Thermal Analysis of Heat Exchanger Tubes : A Review

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Abstract-

Heat transfer is a discipline of thermal engineering that concerns the generation, use, conversion and exchange of thermal energy and heat between physical systems. This paper consists of a review of different a thermal analysis of heat exchanger tube by using different parameters. A model of shell and tube type heat exchanger having both interacting mediums as water and steam is considered. In review of some paper thermal analysis of Heat Exchanger has been taken. Analysis has been done in ANSYS performed by applying several thermal loads on different faces and edges. Some authors have done theoretical calculations C code which is useful for calculating the thermal analysis of a counter flow of water-oil type shell and tube heat exchanger. And some authors found the heat transfer capabilities of several thermal materials which have been compared by assigning different materials.

Keywords: Shell and tube type heat exchanger, Ansys , Thermal analysis,C code,CATIA

I. Introduction

Heat transfer is the science that deals with the rate of exchange of heat between hot and cold bodies called the source and receiver. However, the rates at which either process proceeds is different, vaporization being much more rapid than condensation. A Heat Exchanger is a device used for affecting the process of heat exchange between two fluids that are at different temperatures. Heat Exchangers are useful in many engineering processes those in refrigerating and air-conditioning systems, power systems, food processing systems, chemical reactors and space or aeronautical applications. This paper deals with review on the analysis of a heat exchanger(Tubes) by using CATIA , hyper mesh and Ansys softwares ,so as to satisfy the requirement data collected from the source along with the design External natural convection heat exchangers have evolved as a suitable alternative to forced convection as a means to transfer energy from hot fluid to cold fluid in hot water storage tanks. Determination of performance characteristics of these convection heat exchangers require complicated and lengthy experiments and such a practical problem has been raised during the experimentation of a research work in the heat transfer laboratory. This work uses ANSYS to predict the intensity of thermal stresses induced during heat transfer in the walls of heat exchanger and to find optimum thickness of heat exchanger wall without affecting heat transfer rate. In this research work a heat exchanger is modelled and thermal stress analysis for different materials Copper, Brass and steel is performed using ANSYS to study the behaviour of thermal gradient.

A] Classification Of Heat Exchangers

Classification Based On Working Features:

The heat exchangers are mainly divided into three categories according to their working features

a: Closed type exchanger

Closed type exchangers are those in which heat transfer occurs between two fluids, which do not mix, or physically in contact with each other. The fluids involved are separated from each one other by a pipe or a tube wall or any other surface, which may be involved in heat transfer path.

b: Regenerators

The regenerators are storage type heat exchangers. The heat transfer surface or elements are usually referred to as a matrix in the regenerator. Regenerators are exchangers in which a hot fluid, then a cold fluid, flows through same space alternatively with as little mixing as possible occurring between the two streams. The surface that receives releases thermal energy. Such a device is important.

Material properties of surfaces involved as well as fluid flow properties of the stream along with geometry are qualities that must be known. The analysis needs knowledge of unsteady state convection and conduction. In steam power plants, the air pre-heaters are usually rotor regenerator type.

c: Open type exchangers or mixed type

Open type heat exchangers, as the name implies are devices where in the entering fluid stream flow into the open chamber and complete mixing of the two streams occurs. Hot and cold fluids entering such an exchanger will leave as a single stream.

II. Procedure For Thermal Analysis by using ANSYS

Thermal Analysis is used to determine temperature distribution, thermal gradient, heat flow and other some thermal quantities in structure. Thermal Analysis can be of two types Steady State or Transient.

A. Steady State: It implies that the loading conditions have settled down to a steady level, with little or no time dependency.

B. Transient: It implies conditions that are changing with time

Procedure:

a. Preprocessing
i. Geometry , ii. Meshing
b. Solution
i. Loading, ii. Solve
c. Post processing
i. Review Results, ii. Validate the solution

III. Reviews From Different Papers

A] In this paper as per Author Vindhya Vasiny Prasad Dubey, shell and tube heat exchanger has been designed to cool water from 55^0c to 45^0c by water at room temperature. The design has been done using Kern's method in order to obtain various dimensions such as shell, tubes, baffles etc. A computer model using ANSYS 14.0 has been developed by using the derived dimensions of heat exchanger. Then the steady state thermal simulation in ANSYS has been performed by applying several thermal loads on different faces and edges.

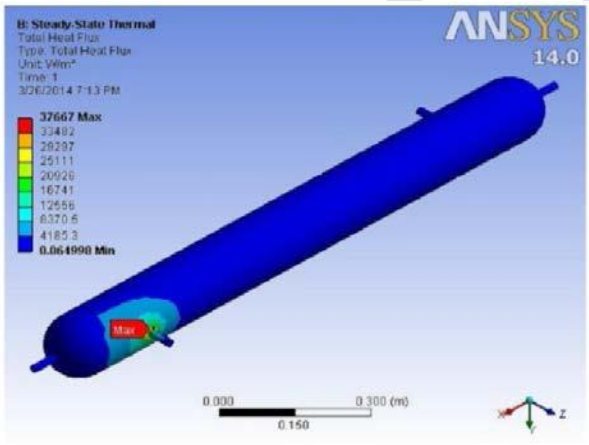

Fig. 1 Shell (Steel 1008), Tubes and Baffles (Copper)

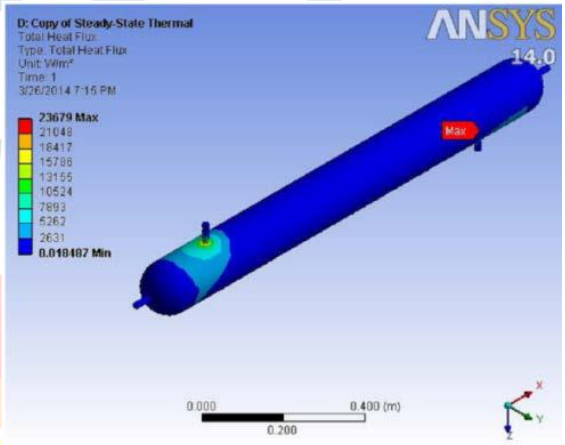

Fig.2 Shell (Steel 1008), Tubes and Baffles (Aluminum)

At first it has assigned Steel 1008 as the material of Shell while the tubes and baffles are of Copper. Under this condition the maximum value of heat flux obtained is 37667 *ww*/*mm*2 while the minimum value is 0.064988 *ww*/*mm*2.

Then assigned Steel 1008 as the material of Shell while the tubes and baffles have been assigned Aluminium. Under this condition the maximum value of heat flux obtained is 25718 *ww*/*mm*2 while the minimum value is 0.0043108 *ww*/*mm*2.

The results of the above study may be summarized as follows:

Table 1: Results

Sr. No	Material of Shell	Material of Tubes & Baffles	Maximum Heat Flux (w/m^2)	Minimum Heat Flux (w/m^2)
1	Steel 1008	Copper	37667	0.064988
2	Steel 1008	Aluminium	25718	0.0043108

From this study it is clear that if it assigns copper to the whole assembly then we shall get the best possible value of heat flux amongst the discussed materials; however that will also be a very costly affair. Secondly the outer surface of shell is generally insulated so that it may be assumed that no heat transfer is taking place in between shell and surroundings. Hence it will be a good deal to assign shell steel and tubes and baffles copper. In case we may also employ aluminium as the material of tubes and baffles, as it is second to none than copper as far as heat transfer is concerned, amongst the discussed materials.

B] In this paper, D.Amrutha Vijay And P. Snehalatha worked on design and analysis of a heat exchanger (oil cooler) by using pro E , hyper mesh and Ansys softwares ,so as to satisfy the requirement data collected from the source along with the design considerations of esteemed TEMA & ASME standards. The main objective is to calculate the temperature distribution & stress value by using Ansys.

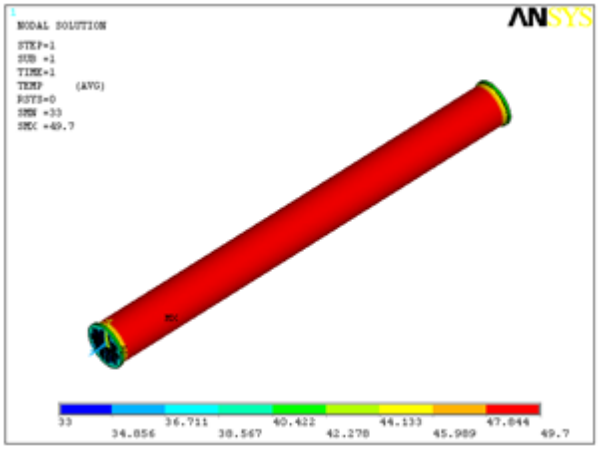

Fig.3 Nodal solution for Temperature Distribution Condition

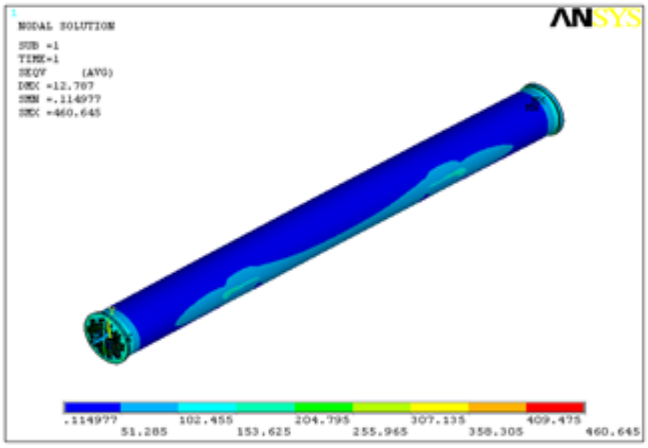

Fig.4 Nodal solution for Von Mises Stress

The thermal solution is coupled with structural analysis for the deflection and the stresses the maximum displacement is observed 1.725mm whereas the maximum stresses is observe red to be 460.645 MPa. Within the present project, the thermal and pressure drop calculations are done by using the empirical formula, as per TEMA and verified with HTRI software package (USA). The pressure drop values on shell side and tube side at the same time, overall heat transfer coefficient values are with a variation of 0.29%. 1.4% and 1.68% respectively and matching with the HTRI software.
The maximum Von Mises stress induced is 460.645Mpa, which is less than allowable stress. Hence the design is safe based on the strength.

C. In this paper, author Hari Haran and Ravindra Reddy emphasized on thermal Analysis of Shell and Tube Heat Ex-changer Using C and Ansys, a simplified model for the study of thermal analysis of shell-and tubes heat exchangers of water and oil type is proposed. thermal analysis by using theoretical formulae for this we have chosen a practical problem of counter flow shell and tube heat exchanger of water and oil type, by using the data that come from theoretical formulae we have design a model of shell and tube heat exchanger using Pro-e and done the thermal analysis by using ANSYS software and comparing the result that obtained from ANSYS software and theoretical formulae. For simplification of theoretical calculations we have also done a C code which is useful for calculating the thermal analysis of a counter flow of water-oil type shell and tube heat exchanger.

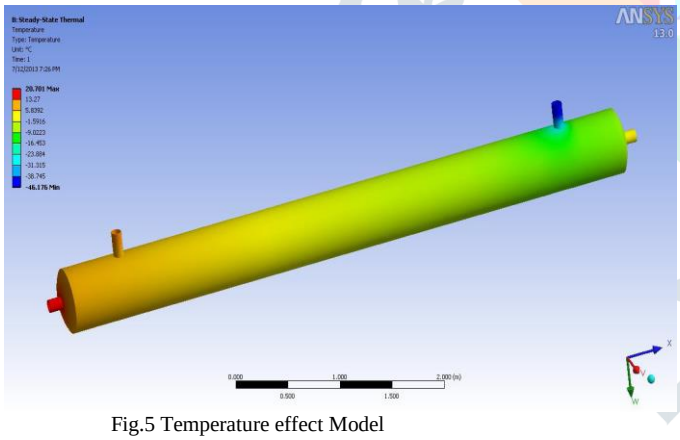

Fig.5 Temperature effect Model

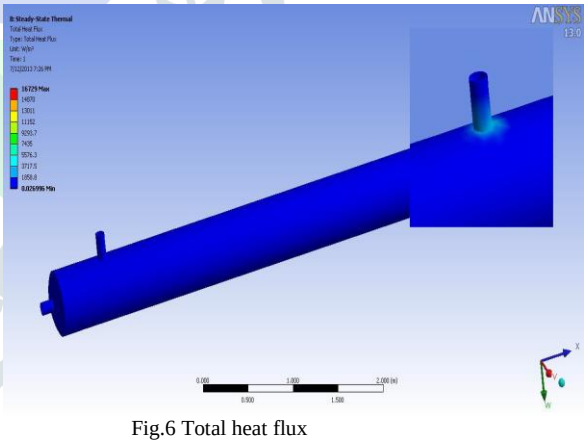

Fig.6 Total heat flux

Thermal analysis of water to oil type of shell and tube heat exchanger using **C** and by using the output that come from **C** it has modelled a shell and tube heat exchanger using Pro-e and imported this model in ANSYS software and run the thermal analysis and compared the both results and getting an error of 0.0274 in effectiveness. By using above process it can do the thermal analysis in less time and our analysis report also most accurate.

D. In This paper, Dr. J. Govardhan, Basawaraj S. Hasu have presented the variations in lay out with water as medium with significant flow at the top level of exchanger and equal distribution of tubes pitch. Analysis comparison with before layout and materials were observed. They studied corrosive effect of alloy materials on heat transfer by thermal analysis .Different Tube arrangements were considered for liquid flow .The rate of heat transfer is studied by varying the tube dia, length of tubes The layout was changed with pitch lay out rate . For this study they had considered steel 1008 material for shell, copper and brass material for tube. Hence these materials have good working properties compared to the other materials such as Silver, Cast Iron, Aluminium etc. They used Baffles to increase the fluid velocity by diverting the flow across the tube bundle to obtain higher transfer co-efficient. The distance between adjacent baffles is called baffle spacing.
The baffle spacing of 0.2 to 1 times of the inside shell diameter is commonly used. Baffles are held in positioned by means of baffle spacers. Closer baffle spacing gives greater transfer coefficient by inducing higher turbulence. The pressure drop is more with closer baffle spacing.

E. In this paper , Nakka Sita Rama Raju, V Jaya Prasad have studied a simplified model of shell and tube type heat exchanger having both interacting mediums as water and steam was studied first designed a shell and tube heat exchanger to heat water from 40º to 70º by steam at 140º temperature. The design has been done using Kern's method in order to obtain various dimensions such as shell, tubes, baffles etc. A computer model using CATIA V5 has been developed by using the derived dimensions of heat exchanger. Then the thermal simulation in ANSYS has been performed by applying several thermal loads on different faces and edges. The heat transfer capabilities of several thermal materials have been compared by assigning different materials

From this study they found that if copper is used for whole assembly the value of heat flux is best among the other materials but copper is not cost effective As well as the outer surface of shell is insulated to avoid heat losses Hence there study said that a combination of steel 1008 and copper as material for heat exchanges.

IV Conclusion

From this literature study we can conclude, It is more efficient to assign shell of heat exchanger will be of steel and tubes baffles are of copper.

From the theoretical modelling the convection heat transfer coefficients along with the bulk temperature and imposed as a boundary conditions to predict the temperature distribution in heat transfer analysis in both the shell and tube. The variation of LMTD and surface area with water inlet temperature decreases and increases respectively and variation in overall heat transfer coefficient decreases with the increase of fouling factor of oil.

The stress is less when brass is used as compared to other materials with more heat transfer rate. Steel 1008 and copper is best suited material for heat exchanges.

The study also shows that the rate of heat transfer increases with baffle and displacement is less with baffles.

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