Thermal Analysis of Shell And Tube Heat Exchanger by Using Ansys

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Abstract- *In this paper, we are proposing the thermal analysis of a simplified model of shell and tube heat exchanger of water and oil type.these heat exchangers having unique importance in boilers,aircoolers,condensers and preheaters. These are also widely used in process applications as well as the refrigeration and air conditioning industry. The structure and medium weighted shape of Shell and Tube heat exchangers make them well suited for high pressure operations. In this project, by using theoretical formulae the thermal analysis of Shell and tube heat exchanger is calculated. For this we choose a practical problem of counter flow shell and tube heat exchanger of water and oil type, by using the data,We are design a model of shell and tube heat exchanger using Pro-E and executing the thermal analysis by using Ansys software and observe the thermal distribution in shell and tube heat exchanger.*

Keywords- Shell & TubeHeat Exchanger, Pro-E, Ansys

I. INTRODUCTION

Heat exchangers are widely used in process industries. Heat exchanger is a device principally designed for valuable conversion of heat from one fluid to another fluid over solid surface. Heat exchangers are widely used in: process industries, conventional and nuclear power stations, petroleum refining and steam generation. In Heat exchangers the temperature of each fluid changes as it passes through the exchangers, and hence the temperature of dividing wall between the fluids also changes along the length of the exchanger. Although they are not especially compact, their structure and their rugged shapes make them well suited for high pressure operations. Moreover, these are adaptable and can be designed to suit for almost any application.

Baffles which are most important components, provide support for tubes, enable a desirable velocity to be maintained for the shell-side fluid flow, and prevent the tubes from vibrating. Baffles also guide the shell-side flow to move forward across the tube bundle, increasing fluid velocity and heat transfer coefficient. Baffle spacing (B) is the line between centre of two adjacent baffles, Baffle is provided with a cut (B_c) which is expressed as the percentage of the segment height to shell inside diameter.

Fig.1 Straight tube type shell and tube heat exchanger

II.SHELL AND TUBE HEAT EXCHANGER

The tubular exchangers are widely used in industry for the following reasons. These are traditionally designed for approaching any capacity and operating conditions, such as from high vacuums to ultra-high pressures (over 100 MPa or 15,000 psig), from cryogenics to high temperatures (about ll00°C, 2000°F), and any temperature and pressure differences between the fluids, limited only by the materials of construction. They can be designed for special operating conditions: vibration, heavy fouling, highly viscous fluids, erosion, corrosion, toxicity, radioactivity, multicomponent mixtures, and so on. These are most adaptable heat exchangers made from a variety of metal and nonmetal materials (graphite, glass, and Teflon) and in sizes from small (0.1 m 2, 1 ft 2) to super-giant (over 100,000 m 2, 10 6 ft2). They are extensively used as process heat exchangers in the petroleum-refining and chemical industries; as steam generators, condensers, boiler feed water heaters, and oil coolers in power plants; as condensers and evaporators in some air-conditioning and refrigeration applications; in waste heat recovery applications with heat recovery from liquids and condensing fluids; and in environmental control.

III. COMPONENTS OF “STHE”

It is essential for the designer to have a good working knowledge of the mechanical features of STHEs and how they influence thermal design. The principal components of an STHE are:

• shell;
• shell cover;

- tubes;
- channel;
- channel cover;
- tubesheet;
- baffles; and
- nozzles.

Other components include tie-rods and spacers, pass partition plates, impingement plate, longitudinal baffle, sealing strips, supports, and foundation. The Standards of the Tubular Exchanger Manufacturers Association (TEMA) describe these various components in detail. An STHE is divided into three parts: the front head, the shell, and the rear head.

IV. LITERATURE REVIEW

The purpose of this chapter is to provide a literature review of past research effort such as journals or articles related to shell and tube heat exchanger and ANSYS software. Moreover, review of other relevant research studies are made to provide more information in order to understand more on this research.

Gang yong Lei et al [1] have showed the effects of baffle inclination angle on flow and heat transfer of a heat exchanger with helical baffles, where the helical baffles are separated into inner and outer parts along the radial direction of the shell. While both the inner and outer helical baffles baffle the flow consistently, smoothly and gently, and direct flow in a helical fashion so as to increase heat transfer rate and decrease pressure drop and impact vibrations, the outer helical baffle becomes easier to manufacture due to its relatively large diameter of inner edge.**Lutcha J et al [2]** have done experiments to the improvement of tubular heatexchangers with helical baffles for investigation of the flowfield patterns generated by various helix angles which isexpected to decline pressure at shell side and increase heattransfer process significantly.**Usman Ur Ehman , G¨oteborg [3]**, Sweden 2011, Master’s Thesis 2011:09 on “Heat Transfer Optimization of Shell-and-Tube & Heat Exchanger through CFD”.In this project instead of computational fluid dynamics software,we use the ANSYS 16.0 software to calculate the practical values. **Timothy J. Rennie et al** have done an experimental study of a double-pipe helical heat exchanger. Flow rates in the inner tube and in the annulus were varied and temperature data recorded. Overall heat transfer coefficients were calculated using Wilson plots.

V. OBJECTIVE OF THE PAPER

This paper contains the thermal analysis of shell and tube heat exchanger with segmental baffles. The model is done by using ANSYS software. Concerned figures are shown below.

Data collection:

Table-1Geometrical parameters of shell and tube:

Shell side: Shell fluid	Water
Outer dia.	213.3mm
Inner dia.	163.3mm
Length	1100mm
Mass flow rate	0.025kg/s
Fluid velocity	1.45m/s
Fouling factor	9×10^{-5} m^2k/W
Tube side : Tube fluid	Engine oil
Outer dia.	20mm
Inner dia.	18mm
Length	1018.281mm
Mass flow rate	0.05kg/s
Fluid velocity	1m/s
Fouling factor	$18\times10^{-5}m^2k/W$

Theoretical analysis:

Theoretical analysis of shell and tube heat exchanger was done by calculating the output temperatures of heat exchanger by using the inlet values of shell and tube. For this we used number of tube units method (NTU) to calculate the output temperatures.

By using various theoretical formulae’s we can calculate heat transfer rate (Q), overall heat transfer coefficient (U_o), heat convective coefficients (h) for both shell and tube are calculated. The various formulae’s are:

$$Q = m.Cp. (T2 – T1)$$

Where:

Q = heat energy (Joules) (Btu),
m = mass of the substance (kilograms) (pounds),
Cp = specific heat of the substance (J/kg°C) (Btu/pound/°F),

(T2 – T1) = is the change in temperature (°C) (°F)

$$Q = U \times A \times \Delta Tm$$

The log mean temperature difference ΔTm is:

$$\Delta Tm = [(T1 - t2) - (T2 - t1)] \div [\ln (T1 - t2) \div (T2 - t1)$$

Where:

T1 = Inlet tube side fluid temperature
t2 = Outlet shell side fluid temperature
T2 = Outlet tube side fluid temperature
t1 = Inlet shell side fluid temperature

When used as a design equation to calculate the required heat transfer surface area, the equation can be rearranged to become:

$$A = Q / (U \times \Delta Tm)$$

Where:

A = Heat transfer area (m2) (ft2)
Q - Heat transfer rate (kJ/h) (Btu\h);
U - Overall heat transfer coefficient (kJ/h.m2.°C) (Btu/hr.°F)
ΔTm - Log mean temperature difference (°C) (°F)

By using basic formulas like heat transfer rate, reynolds number, heat convective coefficients we can calculated the therotecal values.

Design of shell and tube heat exchanger:

By considering the theoretical input values as reference we designed a model in pro-e.

The basic models of shell and tube heat exchangers are shown in below fig.2, fig.3, fig.4.

Fig.2 Assembly design of STHE in Pro-E.
Fig.3 Assembly design of tubes and baffles in Pro-E.

Analysis of shell and tube heat exchanger:

By using the theoretically calculated temperatures as reference and taking as boundary conditions we analysis the shell and tube heat exchanger and examine the temperature distribution for various temperatures. The results are shown below figures

Fig.4 Meshing of STHE in Ansys

Fig.5 Temerature distribution of STHE in ansys at 127˚C.

First we took tube temperature of 127˚C as input and the output is 58.844˚C.Shell temperature of 4˚C as input and the corresponding output is 79.813˚C. The colour coding indicates the temperature distributions of the shell and tube heat exchanger.

The Red colour indicates the maximum temperature which we took as and blue colour indicates minimum temperature of the given fluid. The remaining temparatures indicates the distribution of temperature between the inlet and outlet ports of shell and tube heat exchanger.

Fig.6 Temperature distribution of STHE in ansys at 107˚C
Fig.7 Temperature distribution of STHE in ansys at 87˚C.
Fig.8 Temperature distribution of STHE in ansys at 67˚C.

VI. RESULTS

Theoretical values of shell and tube heat exchanger for various temperatures are shown in table 2.

Table.1 Theoretical results of STHE at various temperatures.

VII. CONCLUSION

We have done the thermal analysis of water to oil type of shell and tube heat exchanger using ansys and by using the output that come from theoretical data. We have modeled a shell and tube heat exchanger using Pro-e and imported this model in ansys software and we have run the thermal analysis and we examine the temperature distribution throughout the shell and tube. By using above process we can do the thermal analysis in less time and our analysis report also more accurate.

Future work

- Rate of heat transfer may be improved by varying the type of tube like U- tube, tube diameter, length and no of tubes.
- By changing the fluent heat transfer may be improved.
- By changing number of baffles heat transfer may be improved.
- By changing the temperature of tubes and medium rate of heat transfer may be improved.
- By changing the materials of tubes heat transfer rate may be improved.

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FIGURES

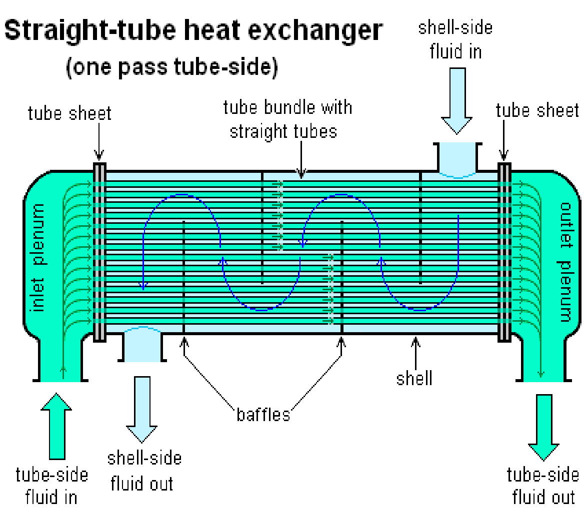

Fig.1 Straight tube type shell and tube heat exchanger

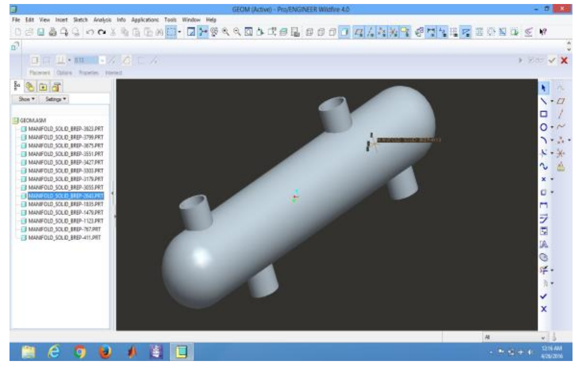

Fig.2 Assembly design of STHE in Pro-E.

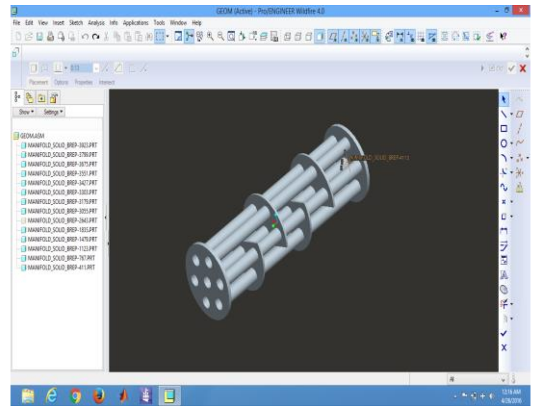

Fig.3 Assembly design of tubes and baffles in Pro-E.

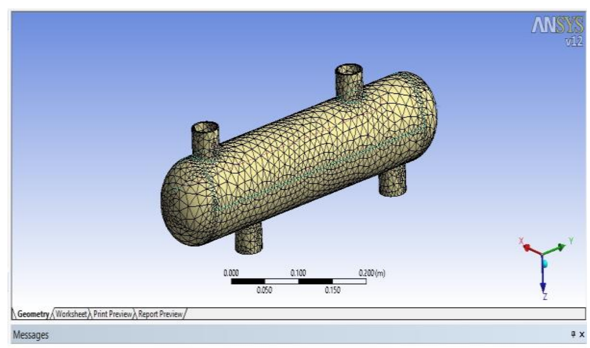

Fig.4 Meshing of STHE in Ansys

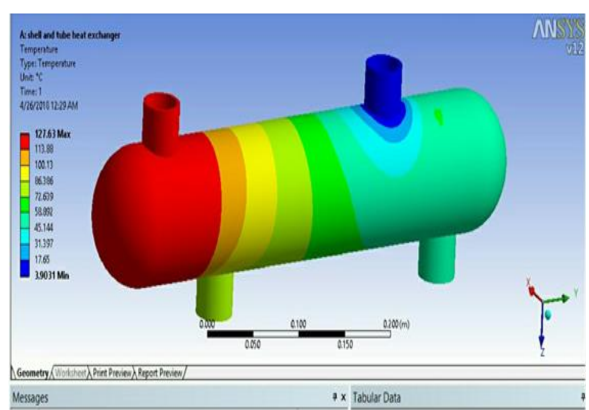

Fig.5 Temerature distribution of STHE in ansys at 127˚C.

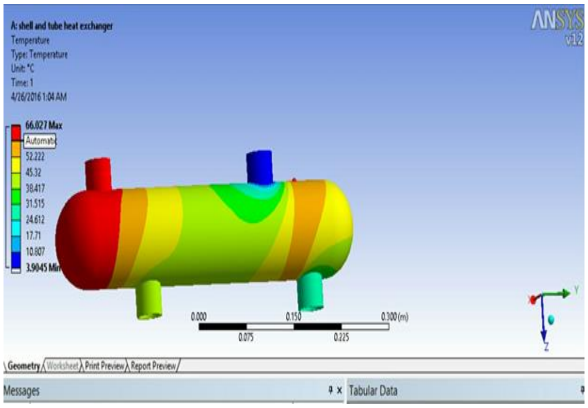

Fig.6 Temperature distribution of STHE in ansys at 107˚C

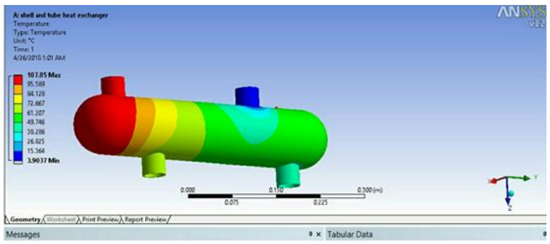

Fig.7 Temperature distribution of STHE in ansys at 87˚C.

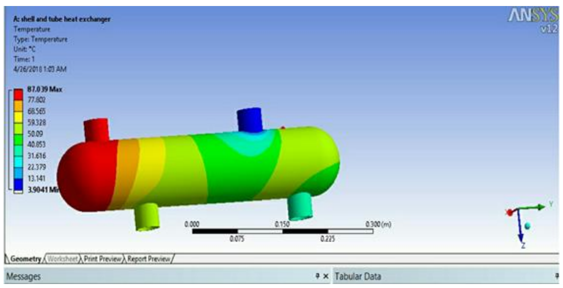

Fig.8 Temperature distribution of STHE in ansys at 67˚C.

Table-2

Input temp. (⁰C)		Output temp. (⁰C)		Convective Heat Transfer coef. (W/m²k)		Overall heat transfer coef.(W/m²k)		Heat Transfer Rate (W)		Effectiveness	LMTD (⁰C)
Shell	Tube	Shell	Tube	Shell	Tube	Outer surface of tube	Inner surface of tube	Shell	Tube		
4	127	79.8	58.8	2213.9	422.3	192.45	98.89	1900.65	184.6	0.616	51.452
4	107	66.4	48.76	2213.9	344.6	178.89	94.87	1464.52	128.4	0.606	42.64
4	87	53.3	39.07	2213.9	263.5	147.45	87.84	1260.16	80.79	0.594	55.64
4	67	40.7	29.95	2213.9	188.4	118.16	78.14	474.18	44.66	0.588	26.13
4	47	28.4	21.24	2213.9	119.9	84.56	63.58	232.54	19.77	0.599	17.9