International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 6 (2018) pp. 299-302

Thermal Analysis of Double Pipe Heat Exchanger

Ashish sharma
[1]*Department of Mechanical Engineering, KIET Group of Institutions, Ghaziabad, India*

Ajay Tyagi
Department of Mechanical Engineering, KIET Group of Institutions, Ghaziabad, India

Ashok Kumar
Department of Mechanical Engineering, KIET Group of Institutions, Ghaziabad, India

Abstract

Heat transfer equipments is well-defined by way of the function it fulfils in a process. On the similar line, heat exchangers,are the equipments,used in various,industrial methods,to recover heat,between two,fluids. These are commonly used in space heating, refrigeration, air conditioning, power, chemical, petrochemical plants, petroleum refineries, and natural gas treating. The operating efficiency of these heat exchangers plays a key role in the overall running cost of a plant. So the designers of heat exchangers always strive to develop heat exchangers which are highly efficient, compact and cost effective. A common practise in refinery is to extract extreme heat from a service stream coming out of a exact process, and to heat a stream. Therefore the objective of present work involves the study of an important refinery process taking place in a double pipe heat exchanger and do the performance rating of such heat exchanger by changing the fin size i.e. circular fins having 9.8% cut.

Keywords: Hear exchanger, fin, crude oil.CFD

1. Introduction

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 different temperatures and in thermal contact. In heat exchangers, there are usually no external heat and work interactions.

In heat exchanger two modes of heat transfer occur such as convection and conduction. Usually convection occurs in both working fluids and conduction through walls of heat exchanger which separates the fluids. Typical applications involve heating or cooling of a fluid stream and evaporation or condensation of single or multicomponent fluid streams. In other applications, the objective may be to recover or reject heat or sterilize, pasteurize, fractionate, distillation, concentrate, crystallize, or control a process fluid. In a few heat exchangers, the fluids exchanging heat are in direct contact.

In most heat exchangers, heat transfer between takes place through a separating wall or into and out of a wall in a transient manner. In many heat exchangers the fluids are separated by a heat transfer surface and ideally they do not mix or leak. Such exchangers are referred to as direct transfer type, or simply recuperators. In contrast, exchangers in which there is intermittent heat exchange between the hot and cold fluids via thermal energy storage and release through the exchanger surface or matrix are referred to as indirect transfer type, or simply regenerators. Such exchangers usually have fluid leakage from one fluid stream to the other due to pressure differences and matrix rotation/ valve switching.

Common examples of heat exchangers are shell and tube exchangers, automobile radiators, condensers, evaporators, air pre heaters, and cooling towers. If no phase change occurs in any of the fluids in the exchanger, it is sometimes referred to as a sensible heat exchanger. There could be internal thermal energy sources in the exchangers, such as in electric heaters and nuclear fuel elements. Combustion and chemical reaction may take place within the exchanger, such as in boilers, fired heater

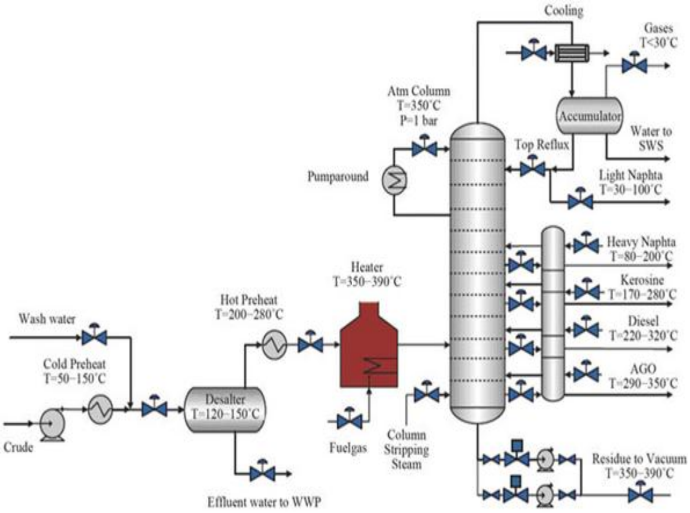
HEAT EXCHANGERS IN REFINERY PROCESS

The separation of crude oil into different fractions is done by distillation process in refinery. The fractions are further treated to convert them into mixtures of more useful products by various methods such as cracking, reforming, alkylation, polymerization and isomerization These mixtures of new compounds are then separated using methods such as fractionation and solvent extraction. Impurities are removed by various methods, e.g. Dehydration, desalting, sulphur removal and hydro-treating. Refinery processes have developed in response to changing to market demands for certain products. With the advent of the internal combustion engine the main task of refineries is to produce of Petrol and Diesel.

Distillation is the first step in the processing of crude oil and it takes place in a tall steel tower, as shown in and is called fractionation column. The inside of the column is divided at intervals by horizontal trays. The column is kept very hot at the bottom (the column is insulated but as different hydrocarbons boil at different temperatures, the temperature gradually reduces towards the top, so that each tray is a little cooler than the one below.

The crude needs to be heated up before entering the fractionation column and this is done at first in a series of heat exchangers where heat is taken from other process streams which require cooling before being sent to rundown. Heat is also exchanged against condensing streams from the main column. Typically, the crude will be heated up in this way up to a temperature of 200-280^{0}C, before entering a furnace.

As the raw crude oil arriving contains quite a bit of water and salt, it is normally sent for salt removing first, in a piece of equipment called a de-salter. Upstream the de-salter, the crude is mixed with a water stream typically about 4 - 6% on feed. Intense mixing takes place over a mixing valve and optionally) as static mixer. The de-salter, a large liquid full vessel, uses an electric field to separate the crude from the

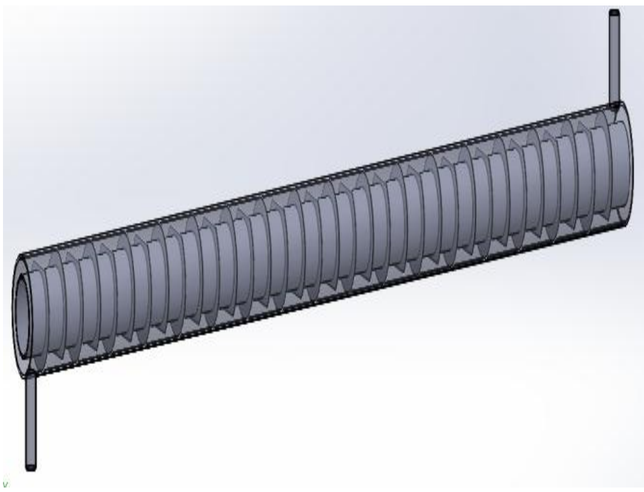


water droplets.

2.COMPUTATIONAL FLUID DYNAMICS

Computational fluid dynamics (CFD) is the science of predicting fluid flow, heat and mass transfer, chemical reactions and related phenomena by solving numerically the set of governing mathematical equations (conservation of mass, momentum, energy, species mass etc.). The results of CFD analyses are relevant in conceptual studies of new designs, detailed product development, troubleshooting and redesign. CFD analysis complements testing and experimentation by reducing total effort and total cost for experiments**.**

Double pipe heat exchanger with circular fins



Double pipe heat exchanger with circular fins

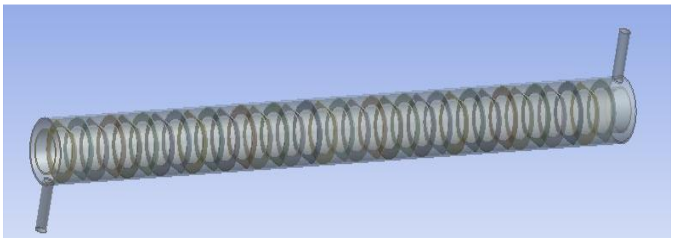
The circular fins are mounted on the outer surface of inner pipe and concentric with inner pipe and outer pipe shows a circular fins with 9.8% cut. Theses fins are arranged in such a manner so that they can work as a baffle plate which helps in guiding the fluid on shell side. In this case the circular fins inner diameter is equal to inner pipe outer diameter (do) and outer diameter of circular fins is equal to outer pipe inner diameter (Di) because of this design of circular fins, they cover the whole area between the inner pipe and outer pipe, only area of cut is responsible for the flow passage of fluid in the shell side. The designed geometry of double pipe heat exchanger with circular fins is then imported into the ANSYS design modular where the geometry is simplified by making a symmetrical section along the X-axis and after design modular part, meshing is done in ANSYS meshing.

3.MESHING

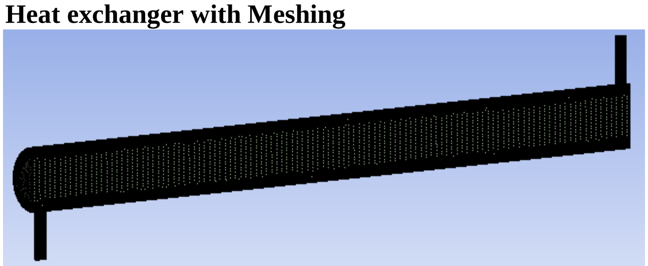
Meshing for both cases of Double pipe heat exchanger is done in ANSYS meshing where different method of meshing is used for different zone of Double pipe heat exchanger model. There are basically two zones, one is solid and second one is fluid. So In this project, two fluid zone i.e. crude oil and diesel oil is used and inner pipe ,outer pipe and fins come in solid zone on the basis of that whole model is divided into three zone i.e. Inner pipe fluid zone , outer pipe fluid zone and solid zone of inner pipe and outer pipe and fins.

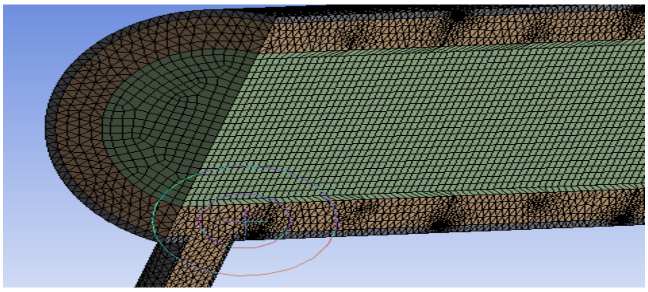
It shows the double pipe heat exchanger with circular fins arrangement along the heat exchanger without mesh. gives the detailed meshing of double pipe heat exchanger which has been done in case of circular fins as shown by, which is more clearly visible.

Heat exchanger with circular fins without mesh



Heat exchanger with Meshing

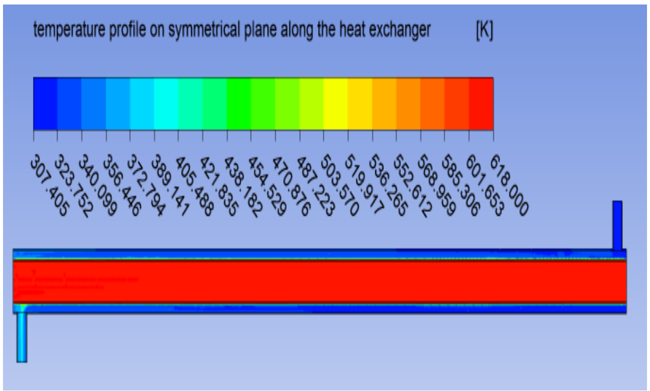




Close view of mesh

The Mesh quality check will be done in ANSYS 13,

TEMPERATURE PROFILE DOUBLE PIPE HEAT EXCHANGER WITHOUT FINS



Temperature profile on a plane along the heat exchanger for without fins

The temperature contours with respective magnitudes are shown. The temperature on the Plane shows a small gain in temperature nearly **52.12 K** along the heat exchanger as the temperature at the cold outlet is **365.126 K** which is too far from the cold outlet targeted temperature i.e. **553 K**. So from the above figure the targeted temperature is not reached due to that reason circular fin and longitudinal fins with different material as well as different fin thickness are chosen in order to increase the temperature of fluid in the shell side. On the basis of that two cases are studied here with material as well as different fin thickness which are as follows:

- Double pipe heat exchanger with circular fins (9.8% cut)
- DETAILS OF COMPARATIVE ANALYSIS
- Table show the comparative analysis of double pipe heat exchanger with different material and different fin thickness in case of circular fins.

Comparative analysis for circular fins

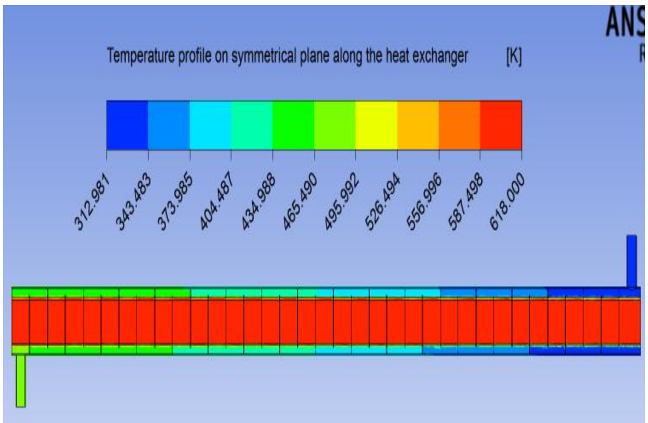
Material/Fin thickness(m)	Steel
t_1	0.002
t_2	0.003
t_3	0.004
t_4	0.005

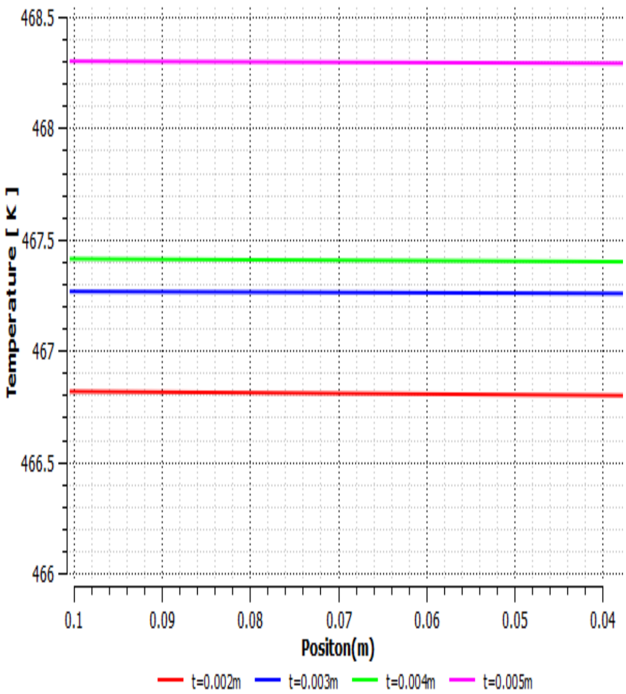
.

4.RESULTS AND DISCUSSIONS

TEMPERATURE CONTOUR FOR STEEL FINS

Temperature profile on plane alone the heat exchanger for steel





Temperature variation across cold outlet for varying fin thickness for steel

The temperature contours with respective magnitudes are shown. The temperature on the plane shows gradual increase in temperature along the heat exchanger in shell side. From Figure temperatures with respect to different thickness of the fin at the cold outlet on position of the line is observed. Initially the temperature variation with **0.002m** fin thickness is taken from the position of the line then temperature is **466.8K** and thereafter with increment of 0.001m fin thickness there is increase in value of temperature as fin thickness increases. As we go on increasing the fin thickness there is gain in temperature of **0.55K, 0.05K** and **0.9K** respectively and finally the temperature is **468.3K** for fin thickness **0.005m**. So, targeted temperature is not reached i.e. **553K**. Likewise, if we go on increasing fin thickness, there is gain in temperature, increase in surface area and heat transfer. But as the quantity of material increases, the cost of material will increase.

5. Conclusions

In this work, a double pipe heat exchanger has been designed for the petroleum refinery on the basis of standard pipe size .The shell side contains cold crude oil and tube side contains hot diesel oil both are flowing in counter current direction. The heat is recovered from hot diesel oil to increase the temperature of crude oil. firstly with circular fins with 9.8% cut for steel materials. Results has been compared and analysed in each case. Main conclusions from the results are listed here:

1. Temperature at the cold fluid outlet of the heat exchanger increases with increasing fin thickness
2. Insignificant changes occur in the pressure and velocity profile with increase of fin thickness on the shell side , that is pressure and velocity do not get affected much by thickness of fin.

3. The outlet temperature obtained from simulation comes to be **468.3K** in case of circular fins which is close to the designed outlet temperature i.e. **553K** .
4. In case of circular fins, the flow inside the shell is turbulent, the flow inside the shell is laminar. When circular fins are employed, the mode of fluid flow switches to turbulent and this phenomena is responsible for better heat transfer due to rapid mixing of fluid particles inside the annular region.

Acknowledgment

We thank our colleagues from KIET who provided in sight and expertise that greatly assisted there search.

References

[1]. R. Kumar, “Three-dimensional natural convective flow in a vertical annulus with longitudinal fins”, International Journal of Heat and Mass Transfer 40 (14) (1997) 3323–3334.

[2]. G. Fabbri, “Heat transfer optimization in internally finned tubes under laminar flow conditions”, Int. J. Heat Mass Transfer 41 (10) (1998) 1243–1253.

[3]. S. Naga Sarada, A.V. Sita Rama Raju1, K. Kalyani Radha2, L. Shyam Sunder “Enhancement of heat transfer using varying width twisted tape inserts, International Journal of Engineering”, Science and Technology Vol. 2, No. 6, 2010, pp. 107.

[4]. B.Yu, J.H. Nie, Q.W. Wang, W.Q. Tao, “Experimental study on the pressure drop and heat transfer characteristics of tubes with internal wave-like longitudinal fins”, Heat Mass Transfer 35 (1999).

[5]. Prabhata K. Swamee , Nitin Aggarwal,“Vijay Aggarwal, Optimum design of double pipe heat exchanger”, International Journal of Heat and Mass Transfer 51 (2008) 2260–2266.

[6]. M. Legay , B. Simony , P. Boldo , N. Gondrexon , S. Le Person , A. Bontemps “Improvement of heat transfer by means of ultrasound: Application to a double- tube heat exchanger” Ultrasonics Sonochemistry 19 (2012) 1194–1200..