International Conference on
Futuristic Trends in Engineering, Science, Pharmacy and Management

A D PUBLICATION

ISBN: 978-81-933386-0-5

Design and Optimization of Lubrication Oil Cooler as per TEMA using HTRI Software as per ASME Section VIII (Division 1)

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ABSTRACT: By using kern method for thermal calculation and number of iteration were done for comparing and analyzed in HTRI software for batter performance of shall and tube type heat exchanger. The oil cooler which is used for injection molding machine in plastic industries consider and discussed as shall and tube type heat exchanger in this work. Design of heat exchanger done by using HTRI and compare with manual calculation. It is observed that number of tubes decreases in HTRI as compared to the tube obtained during manual calculation. Over all heat transfer coefficient is also found adequate enough to run the heat exchanger at an optimal mass flow rate.

Keywords: Heat Exchanger, HTRI, Oil cooler, LMTD

1. Introduction

The shell and tube type oil cooler is a non-fired pressure system consisting of two separate pressure chamber (shell and tube chamber), which is used in a wide variety of industrial, chemical & electronic processes to transfer energy & provide required cooling, it is parallel flow type oil cooler and as lubricating oil SERVO PRIME 68 is used which have good water separation characteristics. Water is used as cooling agent because of its higher specific heat capacity, density and thermal conductivity. Study mainly focused on the oil cooler which is used in the plastic industries and oil cooler is basically shall and tube type heat exchanger. For analysis it is necessary to overcome some theoretical assumptions and serve analytical approach as much as possible for design of the heat exchanger and its optimization. Modelling of the oil cooler is necessary for manufacturing purpose.it is also necessary to ensure the safety of the oil cooler by testing and comparing the manual design with reliable heat exchanger design software. Design and Optimization of lubrication oil cooler as per TEMA using HTRI software and Mechanical design as per ASME section VIII division 1. Rajiv mukhargee (1988)[2] explain the basic of exchanger thermal design, converting such topic as STHE components, the optimum thermal design can be done by sophisticated computer software. Liljana Markovska et.al (2003) [6] studied that increase in fluid velocities results in larger heat transfer coefficient and consecutively less heat transfer are so the cost effectiveness can achieve, on other hand increase in velocity increase pressure drop and require more power for pumping. M serna and A.jimenez (2005)[7] presented compact formulation to related shell side pressure drop and film coefficient based on full Bell Delaware method and found satisfactory performance of proposed algorithms over entire geometry for single phase. Resat Selbas et.al (2006)[9] for optimal design of shall and tube heat exchanger by varying the design variable genetic algorithms was applied and concluded that

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GA is capable to significantly effective for overall cost reduction of heat exchanger. R.Hosseini et al (2007) [10] Experimentally obtained the heat transfer coefficient and pressure drop on the shall side of a shall and tube heat exchanger for three different types of copper tubes (smooth, corrugated and with micro fins).Also experimental data has been compare with theoretical data available. Experimental work shows higher Nusselt number and pressure drop with respect to theoretical correlation based on Bell's method. The optimum condition for flow rate in replacing the existing smooth tube with similar micro finned tube bundle was obtained for the oil cooler of the transformer under investigation. Andre L.H.Costa et.al (2008)[12] studied that technics were employed according to district problem formulation in relation to heat transfer are or total annualized cost, by considering pressure drop and velocity as constraint. The formulation of the problem seeks the minimization of thermal surface of equipment for certain minimum area and maximum pressure drop. Jose M Ponce-Ortega et al.(2009)[14], presented an approach based on genetic algorithms for optimum design of shall and tube heat exchanger and for optimization of major geometric parameters such as number of tube passes, standard internal and external strips inlet and outlet baffle spacing and pressure drop at both tube side were selected.

2. Design procedure

2.1 manual calculations

Design procedure of Heat Exchanger as per TEMA codes. At shell side hydraulic oil and tube side water is used. By using LMTD method different design parameters are calculated i.e mean temperature, true temperature difference, number of tubes, shell diameter, tube side heat transfer coefficient, shell side heat transfer coefficient, overall heat transfer coefficient and both side pressure drop and following values mention in table 1 is achieved.

Table No.1 Input data

Inlet Temp. of hydraulic oil (T_{h1})	60^0C	Outlet Temp. of Water (T_{c2})	34^0C
Outlet Temp. of hydraulic oil (T_{h2})	45^0C	Sp. Heat of hydraulic oil (C_p)	1.97 kJ/kg ^{0}C
Inlet Temp. of Water (T_{c1})	30^0C	Mass flow rate of hydraulic oil (m_0)	25 LPM

Logarithmic Mean Temperature Difference:

$$LMTD = \frac{(\theta_1 - \theta_2)}{In\left(\frac{\theta_1}{\theta_2}\right)}$$

Where, $\theta_1 = T_{h1} - T_{c2}$ and $\theta_2 = T_{h2} - T_{c1}$

True temperature difference by considering temperature correction factor had been calculated.

Number of tubes: Number of tube = provisional area / area of one tube

Where, Provisional Area=Heat load in W / ΔT_M x U.

Similarly by using standard relationship shall diameter, bundle diameter, side clearance, tube side heat transfer coefficient, shall side heat transfer coefficient had been calculated manually for comparison with HTRI results.

2.2 HTRI

Modal of shall tube type oil cooler were prepared and data were feed to HTRI software for further process and the result were got.

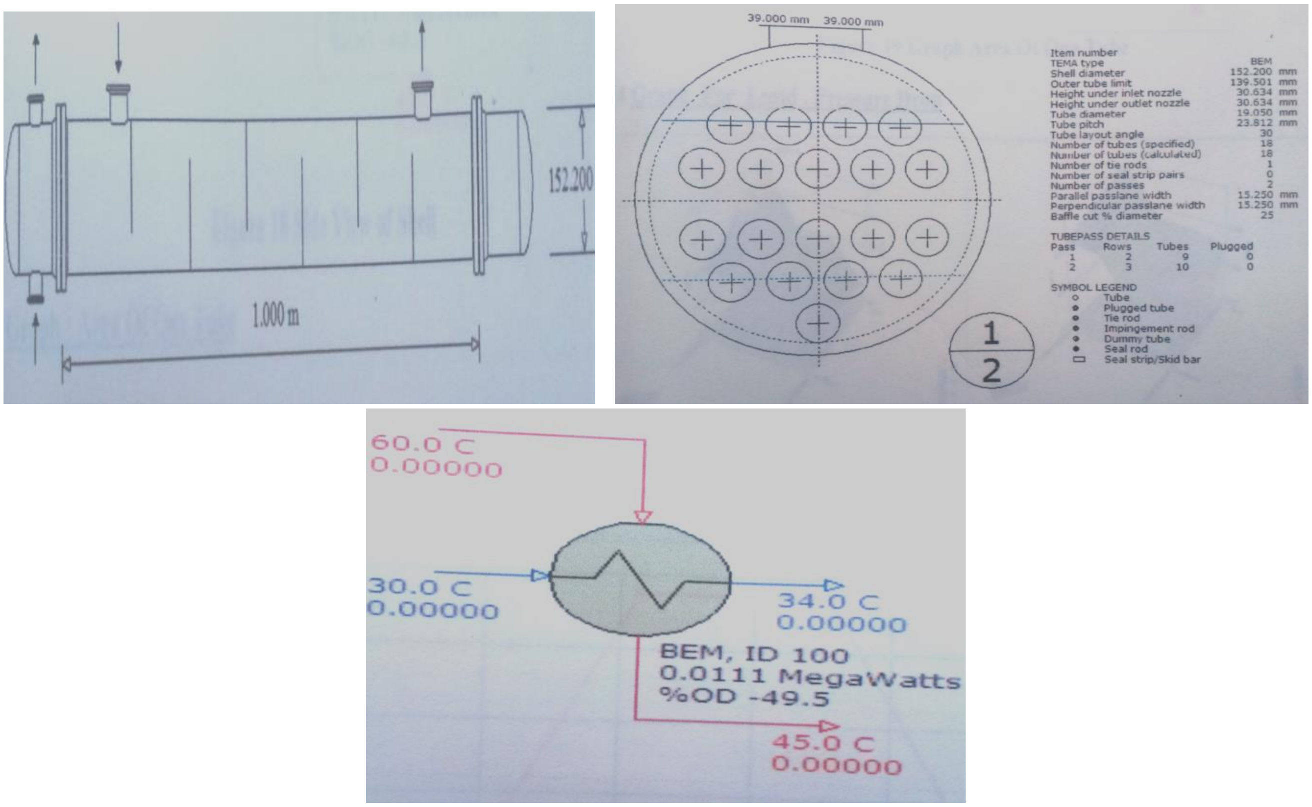
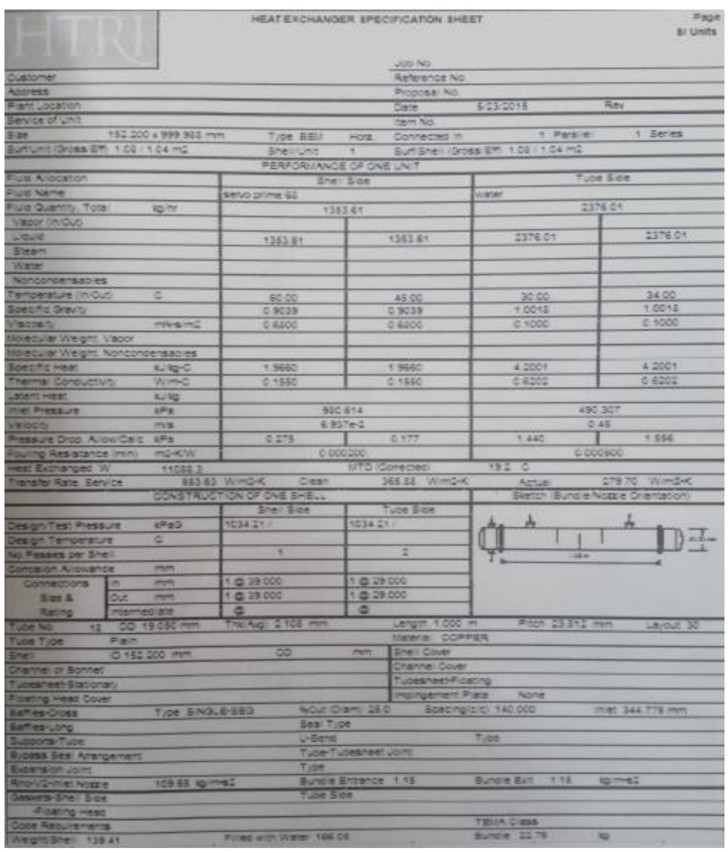


Fig.1. Shall and tube Oil cooler

After processing in HTRI the result were obtained which is similar to the result obtained by manual calculation.



HTRI

HEAT EXCHANGER SPECIFICATION SHEET

Page

SI Units

		Job No	
Customer		Reference No	
Address		Proposal No	
Plant Location		Date	5/23/2015 Rev
Service of Unit		Item No	
Size 152.200 x 999.988 mm	Type BEM Hor.	Connected in	1 Parallel 1 Series
Surf/Unit (Gross/Eff) 1.08 / 1.04 m2	Shell/Unit 1	Surf/Shell (Gross/Eff) 1.08 / 1.04 m2	

PERFORMANCE OF ONE UNIT

Fluid Allocation		Shell Side		Tube Side	
Fluid Name		servo prime 68		water	
Fluid Quantity, Total	kg/hr	1363.61		2376.01	
Vapor (In/Out)					
Liquid		1363.61	1363.61	2376.01	2376.01
Steam					
Water					
Noncondensables					
Temperature (In/Out)	C	60.00	45.00	30.00	34.00
Specific Gravity		0.9039	0.9039	1.0018	1.0018
Viscosity	mN-s/m2	0.6800	0.6800	0.1000	0.1000
Molecular Weight, Vapor					
Molecular Weight, Noncondensables					
Specific Heat	kJ/kg-C	1.9660	1.9660	4.2001	4.2001
Thermal Conductivity	W/m-C	0.1550	0.1550	0.6202	0.6202
Latent Heat	kJ/kg				
Inlet Pressure	kPa	980.614		490.307	
Velocity	m/s	6.937e-2		0.45	
Pressure Drop, Allow/Calc	kPa	0.275	0.177	1.440	1.556
Fouling Resistance (min)	m2-K/W	0.000200		0.000900	

Heat Exchanged W 11088.3 MTD (Corrected) 19.2 C

Transfer Rate, Service 553.63 W/m2-K Clean 368.88 W/m2-K Actual 279.70 W/m2-K

CONSTRUCTION OF ONE SHELL

Sketch (Bundle/Nozzle Orientation)

			Shell Side	Tube Side
Design/Test Pressure		kPaG	1034.21 /	1034.21 /
Design Temperature		C		
No Passes per Shell			1	2
Corrosion Allowance		mm		
Connections Size & Rating	In	mm	1 @ 39.000	1 @ 29.000
	Out	mm	1 @ 39.000	1 @ 29.000
	Intermediate		@	@

Tube No. 18 OD 19.050 mm Thk(Avg) 2.108 mm Length 1.000 m Pitch 23.812 mm Layout 30

Tube Type Plain Material COPPER

Shell ID 152.200 mm OD mm Shell Cover

Channel or Bonnet Channel Cover

Tubesheet-Stationary Tubesheet-Floating

Floating Head Cover Impingement Plate None

Baffles-Cross Type SINGLE-SEG %Cut (Diam) 25.0 Spacing(c/c) 140.000 Inlet 344.779 mm

Baffles-Long Seal Type

Supports-Tube U-Bend Type

Bypass Seal Arrangement Tube-Tubesheet Joint

Expansion Joint Type

RhoV2-Inlet Nozzle 109.65 kg/m-s2 Bundle Entrance 1.15 Bundle Exit 1.15 kg/m-s2

Gaskets-Shell Side Tube Side

-Floating Head

Code Requirements TEMA Class

Weight/Shell 139.41 Filled with Water 166.08 Bundle 22.79 kg

Fig.2 HTRI report

3. Conclusion

The pressure drop is calculate by analytical calculation and nthe basis of this value the other results were generated using HTRI.The number of tubes were calculated 21 by manual calculation and in HTRI it comes out 18.

Table No. 2 Thermal Design Result

Main parameter	Manual calculation	HTRI calculation
Mass flow rate of water	0.66 Kb/s	
Heat Load	11.11 KW	11.11 KW
LMTD (corrected)	19.4^0C	19.8^0C
No. of Tubes	21	18
Tube side pressure drop	0.44 Kpa	1.44 Kpa
Shall side pressure drop	0.2 Kpa	0.275 Kpa
Overall heat transfer coefficient	614.1 W/$m^{2\,0}$c	553.63 W/$m^{2\,0}$c

From the results incorporated in table no.2 it is concluded that the heat transfer coefficient and number of tubes slightly decrease in HTRI compared to manual callculation, so it added advantage in overall fabrication cost will be reduce as the number of tube decreases.The overall heat transfer coefficient obtained was adiquate enough to run the heat exchanger successfully at an optimal mass flow rate.From HTRI report the safty and performance of the desighned heat exchanger is determined to be accepted in the permissible range.

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