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Design and Thermal Analysis of Heat Exchanger with Two Different Materials

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ABSTRACT:

In present day shell and tube heat exchanger is the most common type heat exchanger widely used in oil refinery and other large chemical process, because it suits high pressure application.

The process in solving simulation consists of modeling and meshing the basic geometry of shell and tube heat exchanger using ANSYS WORKBENCH 14.0. The objective of the project is to design of shell and tube heat exchanger of counter flow type using CAD tool and study the temperature difference and Heat flux using ANSYS software tools.

The heat exchanger contains 7 tubes and 600 mm length shell diameter 90 mm. The helix angle of helical baffle will be varied from 00 to 200. In simulation will show how the temperatures vary in tube with two different materials(Steel 1008 and FR-4 Epoxy). And the results are obtained using FEA (ANSYS Workbench 14.0)

1.INTRODUCTION:

To transfer the heat efficiently from one medium to other, a piece of equipment is built which is called as heat exchanger. The separation of the medium is done by the solid wall which prevents mixing, but this principle is as same as the radiator in which the coolant is passed through the coils to make the combustion engine work without any clogs.

The flow of the medium is one of the main criteria in this heat exchanger and they are parallel, counter and cross flow and counter flow gives the major heat transfer between the fluids.

This heat exchange performance can be improved by increasing the surface area of wall, reduce the resistance of the fluid flow in tubes and baffles are used induce turbulence which gives maximum heat transfer. The appropriate mean temperature can be defined by “LMTD” and sometimes “NTU” number if transfer units method is used.

Parameters such as tube pitch ratio, temperature difference are calculated by standard formulae which are derived according to the assumed diameter. Reynolds number and nusselt number are also calculated to know the flow of the fluid and viscosity should be minimal to improve the turbulence and such precautions are taken to design the heat exchanger to make the total performance of the process effectively.

2.HEAT EXCHANGER:

In this paper shell and tube heat exchanger is designed and analysed. Before going to design the modal the description of the following parts are to be known. 1) Shell 2) Tubes 3) Tube sheets 4) Baffles 5) channels (heads).

Shell:

This acts as cover to the exchanger who is made by sheet metal and the heat transfer is done inside the shell and strength of the material should be high.

Tubes:

The tubes are placed inside the shell which carries the coolant that takes the heat from the hot fluid and these tubes performs as a solid walls between the two phases.

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Tube sheets: These are the plates which are drilled with holes of diameter equal to the outer surface of the tubes and the sheets are attached to the shell and allow the fluid to pass through the tubes.

Baffles: This is used to make the flow of the fluid in such a way that it covers the outer cross section of the tubes and increase the time delay for more heat transfer.

Channels: This heads act as a small reservoirs which stores the inlet and outlet fluids. One provides a way to the tubes for heat transfer and other receives the hot fluid which contains higher temperature.

Brief description of the process is explained for heat exchanger. The main function of the HX is to exchange the heat between the fluids which are used for the process. The coolant is sent through the inlet channel and flows through the tubes and simultaneously the hot water flows through the shell and the baffles makes the flow delay which transfers the temperature to the coolant and moves out of the shell for further use in the process. This process is continuously been done nonstop in large industries.

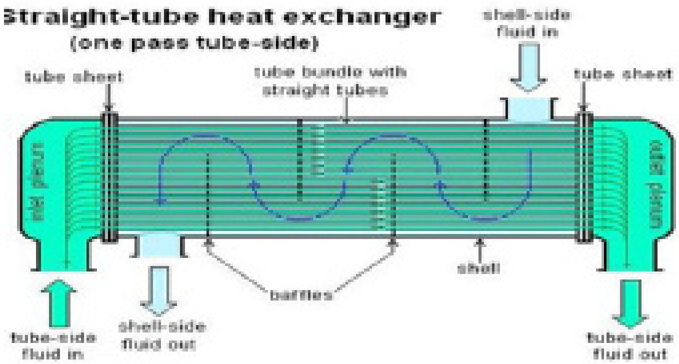

Figure 1: Shell tube heat exchanger

Parameter		Description	Range
Design Variables	x_1	tube pitch ratio (transverse direction), $X_t = S_t/D_o$	$1.0 \le x_1 \le 2.5$
	x_2	tube pitch ratio (longitudinal direction), $X_l = S_l/D_o$	$1.0 \le x_2 \le 2.5$
	x_3	tube outer diameter, $D_o/D_{o,ref}$	$1.0 \le x_3 \le 2.0$
	x_4	height of HX (tube length), H/H_{ref}	$0.5 \le x_4 \le 2.0$
	x_5	length of HX, W/W_{ref}	$0.5 \le x_5 \le 2.0$
	x_6	width of HX, B/B_{ref}	$0.5 \le x_6 \le 2.0$
	x_7^*	margin from the center line of HX, M/D_o (radius of the smallest curvature of U-tube bend)	$0.5 \le x_7 \le 2.0$
Object Function	F	tube material volume / preference volume	$F \le 1.0$
Constraints	ΔT_g	temperature difference of the flow inside tube	$200K \le \Delta T_g$
	ΔP_g	pressure loss of the flow inside tube	$\Delta P_g \le 0.6\%$
	ΔP_c	pressure loss of the flow across tube bank	$\Delta P_c \le 4.0\%$

Fig 2 Design parameters for optimization

3.RELATED WORK

PRO E

Creo elements/Pro offers a wide range of tool to generate the complete digital representation of the product being design. In addition to this industrial and standard pipe work companies uses this geometry tools for other integrated design disciplines and complete wiring definitions, which are also available to support collaborative development.

A number of concept design tools that provide upfront Industrial Design concepts can then be used in the downstream process of engineering the product. These range from conceptual Industrial design sketches, reverse engineering with point cloud data and comprehensive free-form surface tools. As the pro-e is used for designing of HEAT EXCHANGER and the following snapshots shows the process of design in this software.

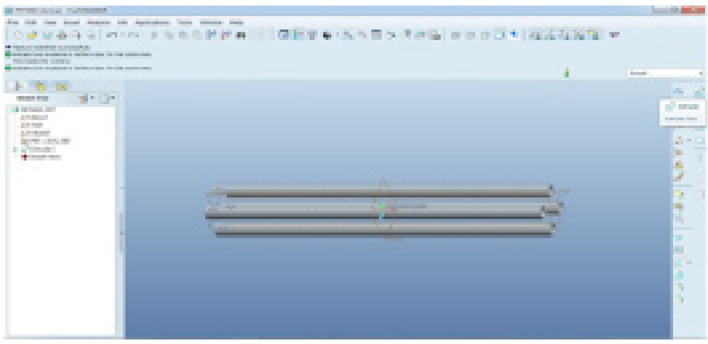

Figure 3: Tubes inside the shell

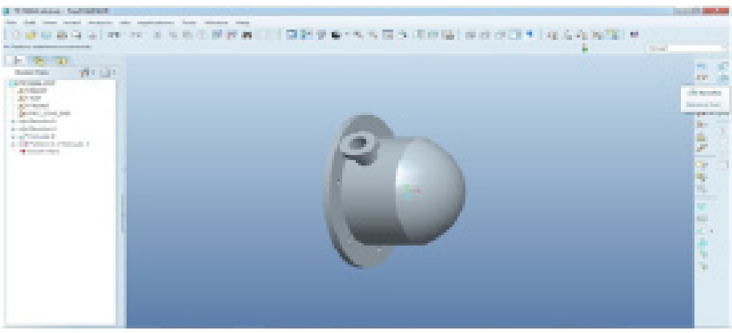

Figure 4: Channel (head) to pass the fluid through the tubes.

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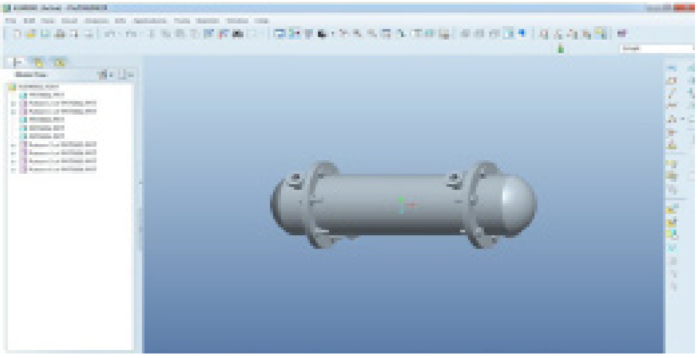

Figure 5: Assembly of heat exchanger

ANSYS :

ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. ANSYS workbenches are used for thermal analysis for two different materials and compare the results for future references in research and development centres.

Steady state thermal analysis
Steel 1008

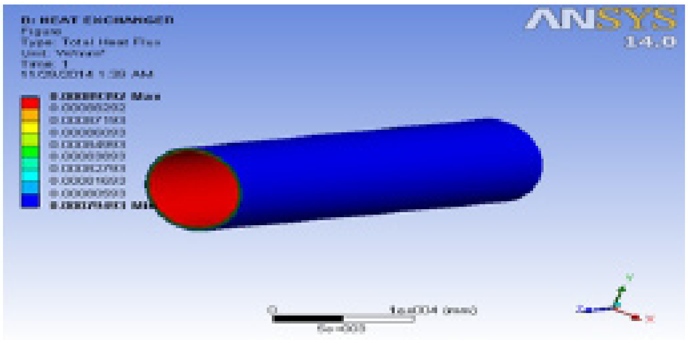

Figure 6: Total heat flux of steel tube

FR-4 Epoxy

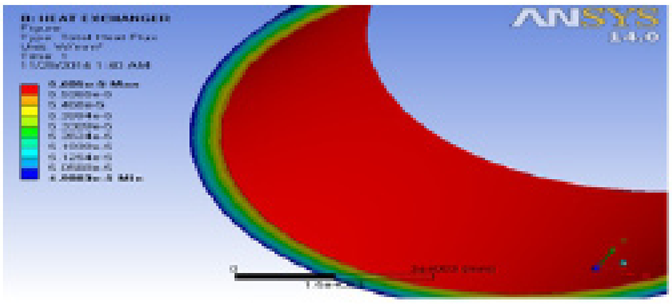

Figure 7: Total heat flux of a FR-4 Epoxy tube

CONCLUSION AND FUTURE SCOPE:

Design and assembly of heat exchanger is done in PRO E software and the 3D computational model is analysed by using ANSYS workbench. Steady state thermal analysis is done on the tubes which provide you the total heat flux inside the tubes. The results are compared between two materials and conclude that FR-4 epoxy tube transfers more heat when compared to steel. Future scope can be seen by analysing the composite materials which are having high thermal conductivity and provides efficient flow.

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