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DESIGN AND ANALYSIS OF HEAT EXCHANGER IN TEMPERTAURE DISTRIBUTION AND PRESSURE DROP

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ABSTRACT:*A Heat Exchanger is a device used for affecting the process of heat exchange between two fluids that are at different temperatures. This project deals with the design and analysis of a heat exchanger (oil cooler) by using design tool like SOLIDWORKS 2015 and simulation software like ANSYS WORKBENCH 17.0. 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 & pressure drop by using theoretical and numerical methods by using Ansys Fluent. Here we concluded that 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 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. As the quantity of oil is varied increasingly the heat load and the overall heat transfer coefficient also increases.*

KEYWORDS: *Heat Exchanger, LMTD, Temperature distribution, Pressure drop,ANSYS, SOLIDWORKS.*

1. INTRODUCTION

A heat exchanger is a component that allows the transfer of heat from one fluid (liquid or gas) to another fluid.
Reasons for heat transfer include the following:

1. To heat a cooler fluid by means of a hotter fluid
2. To reduce the temperature of a hot fluid by means of a cooler fluid
3. To boil a liquid by means of a hotter fluid
4. To condense a gaseous fluid by means of a cooler fluid
5. To boil a liquid while condensing a hotter gaseous fluid

2. DESIGN METHODOLOGY

THERMAL DESIGN CONSIDERATIONS

Thermal design of a shell and tube heat exchanger typically includes the determination of heat transfer area, number of tubes, tube length and diameter, tube layout, number of shell and tube passes, type of heat exchanger (fixed tube sheet, removable tube bundle etc), tube pitch, number of baffles, its type and size, shell and tube side pressure drop etc.

SHELL

The shell thickness of 3/8 inch for the shell ID of 12-24 inch can be satisfactorily used up to 300 psi of operating pressure.

TUBE

The tube length of 6, 8, 12, 16, 20 and 24 ft are preferably used. Stainless steel, admiralty brass, copper, bronze and alloys of copper-nickel are the commonly used tube materials.

TUBE PASSES

The tube passes vary from 1 to 16. The tube passes of 1, 2 and 4 are common in application

TUBE SHEET

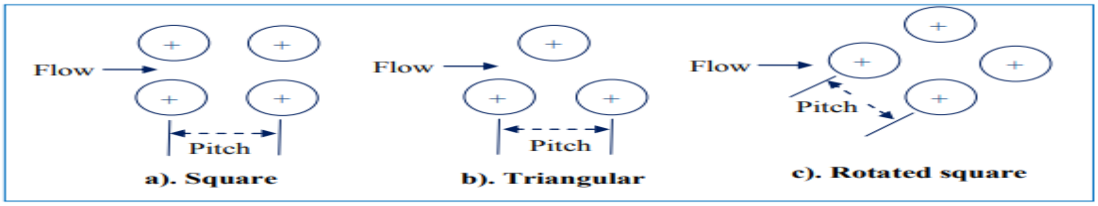
The tube sheet thickness should be greater than the tube outside diameter to make a good seal. The recommended standards (IS:4503 or TEMA) should be followed to select the minimum tube sheet thickness.

BAFFLES

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. Baffle cuts from 15 to 45% are normally used. A baffle cut of 20 to 25% provide a good heat-transfer with the reasonable pressure drop. The % cut for segmental baffle refers to the cut away height from its diameter.

TUBE PITCH, TUBE-LAYOUT AND TUBE-COUNT

Tube OD, in	Pitch type	Tube pitch, in
3/4	Square	1
1		1 1/4
3/4	Triangular	15/16
3/4		1



FOULING CONSIDERATIONS

The effect of fouling is considered in heat exchanger design by including the tube side and shell side fouling resistances.

3. PROBLEM STATEMENT

150000 lb per hour of kerosene will be heated from 75 to 120°F by cooling a gasoline stream from 160 to 120°F. Inlet pressure will be 50 psia for each stream and the maximum pressure drop of 7 psi for gasoline and 10 psi for kerosene are permissible. Published fouling factors for oil refinery streams should be used for this application. Design a shell and tube heat exchanger for this service.

Given data:

Hot fluid inlet temperature (T1)= 160°F
Hot fluid outlet temperature (T2) = 120°F
Cold fluid inlet temperature (t1) = 75°F
Cold fluid outlet temperature (t2) = 120°F
Fouling factor of hot fluid (Rdg) = 0.0005 (for gasoline)
Fouling factor of cold fluid (Rdk) = 0.001 (for kerosene)
Pinlet (for hot fluid) = 50 psia
Pinlet (for cold fluid) = 50 psia
Δpmax (for hot fluid) = 7 psi
Δpmax (for cold fluid) = 10 psia
Mass flow rate of cold fluid (mk) = 150000 lb.h-1
(Subscripts „k' for kerosene and „g" for gasoline).

THERMAL DESIGN DATA (PROVIDED BY B.H.E.L)

Heat duty =65000 kcal/hr (Input data)
Quantity of water = 50m3/hr (Assumed)
Quantity of oil = 14.75m3/hr (Input data)
Water inlet temperature = 33 °c (Input data)
Oil outlet temperature = 45 °c
Allowable pressure drop on water side = 0.6 kg/cm2 (Input data)
Allowable pressure drop on oil side = 0.6 kg/cm2 (Input data)
Fouling factor on water side = 0.0004 hr-m2- c/kcal
(Input°Fouling factor on oil side = 0.0002 hr-m2- data)
Tube material =Admiralty brass
Thermal conductivity of tube material = 66 BTU/hr-ft2 0F (From TEMA)
Number of tubes = 90
Number of tube passes = 2
Length of tube = 3300mm=3.300 m
Outside diameter of the tube = OD=19.05mm=0.01905m
Thickness of tube = 1.650mm=0.00165m
Inside diameter of tube = OD-2*Thk = 15.75mm=0.01575m
Tube type = Plain type

Tube pitch = 25.4mm=0.0254m
Ratio of outside to inside surface area=Ao/Ai diL = 1.209
Number of baffles = 33
Baffle cut =22%
Type of heat exchanger = Shell and tube AEW type heat exchanger (floating rear tube sheet)
Baffle thickness = 6mm=0.006m
Shell inside diameter = 307mm=0.307m
Shell outside diameter =323.8mm=0.3238m
Shell thickness = 8.4mm=0.0084m
Baffle spacing = 86mm=0.086m

4. RESULTS AND DISCUSSION

5.

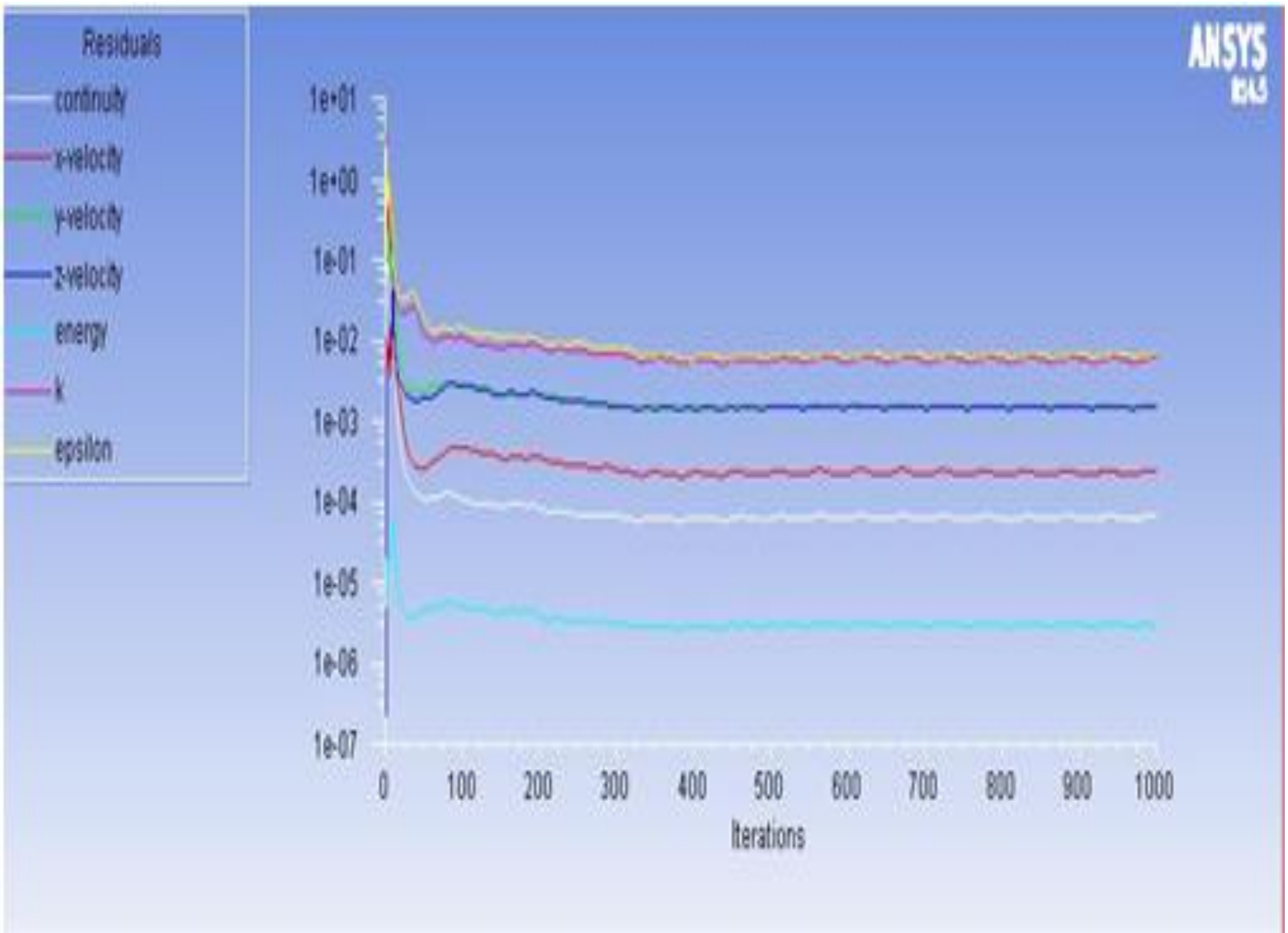


Figure 1 : Residuals for Heat exchanger

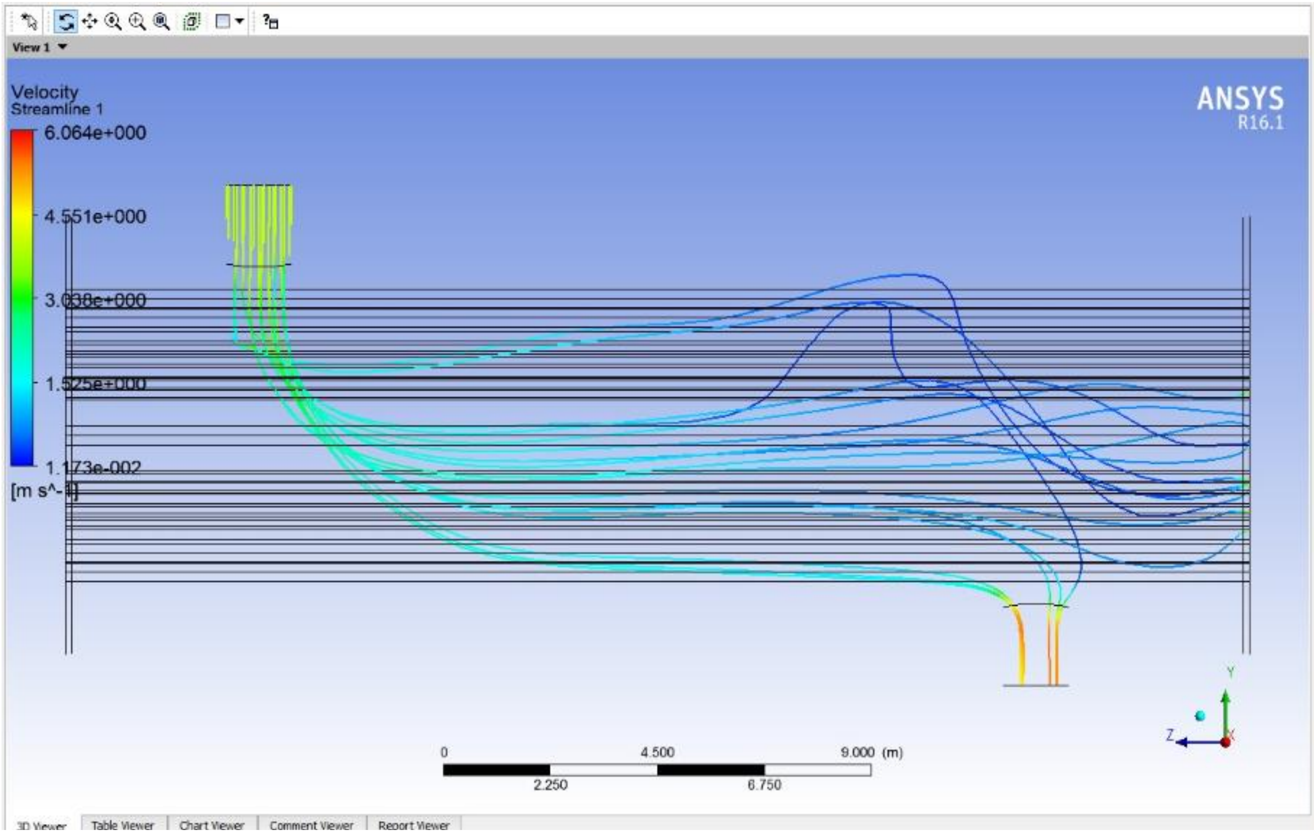


Figure 2: Velocity Streamlines in parallel flow heat exchanger

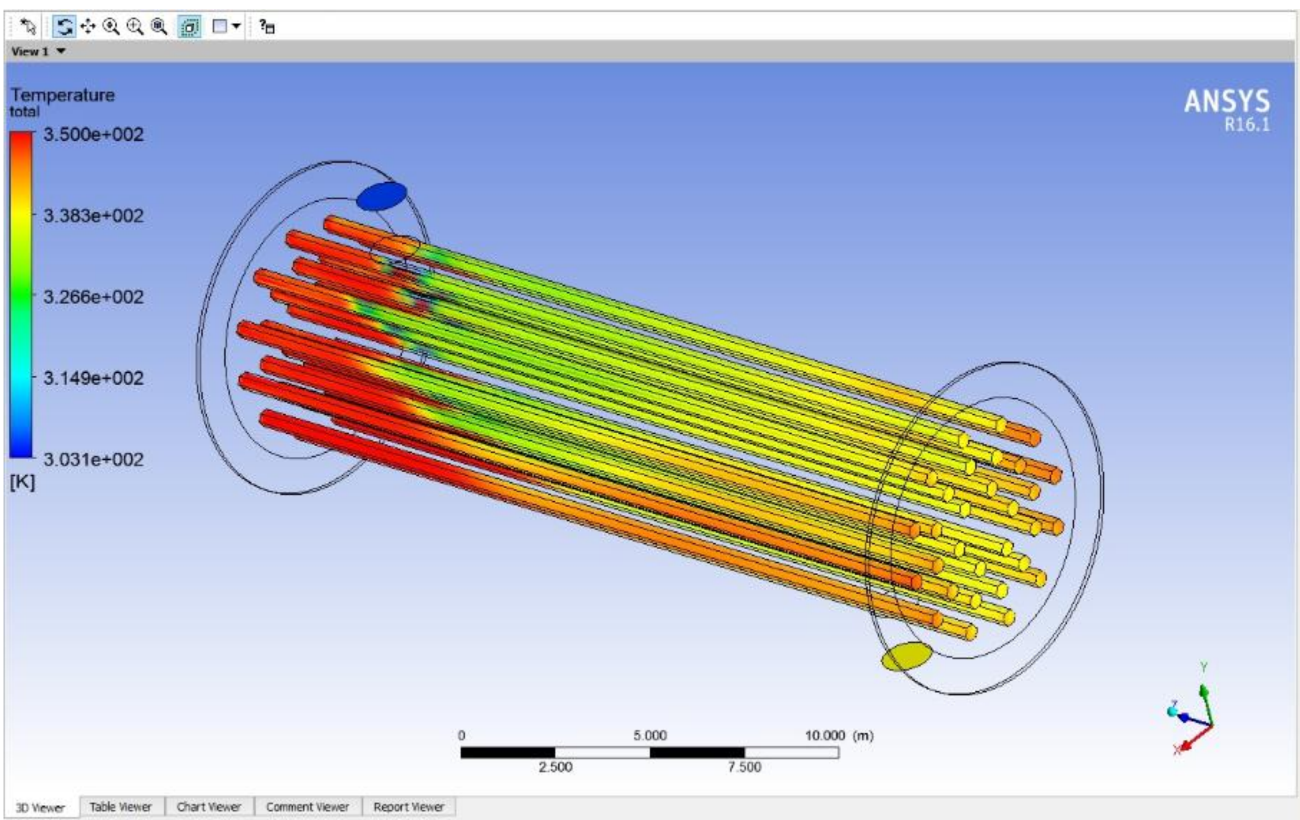


Figure 3: Temperature distribution in tubes arrangement

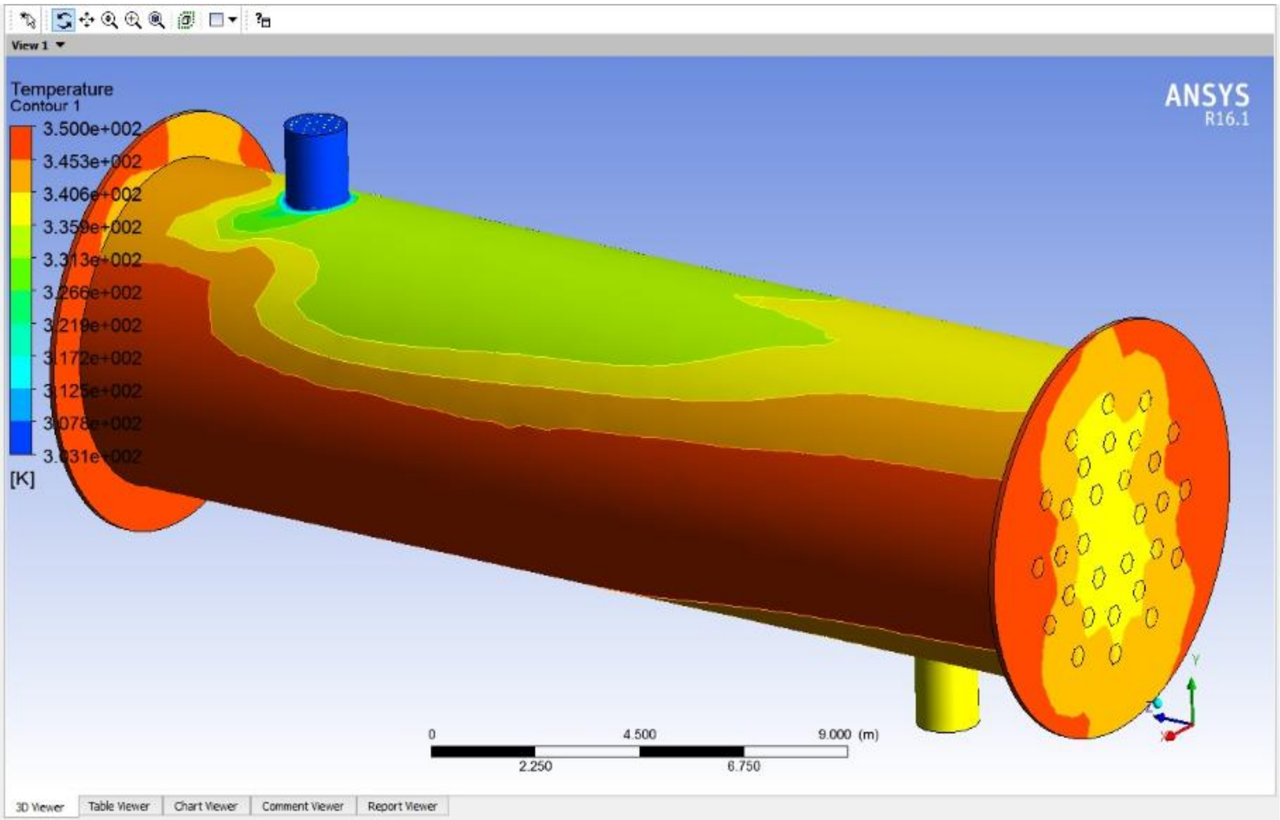


Figure 4: Temperature variation in heat exchanger in isometric view

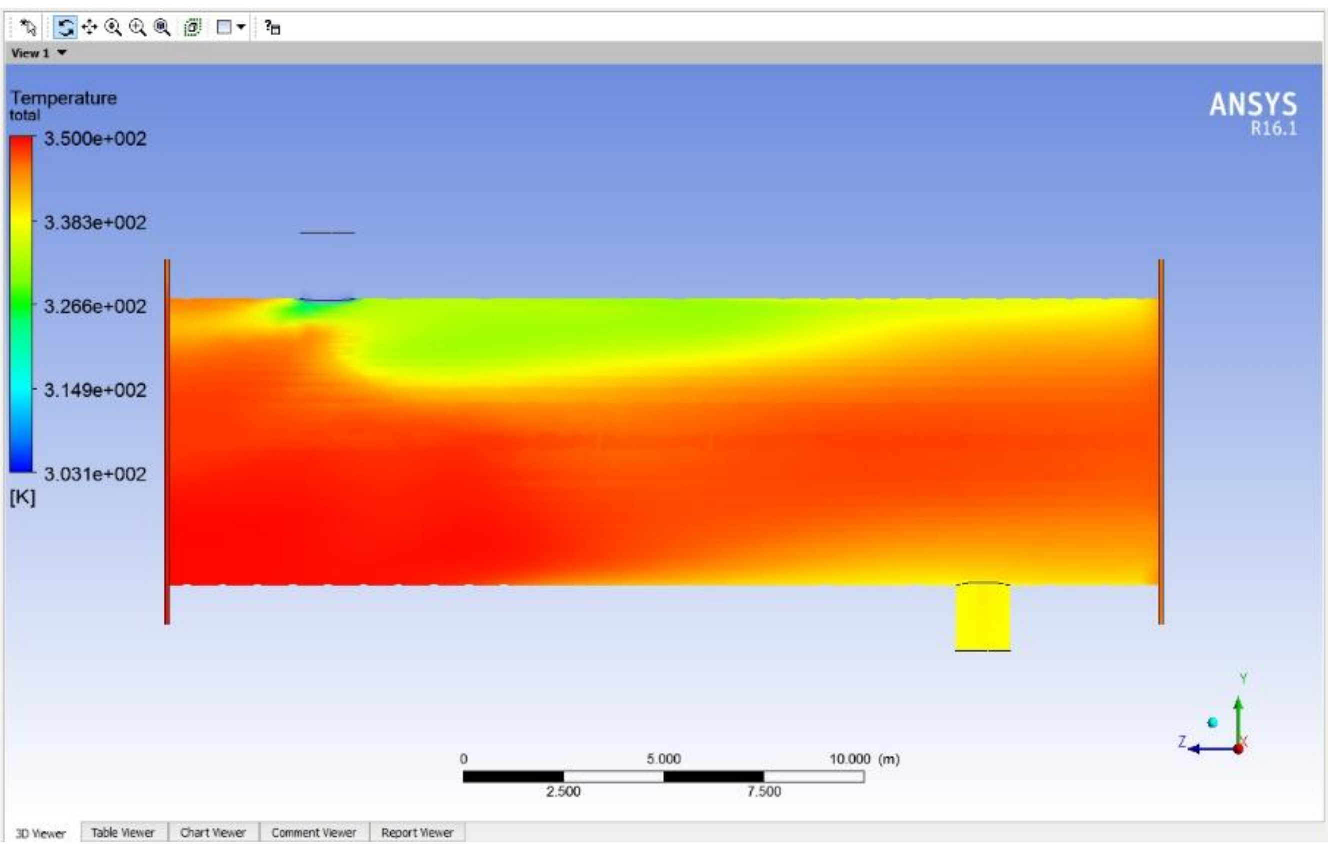


Figure 5: Temperature variation in heat exchanger in side view

S.NO	Pressure drop				Overall heat transfer coefficient, Kcal/hr-m^2/^{0}C		
		Theoretical	HTRI	% Error	Theoretical	HTRI	% Error
1	Shell Side	0.336	0.335	0.29	244.9	249.035	1.68
2	Tube Side	0.2629	0.229	1.4			

Table 1: Comparison of pressure drop & overall heat transfer coefficient values with HTRI

S.no	Water inlet temp t1 °C	LMTD °C	Area required mm2	% Margin
1.	30	18.78	13.887	23.73
2.	31	17.76	14.684	17.01
3.	32	16.74	15.57	10.32
4.	33	15.72	16.586	3.59
5.	34	14.7	17.7	-3.10
6.	35	13.67	19.07	-9.90
7.	36	12.64	20.632	-16.0

Table 2: Variation of LMTD and surface area with water inlet temperature

S.no	Fouling factor of oil Hr-m2-°c/kcal	Heattransfer coefficient of oil Kcal/hr-m2-°C	Overall heat transfer coefficient Kcal/hr-m2-°C
1.	0.0001	331.196	276.595
2.	0.0002	320.578	249.035
3.	0.0003	310.620	237.228
4.	0.0004	301.263	226.479

Table 3: Variation of overall heat transfer coefficient with fouling factor of oil

S.no	Oil quantity 1000 kg/ hr(m)	Heat load Q_s Kcal/hr	Reynolds No	Heat transfer coefficient of oil Kcal/hr-m^2-°C	Overall heat transfer coefficient Kcal/hr-m^2-°C
1.	11.0655	48760.513	154.83	273.898	219.971
2.	11.8032	52011.213	165.125	283.207	225.885
3.	12.5409	55261.914	175.472	292.274	231.616
4.	13.2766	58512.615	185.79	301.048	237.092
5.	14.0163	61763.331	196.119	309.572	242.347
6.	14.754	65014	209.873	320.578	249.035
7.	15.4917	68264.71	216.757	325.944	252.267
8.	16.2294	71515.419	227.085	333.831	256.966

Table 4: Variation of heat load and overall heat transfer coefficient with oil quantity

6. CONCLUSION

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 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. As the quantity of oil is varied increasingly the heat load and the overall heat transfer coefficient also increases.

From the theoretical modeling 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.

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