leads to the transfer the heat between the two fluids. The heat transfer rate associated with this spiral tube has a higher hand than the straight tube heat exchanger. In addition to this a considerable amount of surface can be in a given space by spiralling in this spiral tube heat exchanger, problem of thermal expansion is not probably occurring and self cleaning is also possible.

This spiral tube heat exchanger is a coil assembly fitted in a shell that allows to optimize the heat transfer efficiency and minimise the space. Each and Every spiral coil assembly has welded tube manifold joints and uses stainless steel as a minimum material requirement for durability and strength. The spiral heat exchanger uses multiple parallel tubes which are connected to pipe or header to create a tube side flow. The gaps or spaces between the coils of the spiral tube bundle becomes the shell side flow path when there is a bundle placed in the shell.

Shell side and tube side connections on the bottom or top of the assembly allows for different flow path configurations. The spiral shape of the flow for the tube side and shell side fluids create centrifugal force and secondary circulating flow that can enhance the heat transfer on both sides in a true counter flow arrangement.

Since the baffles provided is zero in to this system due to its lower velocities and heat transfer coefficients. The performance is optimized. In addition since there are a various multiple parallel tube configurations those are not constrained by the diameter sizes of the limited shell as it is in shell and tube designs. The profile of this spiral is very compact and fits in a smaller path than a normal shell and tube design. Since the tube bundle is coiled, space requirements for tube bundle removal are almost eliminated.

When the exotic material is required, at that time this spiral tube heat exchanger minimizes the material used in this since manifolds replace the channels, tube and head sheets of a conventional shell and tube design. The spiral tube heat exchanger uses single channel technology, which allows fully counter-current flow. one of the fluid (HOT FLUID) enters the centre of the unit and flows towards the boundary, the other fluid (COLD FLUID) enters the unit at the periphery and moves towards the centre.

The channels are curved and thus it has a uniform cross section, which creates spiral motion within the fluid. The fluid in this spiral heat exchanger is fully turbulent at a much lower velocity than straight tube heat exchangers, and this fluid travels at constant velocity throughout the whole unit.

1.6.5 Overall Analysis

The overall heat transfer effectiveness of a counter current spiral tube heat exchanger is expressed as a number of transfer units, ratio of flow capacity rates, number of transfer units, ratio of flow capacity rates, number of spiral turns , and dimensionless start – point of a spiral (DIMENSIONLESS ANGULAR ANGLE OF START POINT OF A SPIRAL CURVE CONSTITUTING THE SOLID WALL OF THE HEAT EXCHANGER).

The heat transfer effectiveness is weakly dependent on the dimensionless start – point angle of spiral turns, As the number spiral turns is less than 20 so, the heat transfer effectiveness of this spiral heat exchanger does not approaches that of a counter flow heat exchanger.

The heat transfer effectiveness of the spiral tube heat exchanger is maximum. The optimum number of transfer units at the maximum heat transfer effectiveness increases along with the number of spiral turns, whereas it increases with a decrease of the ratio of its flow capacity rates.

In the second-law analysis, an best-case scenario hot flow- to- cold flow rate of capacity ratio is found, For obtaining a large net recovered energy rate, the spiral heat exchanger needs to possess a large number of transfer units and operate at a near balanced- flow- condition. In addition, a small consumed mechanical power is demanded.

At first the air (hot fluid) exists from the condenser then it transfers to the evaporator and from the exists of the evaporator it transfers to the compressor where the air gets compressed and with the increase in temperature the hot fluid transfers to the spiral tube heat exchanger, where the process mentioned above takes place it reduces the temperature of the hot fluid and then it transfers to the condenser and the process will be proceeding in a bicycle method.

This spiral tube heat exchanger has a heat transfer rate which depends up on the coil diameter that causes an increment in rate of heat transfer, as maximum heat transfer rate has been obtained then the heat transfer rate is proportional to the diameter of coil. So the highest heat transfer rate is obtained for heat exchanger that has largest diameter, they both vary linearly because of increase in cross sectional area. Increase in diameter

of coil causes decrease in the velocity of fluids, which led to decrease in the number in same mass flow rate.

Due to the increase in mass flow rate for same coil diameter of heat exchanger results in the increase of velocity of fluid. With the increase in mass flow rate number decrease. The Reynolds number in this spiral heat exchanger depends upon the mass flow rate. Increase in the mass flow rate leads to the increase in Reynolds number.

1.7 ANSYS WORKBENCH 16.0

Open the workbench, click on the fluid flow (fluent) option in the toolbox, where you can see in the left side of the window. Double click on the fluid flow option, a pop-up menu will appear. In that menu, you can see these options like Geometry, Mesh, Setup, Solution, and Results. Right click on the geometry option and click on edit and the geometry page will be opened.

1.7.1 Geometry

In the geometry window, click on the file option which is in the top of the window. The file shows more options, in those options click on the import geometry. By clicking on that option, it will direct you to the file manager. There you can select the cad file, which we already saved in the .igs format in solidworks software. The cad file will be imported.

Then, click on the enclosure option in the tools, which is in the top of the window. After that, select the geometry that we are going to apply the enclosure. Then the enclosure will be applied, where you can see the rectangular box around the geometry. Then click on the file option and select the close design modeler then the geometry window will be closed and it directs you to the main window.

1.7.2 Mesh

Then click on the second option option which is mesh one. After clicking the mesh option, the mesh window will appear. In the window, click on the geometry option, which is in the left side of the window. By clicking the geometry it shows the part1 option. Select part 1

option, that shows the menu downwards. In that menu, click on the materials option and select the fluid in the fluid/solid point. After that, right click on the mesh option, and click on the generate mesh to mesh the geometry. Then the geometry will be meshed. After that close the mesh window.

1.7.3 Setup and Solution

Right click on the set up option in the main window, then click on the edit button. A popup menu will appear, in that menu select the double precision in options and select the parallel in processing option and click ok, then the setup window will be opened.

In the setup window, click on the general option and select the pressure-based in type, absolute in velocity formulation and steady in time options. Then click on the models option and On the energy equation option. After that, click on the materials then select air in fluid option and aluminum in solid option.

And in the boundary conditions options, select the interior part and exterior wall part. Then click on the reference value option then select part and enter those reference values. Then click on the solution initialization option, and select the standard initialization after that click on the initialize button. Finally click on the Run calculation option, and enter the number of iterations and click on the calculate button.

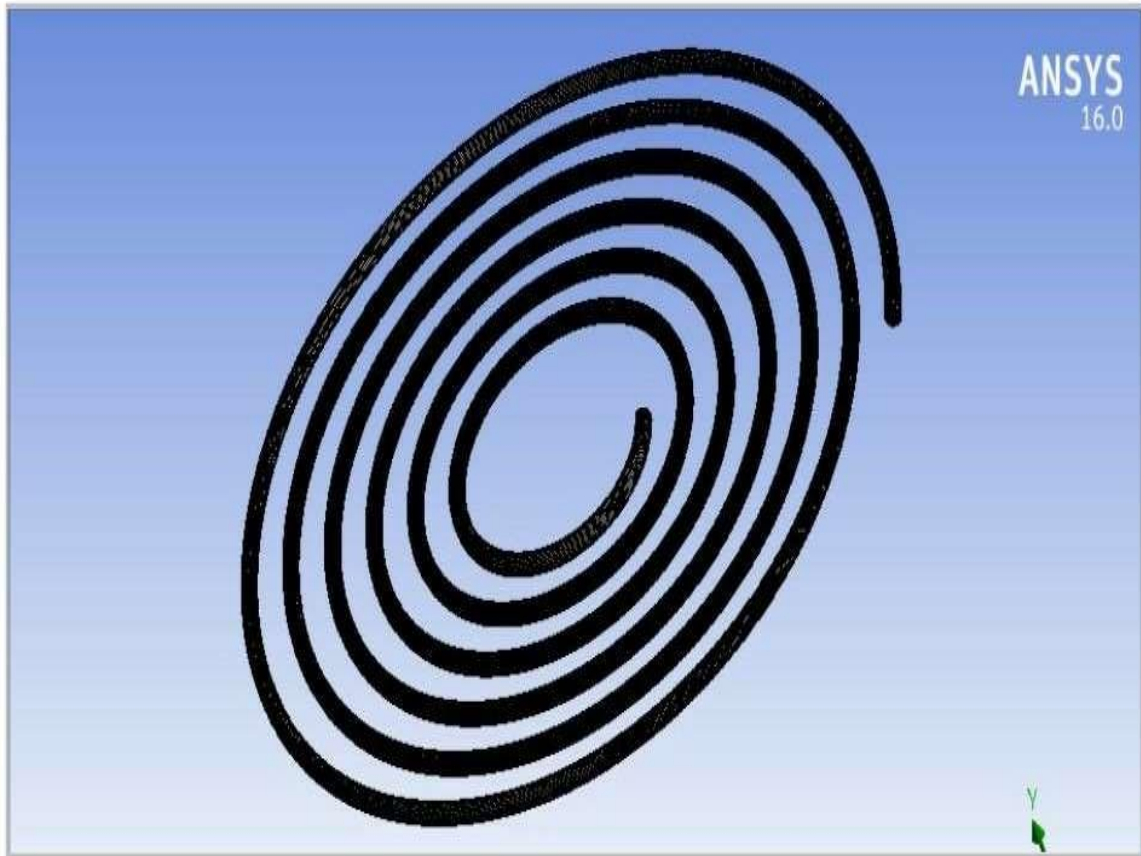


Fig 1.7-Ansys of Spiral Heat Exchanger

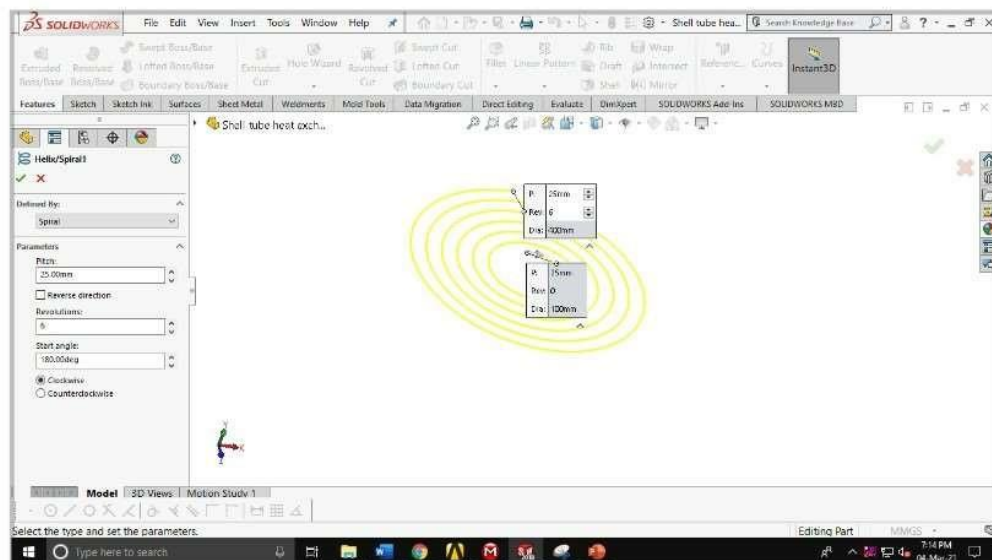


Fig 1.8- Design of solidworks Part 1

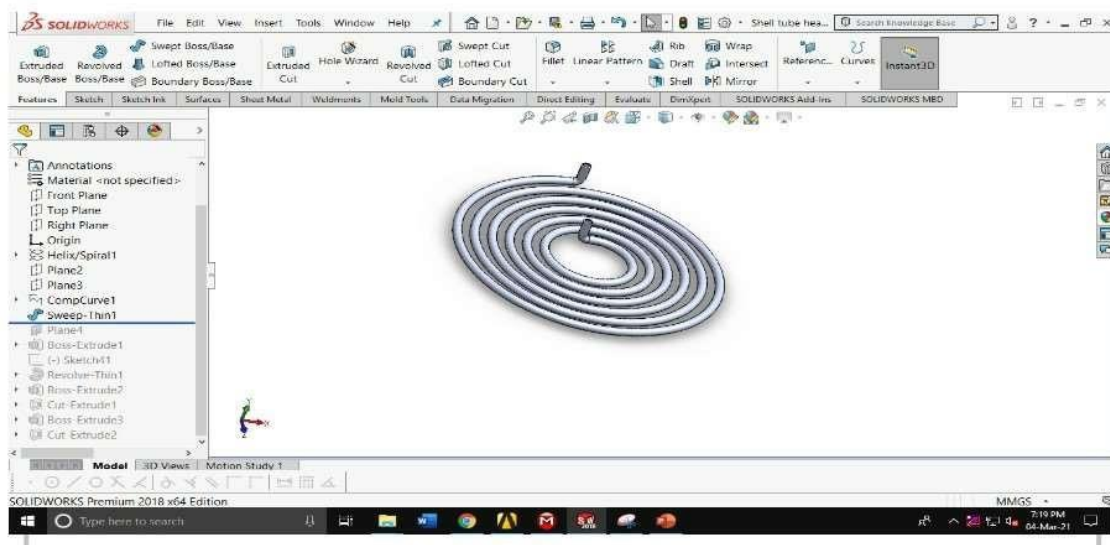


Fig 1.9 – Design of solidworks part 2

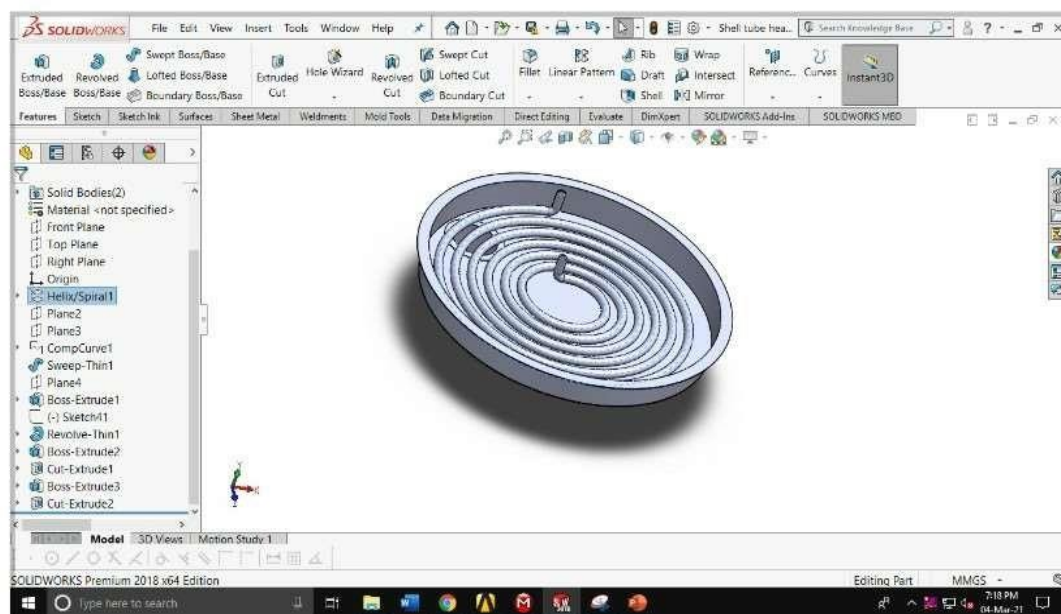


Fig 1.10 – Design of solidworks part 3

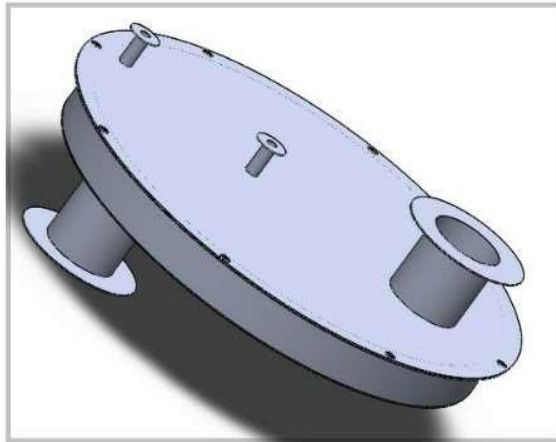


Fig 1.11 – Design of solidworks part 4

CHAPTER 2

2 LITERATURE REVIEW

A wide range of examinations are already done to study the flow descriptions and heat transfer in helical heat exchangers. The development of the heat transfer in the helically spiral tubes is due to the centrifugal forces. A secondary flow field is produced due to the twist of the tube with a circulatory motion, which causes the fluid particles to move towards the core region of the tube.

Kevin M. Lunsford-1998 Kevin M. Lunsford assessed the increasing heat exchanger functioning through a logical series of steps. The first step considers if the exchanger is primarily operating correctly. The second step deliberates increasing pressure drop if obtainable in exchangers with single-phase heat transfer. Augmented velocity results in higher heat transfer coefficients, which may be sufficient to improve execution. Next, a critical assessment of the estimated fouling factors should be deliberated. Heat exchanger working can be increased with periodic cleaning and less conservative fouling factors. Lastly, for certain conditions, it may be realistic to consider heightened heat transfer through the use of finned tubes, inserts, twisted tubes, or modified baffles. Most of these proprietary expertise can not be predicted a priori. However, combined with the augmentation information obtained from the vendors for specific cases along with assessments of heat transfer film coefficients, engineers can perform introductory evaluations using these new methods to increase shell-and-tube heat exchanger performance.

Durgesh Bhatt, Priyanka M Javhar-2012 Durgesh Bhatt, Priyanka M Javhar piloted a Shell and Tube Heat Exchanger Performance Evaluation. It is observed that by altering the value of one variable the by observance the rest variable as relentless we can obtain the different outcomes. Based on that outcomes we can enhance the design of the shell and tube type heat exchanger. Higher the thermal conductivity of the tube metallurgy higher the heat transfer rate will be attained. Less is the baffle spacing, more is the shell side passes, higher the heat transmission but at the rate of the pressure drop.

JAY J. BHAVSAR, V K. MATAWALA-2013 The preceding works carried out by different authors were limited to spiral coil heat exchanger and spiral plate heat exchanger. The spiral tube heat exchanger is compacted in size and more heat transfer can be conceded out. The objective of present work is to rationalise design methodology of spiral tube heat exchanger. The premeditated spiral tube heat exchanger is required to be developed and testing will be performed on it to analyses pressure drop and temperature variation in hot and cold fluid on shell side and tube side.

Vindhya Vasiny Prasad Dubey, Raj Rajat Verma-2014 Dubey and Verma conducted a Performance Analysis of Shell & Tube Type Heat Exchanger under the Effect of Varied Operating Circumstances and concluded that It may be said that the insulation is a good tool to surge the rate of heat transfer if used properly well below the level of acute thickness. Midst the used materials the cotton wool and the tape have given the best values of efficiency. Moreover the efficiency of the heat exchanger also depends upon the value of commotion provided. However it is also seen that there does not exists straight relation between the turbulence and effectiveness and effectiveness attains its peak at some intermediary value. The ambient conditions for which the heat exchanger was performed do not show any substantial effect over the heat exchanger's enactment.

CHAPTER 3

METHODOLOGY

Shell and tube heat exchangers are intended normally by using either Kern's method or Bell-Delaware method. Kern's method is typically used for the preliminary design and provides conservative outcome whereas, the Bell-Delaware method is more precise method and can provide detailed outcome. It can foresee heat transfer coefficient with better accurateness. In this paper we have planned a simple counter flow shell and spiral tube type heat exchanger to cool the water from 85 to 55 by using water at room temperature by using Kern's method.

1. First we consider the energy balance to find out the values of some unknown temperature values. The energy balance equation may be given as:

$$Q = m_1 c_1 (T_1 - T_2) = m_2 c_2 (T_2 - T_1)$$

2. Then we consider the LMTD expression to find its value:

LMTD or $\Delta T_m = (\Delta T_1 - \Delta T_2) / \ln(\Delta T_1 / \Delta T_2)$ Where $\Delta T_1 = T_1 - T_2$, $\Delta T_2 = T_2 - T_1$

3. Then by using the amount of heat transfer formula we can get the heat transfer quantity:

$$Q = UA(\Delta T_m)$$

4. Then we intended to find the Effectiveness of heat transfer by the following:

$$\Delta = Q / (C_{min} * (T_1 - t_1))$$

Design and fabrication Methodology: (Order)

1. Choosing the field of project.
2. Referring of research journals.
3. 2D&3D modelling with dimensioning.
4. Analysing the project in the software
5. Results and observations.

CHAPTER 4

4 DESIGN CALCULATIONS

Design of spiral tube

Diameter of the inner tube $d_i = 10\text{m}^2$

Diameter of the outer tube $d_o = 12\text{m}^2$

Number of turns on the tube $N = 6$

Pitch of the spiral on the tube $P = 24\text{m}^2$

Outside diameter of the coil $D = 100\text{m}^2$

Design of Outer shell

Thickness of the shell $t = 1.2\text{m}^2$

Diameter of the shell $d = 200\text{m}^2$

Length of the shell $L = 600\text{m}^2$

Area of the shell $= \pi(r)^2 = \pi(100)^2 = 31.4 \text{ m}^3$

Circumference of the shell $= 2\pi r = 2 * \pi * 100 = 628\text{m}^2$

Flow calculations:

Entry temperature of hot fluid $T_1 = 70^\circ\text{C}$

Exit temperature of hot fluid $T_2 = 52^\circ\text{C}$

Entry temperature of cold fluid $t_1 = 31.3^\circ\text{C}$

Exit temperature of cold fluid $t_2 = 38^\circ\text{C}$

CALCULATION OF CALORIC TEMPERATURE

For the calculation of caloric temperature

$$r = \frac{\Delta_{tc}}{\Delta_{th}} = \frac{T_2 - t_1}{T_1 - t_2} = \frac{120 - 70}{160 - 120} = 1.25$$

°API of hot liquid=76°; Therefore $K_c=1$; $F_c=0.455$

Caloric temperature of hot liquid, $T_{hc}=T_2+F_c(T_1-T_2)$

$$=120+0.455 \times (160-120)$$

$$=327.14\text{k}$$

Caloric temperature of the cold fluid, $T_{cc}=t_1+F_c(t_2-t_1)$

$$=75+0.455 \times (120-75)$$

$$=307.91\text{k}$$

Fluid properties at caloric temperature

Viscosity

76°API gasoline, $\mu_g = 0.2_{cp}(0.484(\text{m}^2/\text{s}))$

46°API kerosene, $\mu_k = 1.6_{cp}(3.872(\text{m}^2/\text{s}))$

Density

$$\underline{C_g}=685 \text{ kg.m}^{-3}$$

$$\underline{C_g}=800 \text{ kg.m}^{-3}$$

Thermal conductivity

$$K_g=0.075 \text{ W/mk}$$

$$K_k=0.083 \text{ W/mk}$$

Specific heat capacity

$$C_g=0.57 \text{ J/(kg K)}$$

$$C_k=0.48 \text{ J/(kg K)}$$

Specific gravity

$$S_g = 0.685$$

$$S_k = 0.80$$

Energy Balance

Assume no heat loss to surrounding

$$Q_g = Q_k = m_k C_k (t_2 - t_1) = m_g C_g (T_1 - T_2) = 3240000 \text{ Btu/h}$$

$$= 150000 \times 0.48 \times (120 - 75) = m_g \times 0.57 \times (160 - 120)$$

$$m_g = 17.9 \text{ kg/s}$$

Calculation of heat transfer area and tube numbers

Iteration #1

The first is started assuming 1 shell pass and 2 tube pass shell tube exchanger with following dimensions and considerations.

- Fixed tube plate
- 1" OD tubes(d_o) on 1^{1/4}" square pitch(P_T)
- Outer diameter of tube = 1"
- Tube length (L_t) = 16'
- Tube ID(d_i) = 0.834"
- Fluid arrangement: Kerosene is placed in tube side because it has the higher fouling tendency

The log mean temperature correction factor(F_T) for 1-2 shell tube exchanger

$$F_T = \frac{\frac{\sqrt{R^2 + 1} \ln(1 - S)}{1 - RS}}{\frac{(R - 1) \ln(2 - S(R + 1 - \sqrt{(R^2) + 1}))}{2 - S(R + 1 + \sqrt{(R^2) + 1})}}$$

$$= \frac{\sqrt{0.29^2 + 1} \ln \frac{(1 - 0.529)}{(1 - 0.89 \times 0.529)}}{(0.89 - 1) \ln \frac{(2 - 0.529(0.89 + 1 - \sqrt{0.89 + 1}))}{2 - 0.529(0.89 + \sqrt{(0.89 + 1 + \sqrt{0.89^2 + 1}))}}}$$

$$= 0.802$$

$$\text{Where, } R = \frac{T_1 - T_2}{t_2 - t_1} = \frac{160 - 120}{120 - 75} = 0.889$$

$$S = \frac{t_2 - t_1}{T_1 - t_1} = \frac{120 - 75}{160 - 75} = 0.529$$

$$LMTD = \frac{(T_2 - T_1) - (t_2 - t_1)}{\ln \frac{T_2 - T_1}{t_2 - t_1}}$$

$$= \frac{(160 - 120) - (120 - 75)}{\ln \frac{(160 - 120)}{(120 - 75)}}$$

$$= 278.91 \text{ K}$$

Logarithm mean temperature difference = 278.91 K

Determining the heat transfer area ('A')

The value of overall heat transfer coefficient (U) of 45 Btu h⁻¹ft⁻²°F⁻¹ is assumed to initiate the design calculation for the kerosene and gasoline heat exchanger. The approximate range of overall heat transfer coefficient depending on the hot and cold fluid can be found out from text books

$$A = \frac{Q}{U \times LMTD \times F_T}$$

$$\frac{m_g C_g (T_1 - T_2)}{U \times LMTD \times F_T}$$

$$\frac{142105 \times 0.57 \times (160 - 120)}{45 \times 42.75 \times 0.82}$$

$$= 2100 \text{ W/m}^2\text{k}$$

Calculating no. of tubes(n_t)

$$n = \frac{A}{\pi d_o L_t}$$

$$\frac{2100}{\pi \times \frac{(1)}{(12)} \times 16} = 502$$

$n_t=518$ is taken corresponding to the closet standard shell of 35" for fixed tube sheet, 1-shell 2-tube pass exchanger with 1" tube OD on 1^{1/4}" square pitch.

Check for fluid velocity

$$Re = \frac{4m_k \left(\frac{n_p}{n_t} \right)}{\pi d_i \mu}$$

$$Re = \frac{4 \times (150000) \times \frac{2}{518}}{\pi \times \frac{0.834}{12} \times 3.872}$$

$$= 2740.2 < 10^4$$

CHAPTER 5

RESULT

In the overall results shows that spiral heat exchanger is far more better than other type of heat exchanger due to it's compact size and more durability. The below give the CFD ansys results which shows results in detail, you can see the image displaying differentiate colour the more heavier the colour, the more heat. We have demonstrated for Pressure, Density, Temperature, velocity.

DENSITY

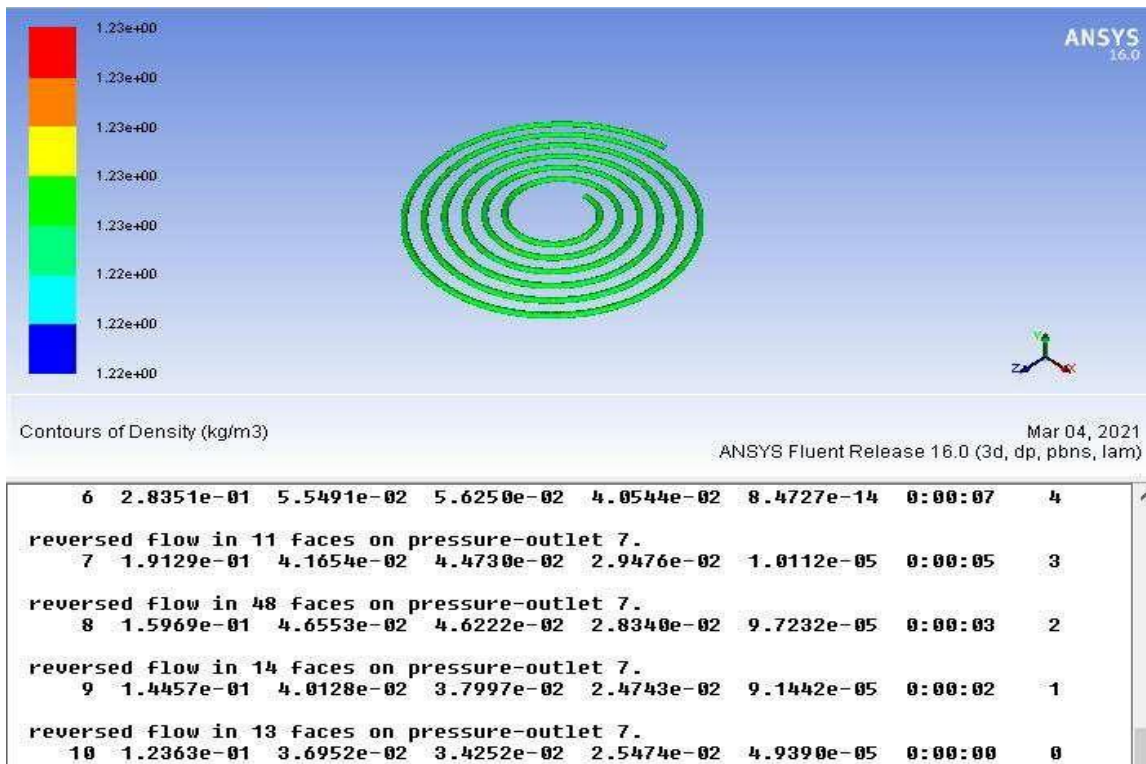


Fig 5.1-Density

TEMPERATURE

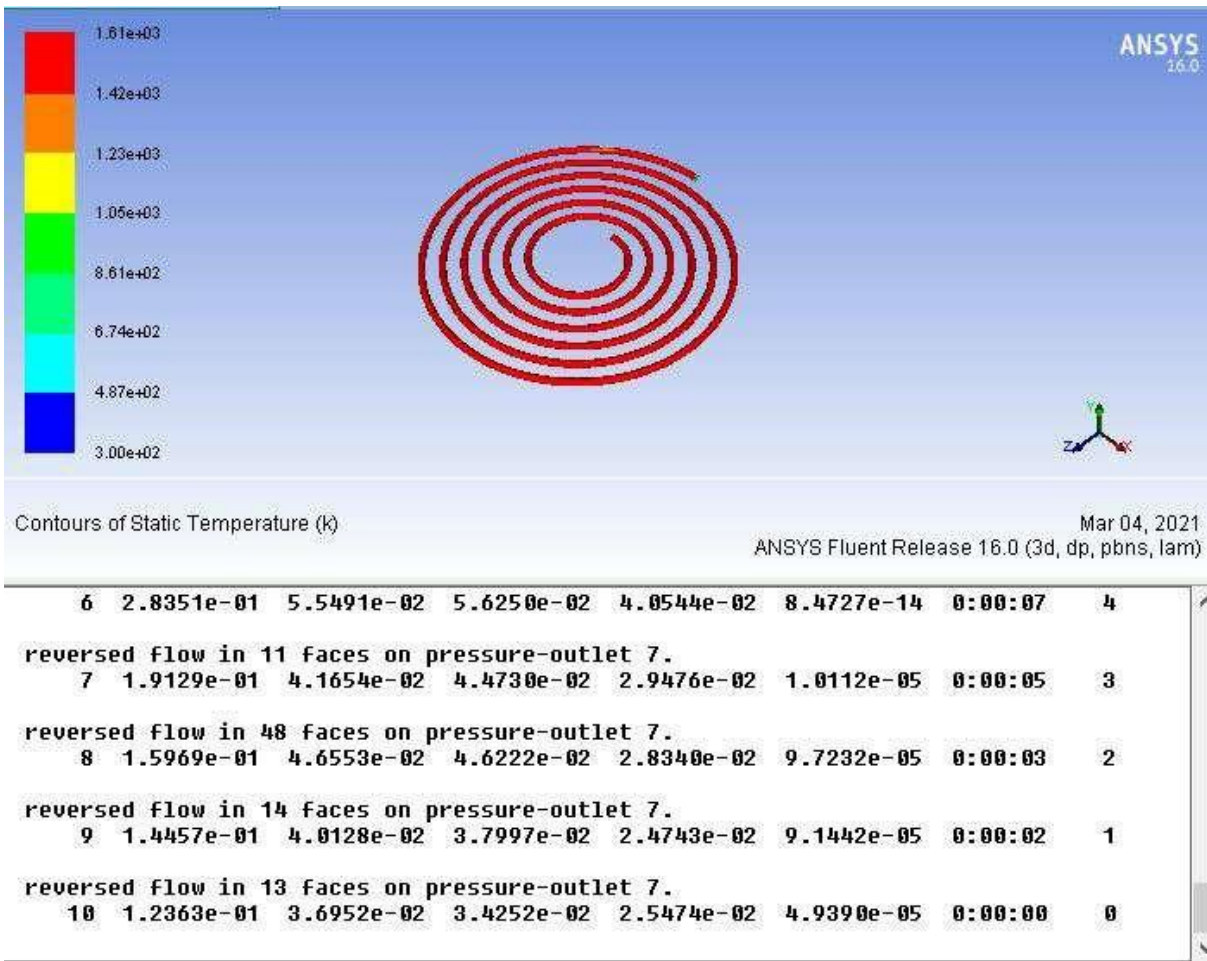


Fig 5.2- Temperature

VELOCITY

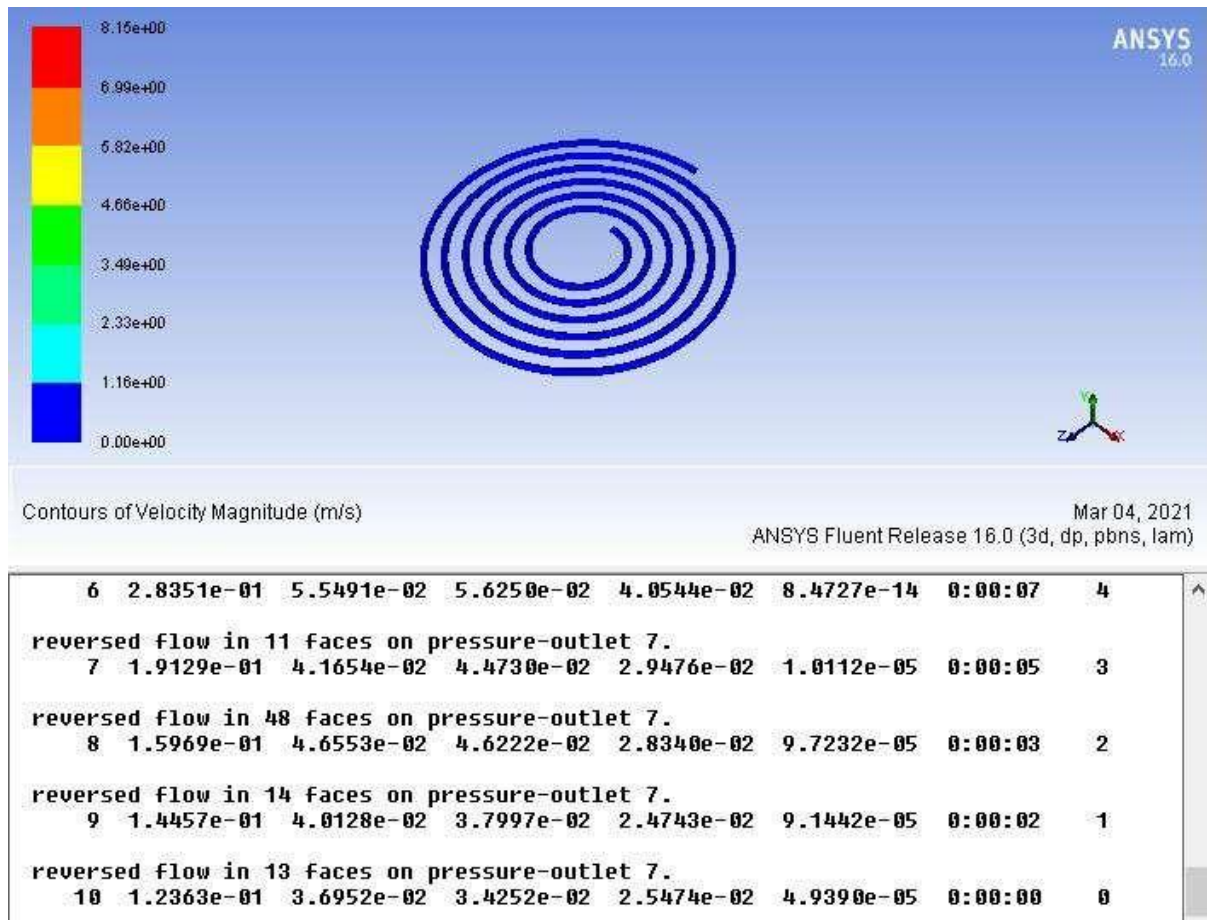


Fig 5.3- Velocity

PRESSURE

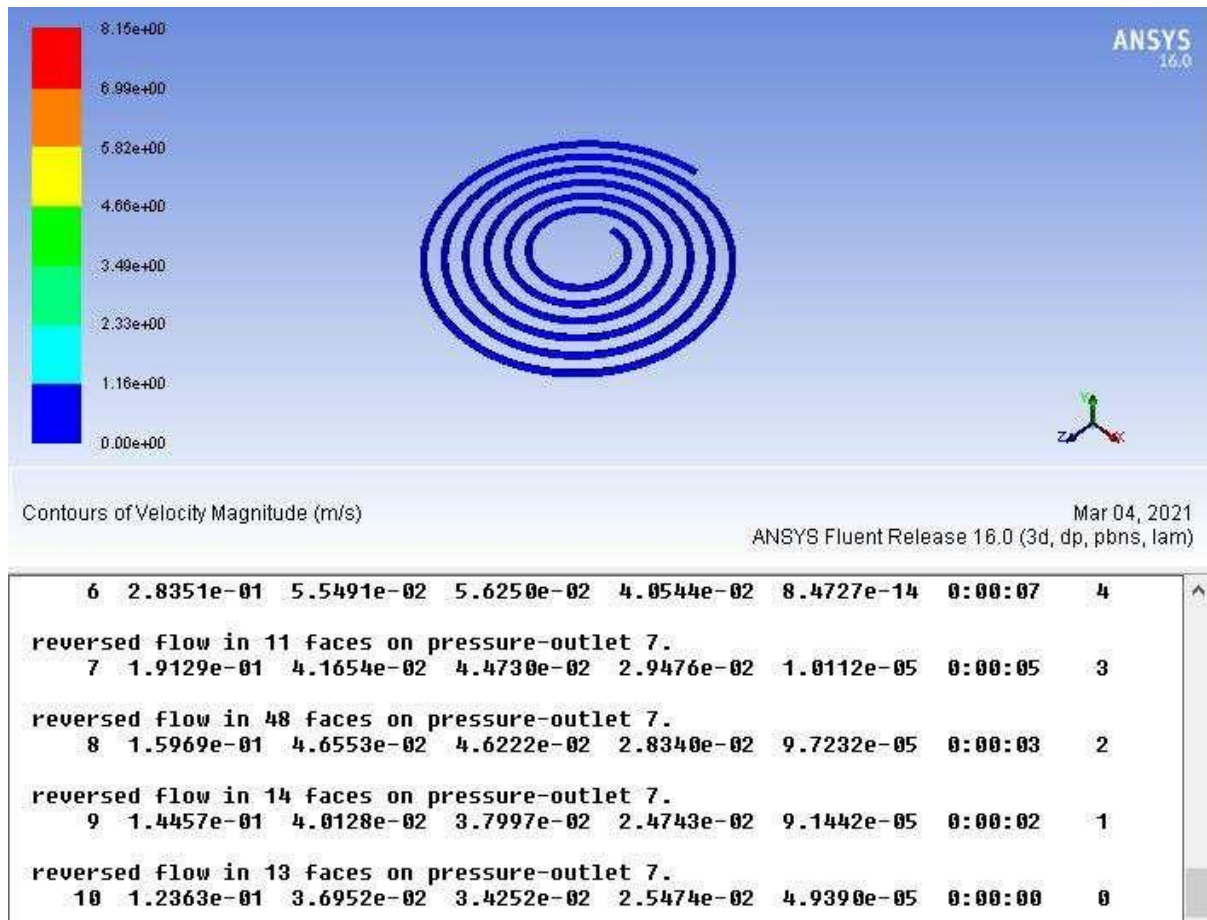


Fig 5.4- Pressure

CHAPTER 6

CONCLUSION

The final research were found valid and satisfactory. The spiral tube heat exchanger is compact in size and more heat transfer can be carried out. The designed spiral tube heat exchanger is required to be developed and experiments will be performed on it to analyses pressure drop and temperature change in hot and cold fluid on shell side and tube side. The constructed heat exchanger will show good heat transfer behavior in both channels as can be interpreted from software outlets. Heat transfer is going to be very well along the heat exchanger. Fluid flow will become completely turbulent. Especial shape of the heat exchanger and secondary flows lead to random movement of the fluid particles in all directions so that axial, radial, and swirly movements exist together that mix the fluid very well and force the flow to be turbulent. By increasing the number of turns this spiral coil enhances the rate of heat transfer. It was observed that the heat transfer rate increases almost linearly with increasing Reynolds number.

ADVANTAGES

- i. Due to its spiral flow oaths that are imparted to the tube and shell-side fluids, the effects of the secondary circulating and the centrifugal flow enhances the heat transfer on both sides in a (counter flow arrangement).
- ii. As the fluid is fully turbulent at a lower velocity in comparison with the straight tube heat exchangers, the fluid travels at a constant velocity through the whole unit, and thus the sticking of oil the defect will also be eliminated.
- iii. This spiral heat exchangers requires a smaller area for its mounting resulting in less installation cost while comparing it with others.
- iv. While comparing it with the other heat exchangers, this spiral units provides the best access to the heat transfer area which has no special tools or there is no requirement for lifting materials.

- v. It has very low pressure drop on the vapour side that required for high vacuum condensation.
- vi. It is used for toughening process for the fluids such as fermentation broth, sewage sludge.
- vii. This spiral tube heat exchanger is more economical.

REFERENCE

1. K.S. Bharuka, D.Y. Kasture(1984), Flow through a helically coiled annulus, Applied Science Research, 41, 55–67.
2. Dawit Bogale(2014) , AJER, e-ISSN : 2320-0847 p-ISSN : 2320-0936
Volume-03, Issue-10, pp-99- 109 (Design and Development of Shell and Tube Heat Exchanger for Harar Brewery Company Pasteurizer Application (Mechanical and Thermal Design))
3. Durgesh Bhatt, Priyanka M Javhar,IJSR,ISSN(2011):23197064,research paper on Shell and Tube Heat Exchanger Performance Analysis.
4. Kevin.L.Luthersford conducted a experiment to increase the heat exchanger performance It may be feasible to consider enhanced heat transfer through the use of finned tubes, inserts, twisted tubes, or modified baffles.(1998)
5. Ramesh K shah and Dusan P. Sekulic(2013), “Fundamental of heat exchanger design”, Rochester Institute of Technology, Rochester New York.
6. Sandeep K. Patel, Professor Alkesh M. Mavani (2012)ISSN2249–8974IJAERS/Vol. II/ Issue I/130- 135, Research Paper on Shell and tube heat exchanger thermal design with optimization of mass flow rate and baffle spacing .

7. kondahkar, G.E. and Kapatkat, V.N. (2012) Performance Analysis of Spiral Tube Heat Exchanger Used in Oil Extraction System. International Journal of Modern Engineering Research, 2, 930-936.