# Thermal Analysis of Shell and Tube Heat Ex-Changer Using C and Ansys

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***Abstract*****—** In this paper, a simplified model for the study of thermal analysis of shell-and-tubes heat exchangers of water and oil type is proposed..Shell and Tube heat exchangers are having special importance in boilers, oil coolers, condensers, pre-heaters. They are also widely used in process applications as well as the refrigeration and air conditioning industry. The robustness and medium weighted shape of Shell and Tube heat exchangers make them well suited for high pressure operations. In this paper we have shown how to done the 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.

**Key words**: Counter flow of shell and tube heat exchanger of oil and water type, ANSYS software, C software.

## 1. Introduction

### 1. HEAT EXCHANGER

A device whose primary purpose is the transfer of energy between two fluids is named a heat exchanger[4]. A heat Exchanger may be defined as an equipment which transfers the energy from a hot fluid to a cold fluid, with maximum rate and minimum investment and running costs[5].

### 1.1 Shell and Tube Heat exchanger

In this type of heat exchanger one of the fluids flow through a bundle of tubes enclosed by a shell. the outer fluid is forced through a shell and it flows over the outside surface of the tubes . such an arrangement is employed where reliability and heat transfer effectiveness[4]. It is the most common type of heat exchanger in oil refineries and other large chemical Processes, and is suited for higher-pressure applications. This

Type of heat exchanger consists of a shell (a large pressure vessel) with a bundle of tubes inside it. One fluid runs through through the shell) to transfer heat between the two fluids

**Fig-1**:Shell and Tube Heat exchanger of type Water to oil .

## I. Type Style and Fonts

## 2.THERMAL ANALYSIS

A thermal analysis calculates the temperature distribution and related thermal quantities in Shell and tube heat exchanger typical thermal quantities are:

1. The temperature distribution
2. The amount of heat lost or gained
3. Thermal fluxes

**Types of thermal analysis:**

1. A steady state thermal analysis determines the temperature distribution and other thermal quantities under steady state loading conditions. A steady state loading condition is a situation where heat storage effects varying over a period of time can be ignored.

2. A transient thermal analysis determines the temperature distribution and other thermal quantities under conditions that varying over a period of time.

**Planning the analysis:**

In this step a compromise between the computer time and accuracy of the analysis is made. The various parameters set in analysis are given below:

Thermal modelling

II. Analysis type. thermal h-method.

III. Steady state or Transient or Transient

IV. Thermal or Structural or Thermal

V. Properties of the material or Isotropic

VI. Objective of analysis- to find out the temperature distribution in the when the process of shell and tube is done.

## 3.DESIGN CALCULATION [ 1]

### 3.1 THEORITICAL DESIGN CALCULATIONS:

$M_C$ = MASS FLOW RATE OF COLD FLUID ,

$M_C$ = 0.9 KG/SEC

$M_H$ = MASS FLOW RATE OF HOT FLUID

$M_H$ = 2.5 KG/SEC

$CP_C$ = SPECIFIC HEAT OF COLD FLUID

$CP_C$ = 4.2 KJ/KG $^{O}$K

$T_{HI}$ = INLET TEMPERATURE OF HOT FLUID

$T_{HI} = 383^{O}K$

$T_{H2}$ = OUTLET TEMPERATURE OF HOT FLUID

$T_{H2} = 360^{O}K$

$T_{C1}$ = INLET TEMPERATURE OF COLD FLUID

$T_{C1} = 308^{O}K$

$T_{C2}$ = OUTLET TEMPERATURE OF COLD FLUID

$T_{C2}$ = ?

P= DENSITY OF OIL

P= 850 KG/M$^3$

$U_O$ = OVERALL HEAT TRANSFER COEFFICIENT

Σ = EFFECTIVENESS OF HEAT EXCHANGER

$U_O$ = 350 W/M$^2$ $^{O}$K

$\Delta T_{LM}$ = LOGARITHMIC MEAN TEMPERATURE DIFFERENCE

Q = TOTAL HEAT TRANSFER

$Q = M_C C_C \Delta T_{LM}$

Q = HEAT GAIN BY THE COLD LIQUID = HEAT LOSS BY THE HOT LIQUID

$Q = M_C C_C \Delta T_{LM} = M_H C_H \Delta T_{LM}$

$0.9x4.2x(T_{C2} -308) = 2.5x2.5x(383\text{-}360)$

$= 346.02\ ^{O}K$

OUTLET TEMPERATURE OF COLD LIQUID

$T_{C2} = 346\ ^{O}K$

$Q = M_C C_C \Delta T_{LM}$

$= 0.9x4.2x(346\text{-}308) = 143.74$KW

RATE OF HEAT TRANSFER = 143.74KW

**Logarithmic mean temperature distribution for counter flow heat exchanger (LMTD)**

$\Delta T_{lm} = (\Delta T_1 - \Delta T_2)/\ln(\Delta T_1/\Delta T_2)$

$\Delta T_1 = T_{h1} - T_{c2}$

$\Delta T_2 = T_{h2} - T_{c1}$

$= ((383\text{-}346)\text{-}(360\text{-}308))/\ln((383\text{-}346)/(360\text{-}308))$

$= 44.07\ {}^{o}k$

**Area of shell**

$A = Q/(U_o\ \Delta T_{lm})$

$= 143.74X10^3 / (350X44)$

$A = 9.318m^2$

**Area of Tube**

$A_t = m_h/\ \rho v$

$= 2.5/(850x0.35)$

$= 0.0084m^2$

***Number of tubes***

$A_t = n\pi\ (d^2/4)$

$= (0.0084\times4)/\ \pi(0.02^2)$

$n = A_t\times4/\pi d^2$

$n = 26.93 = 27$ tubes

**Length of tubes**

$A = n\pi dL$

$L = 9.318 / (27\times\pi\times0.02)$

$L = 5.49m$

**Shell outer diameter**

$D_o = A/\pi L$

$= 9.318/(\pi\times5.49) = 0.540m$

$D_o = 0.540m$

**Effectiveness**

$\Sigma = (C_{max}(T_{h1}–T_{h2}))/\ (C_{min}(T_{h1}–T_{h2}))$

$C_{max}$ = max of $C_h$ or Cc

$C_{min}$ = max of $C_h$ or Cc

$C_{min} = Cc = m_cCp_c = 0.9x4.2 = 3.78$

$C_{max} = C_h = m_hCp_h = 2.5x2.5 = 6.25$

$= Cc(T_{h1}–T_{c2})/\ Ch(T_{h1}–T_{c1})$

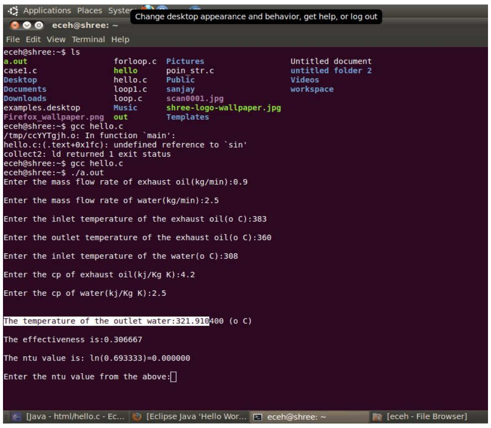
$= (6.25(383\text{-}360))/(3.78(383\text{-}308))$

$\Sigma = 0.507050$

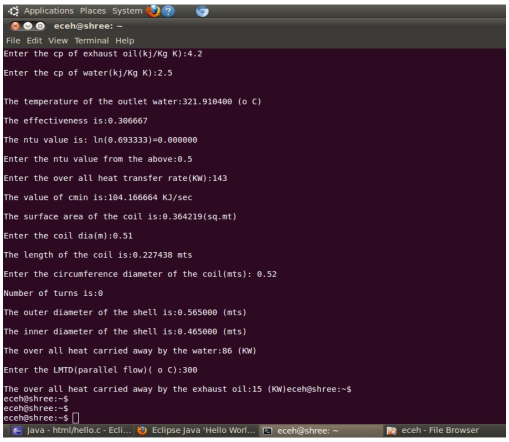
## 4. THERMAL ANALYSIS CALCULATIONS BY USING C PROGRAM.

For thermal analysis calculations by using C program we have to provide some parameters like mass flow rate of hot liquid and cold liquid. Temperatures of inlet and outlet of hot liquid and inlet temperature of cold liquid.

**Input**



**Output**




## 5.MODELING OF SHELL AND TUBE HEATEXCHNAGER USING PRO-E

**SHELL**

Outer diameter of the shell is 540mm

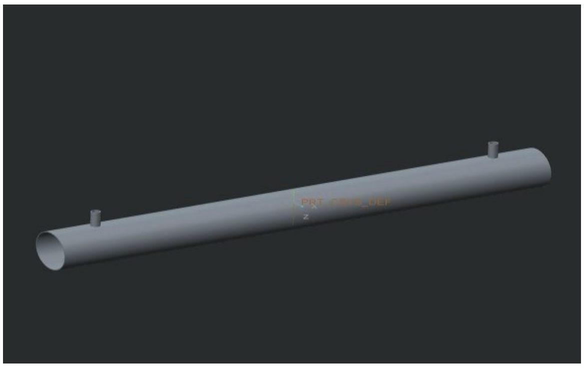
Inner diameter of the shell is 520mm

Thickness of the shell is 10mm

Material we have taken for shell is stainless steel Length of the shell 5.49m

Inlet and outlet nozzle diameter of the shell is 100mm

Thickness is 10mm



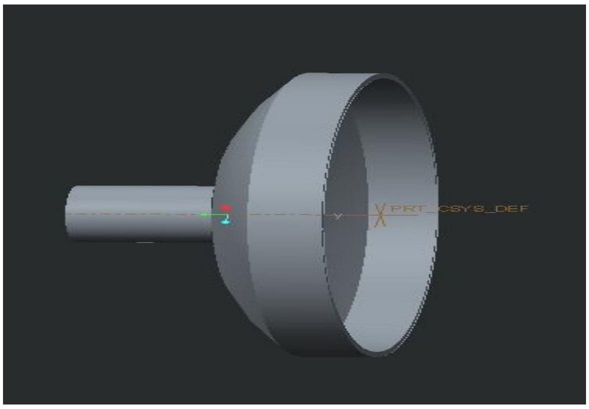
**FLANGE**

Outer Diameter of the flange is 540mm

Inner Diameter of the flange is 520mm

Thickness is 10mm

Outer diameter of the nozzle is 100mm

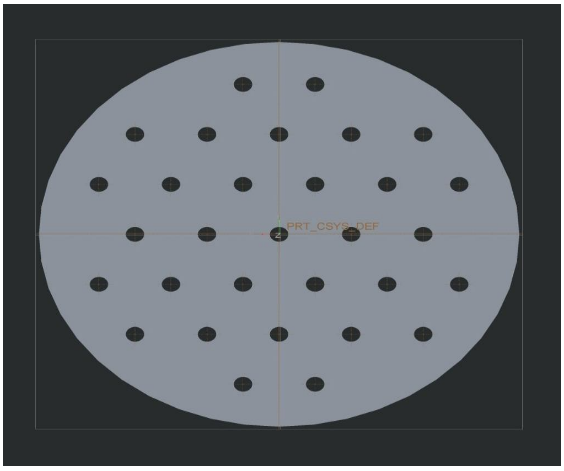


Inner diameter of the nozzle is 80mm

**BAFFLE END PLATE**

Diameter of the baffle end plate is 520mm

Number of holes on the baffle end plate is 31

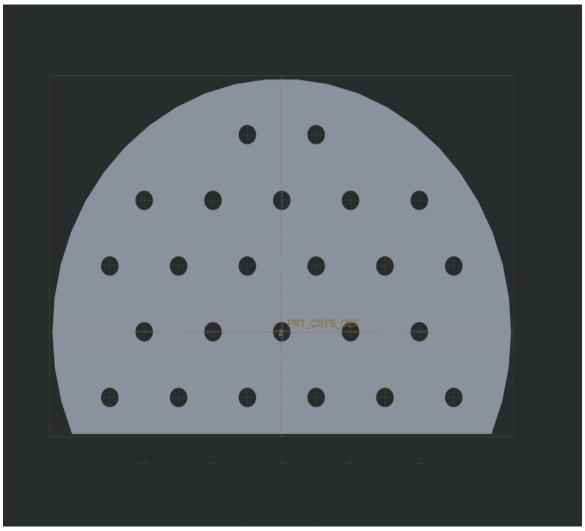


Hole diameter is 20mm

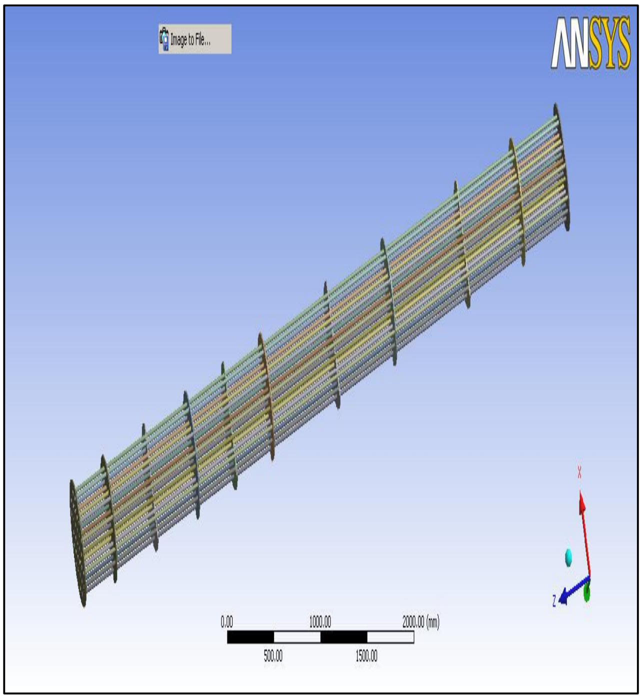
**BAFFLE PLATE**

Baffle cut is 25%

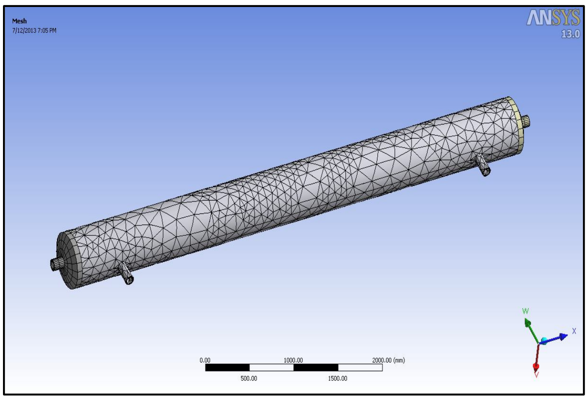
Thickness of the baffle plate is 10mm



**Assembly Model**



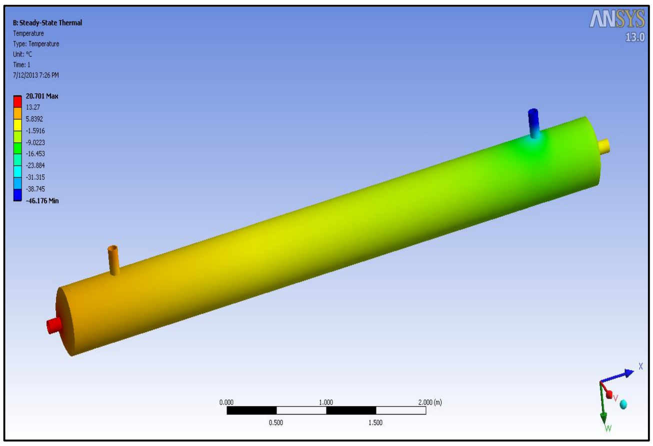
**Meshing**



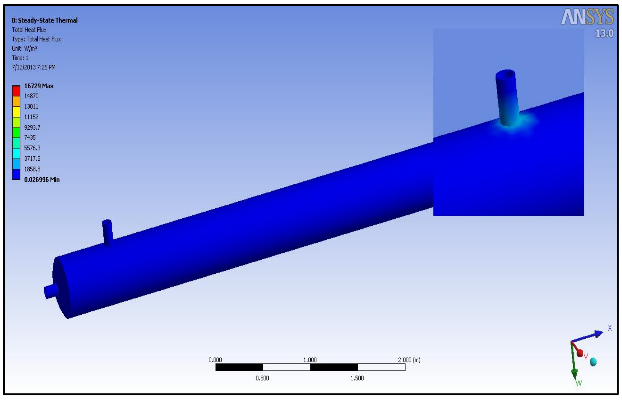
## THERMAL ANALYSIS USING ANSYS

By using the thermal analysis result that obtained from theoretical formulae. We have designed a Pro-e Model, and the materials we used for thermal analysis for tubes is copper and shell is stainless steel because Copper is one of the best conductors of heat, while stainless steel is a mediocre conductor. Using copper would increase the rate at which heat was transferred from oil to the water which is imported into the ANSYS software and started the analysis, the results that obtained from ANSYS where represented by contour plots.

**Temperature**



**Total Heat flux**




## CONCLUSION

We have done the thermal analysis of water to oil type of shell and tube heat exchanger using **C** and by using the output that come from **C** 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 compared the both results and we are getting an error of **0.0274**in effectiveness .By using above process we can do the thermal analysis in less time and our analysis report also most accurate .

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