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“Optimal Design and Performance Analysis of Heat Exchangers Using Catia and Ansys”

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***Abstract*— Tubular Heat exchangers can be designed for high pressures relative to environment and high-pressure differences between the fluids. Tubular exchangers are used primarily for liquid to liquid. An attempt is made in this paper is for the Design of shell and tube heat exchangers by modeling in CATIA V5 by taking the Inner Diameter of shell is 400 mm, length of the shell is 700 mm and Outer diameter of tube is 12.5mm, length of Tube is 800mm and Shell material as Steel 1008, Tube material as Copper and Brass. By using modeling procedure Assembly Shell and Tube with water as medium is done. By using ANSYS software, the thermal analysis of Shell and Tube heat exchangers is carried out by varying the tube materials comparison is made between the Experimental results, ANSYS. With the help of the available numerical results, the design of Shell and Tube heat exchangers can be altered for better efficiency**

***Index Terms*— Tubular heat exchangers, CAD, CATIA V5, ANSYS.**

I. INTRODUCTION

Heat transfer is a discipline of thermal engineering that concerns the generation, use, conversion, and exchange of thermal energy and heat between physical systems. Heat transfer is classified into various mechanisms, such as thermal conduction, thermal convection, thermal radiation, and transfer of energy by phase changes. Improvement of HX performance affects both directly and indirectly the performance of various devices and systems. Especially in the aerospace industries, these environmental issues and airlines require gas turbine manufacturers to produce environmentally friendly gas-turbine engines with lower emissions and improved specific fuel consumption.

Hence, the object of this work is an optimal design and a performance analysis of high-performance HX used in a high temperature and high pressure system.

II. LITERATURE SURVEY

Extensive work has been reported in the literature on analysis of heat exchangers. (1) Resat Selbas et al has studied the genetic algorithms (GA) for the optimal design of shell-and-tube heat exchanger by varying the design variables outer tube diameter, tube layout, number of tube passes, outer shell diameter, baffle spacing and baffle cut. (2) G.N. Xie, et al had carried-out an experimental system for investigation on performance of shell-and-tube heat exchangers, and limited experimental data is obtained. (3) José M. Ponce-Ortega et al has presented an approach based on genetic algorithms for optimum design of shell and tube heat exchanger and for optimization major geometric parameters such as the number of tube-passes, standard internal and external tube diameters, tube layout and pitch, type of head, fluids allocation, number of sealing strips, inlet and outlet baffle spacing, and shell side and tube-side pressure drops were selected. (4) M. M. El-Fawal et al has presented in this paper a computer program for economical design of shell and tube heat exchanger using specified pressure drop is established to minimize the cost of the equipment. (5) Zahid H. Ayub has calculate single-phase shell side heat transfer coefficient in a typical TEMA style single segmental shell and tube heat exchanger. A case study of rating water-to-water exchanger is shown to indicate the result from this method with the more established procedures and software’s available in the market. (6) R. Hosseini etal is presented experimentally obtained the heat transfer coefficient and pressure drop on the shell side of a shell -and-tube heat exchanger for three different types of copper tubes (smooth, corrugated and with micro-fins).

III. INTRODUCTION TO CAD/CAM/CAE

The Possible basic way to industries is to have high quality products at low costs is by using the computer Aided Engineering (CAE), Computer Aided Design (CAD) And Computer Aided Manufacturing (CAM) set up. Further many tools is been introduced to simplify & serve the requirement CATIA, PRO-E, UG are some among many. CATIA is a robust application that enables you to create rich and complex designs. The goals of the CATIA course are to teach you how to build parts and assemblies in CATIA, and how to make simple drawings of those parts and assemblies.

IV. MODELING, MESHING AND ANALYSIS OF HEAT EXCHANGERS

Based on the above data, in this paper work has taken 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, Aluminum etc. CATIA version is a process-centric computer-aided design/computer-assisted manufacturing/computer-aided engineering (CAD/CAM/CAE) system that fully uses next generation object technologies and leading edge industry standards. Seamlessly integrated with D assault systems Product Lifecycle Management (PLM) solutions, it enables users to simulate the entire range of industrial design processes from domains (elements) in order to facilitate the numerical solution of initial concept to product design, analysis, assembly, and a partial differential equation. The CATIA V5 product line covers mechanical and shape

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design, styling, product synthesis, equipment and systems engineering, NC manufacturing, analysis and simulation, and industrial plant design.

Data Collection & Modeling:

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V. DIMENSIONS OF SHELL AND TUBE HEAT EXCHANGERS:

No. of tubes = 45
Length of the tubes = 805 mm
Tube diameter = 26 mm
Tube pitch = 33 mm
Clearance = Pt – do =33 – 26 =7 mm
Tube layout = 90
Shell length = 800 mm
Shell diameter = 136
Thickness = 8 mm

NOMENCLATURE:

E Young's Modulus
µ Poisson's ratio
K Thermal conductivity
ρ Density
Cp Specific heat
Thermal properties of copper and brass

VI. RESULTS & DISCUSSIONS

This Tutorial will use a readymade file to speed up the learning process for the student. This file is provided in Para solid format. The intention of this tutorial is to get the student to run a straight forward simulation. By the end of this tutorial a check list for the required procedure can be formulated by the student. ANSYS as software is made to be user-friendly and simplified as much as possible with lots of inter face options to keep the user as much as possible from the hectic side of programming and debugging process.

Table 1: Model > Geometry

Object Name	*Solid*
State	Meshed
Graphics Properties	
Visible	Yes
Transparency	1
Definition	
Stiffness Behavior	Flexible
Coordinate System	Default Coordinate System
Reference Temperature	By Environment
Material	
Assignment	Steel 1008
Nonlinear Effects	Yes
Thermal Strain Effects	Yes
Bounding Box	
Length X	10000 mm
Length Y	10000 mm
Length Z	30000 mm
Properties	
Volume	4.4768e+011 mm^3
Mass	3.5241e+006 kg
Centroid X	1.4889e-013 mm
Centroid Y	2.127e-013 mm
Centroid Z	15000 mm
Moment of Inertia Ip1	3.0243e+014 kg·mm^2
Moment of Inertia Ip2	3.0243e+014 kg·mm^2
Moment of Inertia Ip3	7.8927e+013 kg·mm^2
Statistics	
Nodes	12098
Elements	1804
Mesh Metric	None

Coordinate Systems

Object Name	*Global Coordinate System*
State	Fully Defined
Definition	
Type	Cartesian
Coordinate System ID	0.
Origin	
Origin X	0. mm
Origin Y	0. mm
Origin Z	0. mm
Directional Vectors	
X Axis Data	[1. 0. 0.]
Y Axis Data	[0. 1. 0.]
Z Axis Data	[0. 0. 1.]

Table 2: Model > Coordinate Systems > Coordinate System

Steady-State Thermal

Object Name	*Steady-State Thermal (B5)*
State	Solved
Definition	

Physics Type	Thermal
Analysis Type	Steady-State
Solver Target	Mechanical APDL
Options	
Generate Input Only	No

Table 3: Model > Analysis

Object Name	*Initial Temperature*
State	Fully Defined
Definition	
Initial Temperature	Uniform Temperature
Initial Temperature Value	22. °C

Table 4: Model > Steady-State Thermal > Initial Condition

Model > Steady-State Thermal > Temperature

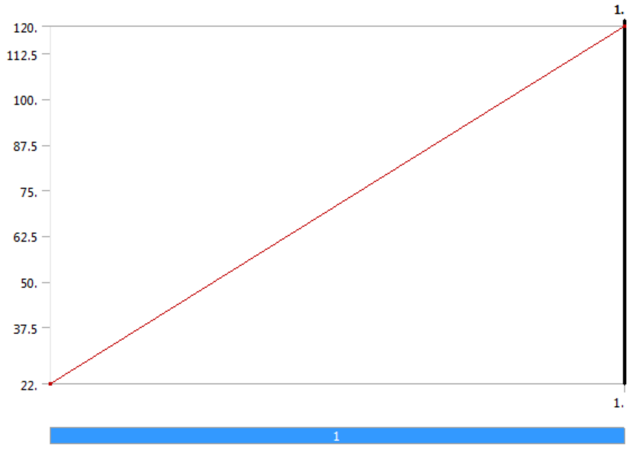


Fig 1: Graph showing the steady state thermal temperature

Model > Steady-State Thermal > Radiation Model > Steady-State Thermal > Radiation

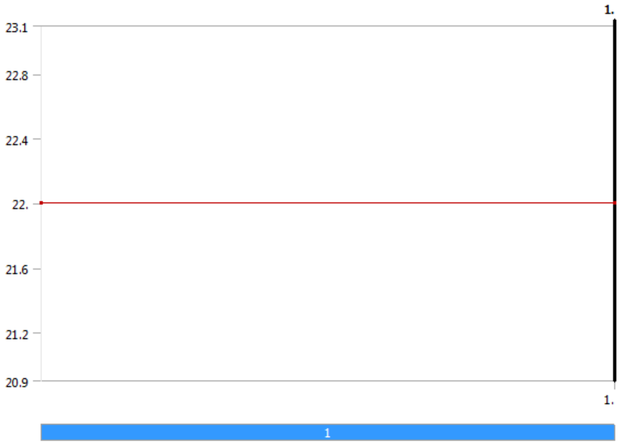


Fig 2: Graph showing the steady state thermal Radiation

Solution:

Object Name	*Solution (B6)*
State	Solved
Adaptive Mesh Refinement	
Max Refinement Loops	1.
Refinement Depth	2.
Information	
Status	Done

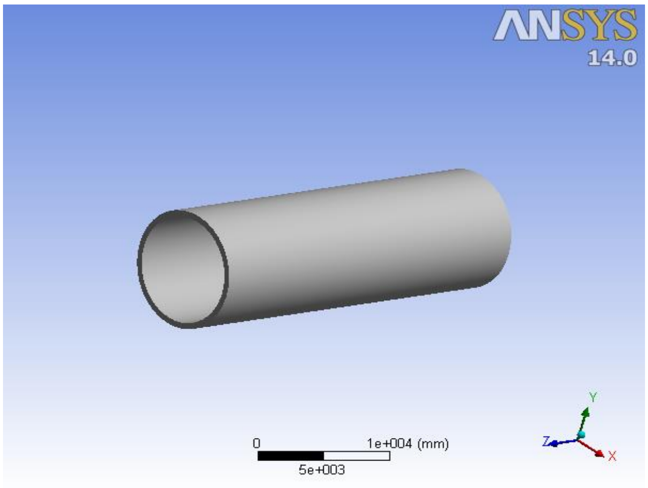
Table 5: Model > Steady-State Thermal > Solution

Object Name	*Solution Information*
State	Solved
Solution Information	
Solution Output	Solver Output
Update Interval	2.5 s
Display Points	All
FE Connection Visibility	
Activate Visibility	Yes
Display	All FE Connectors
Draw Connections Attached To	All Nodes
Line Color	Connection Type
Visible on Results	No
Line Thickness	Single
Display Type	Lines

Table 6: Model > Steady-State Thermal > Solution > Solution Information

Object Name	*Temperature*	*Total Heat Flux*
State	Solved	
Scope		
Scoping Method	Geometry Selection	
Geometry	All Bodies	
Definition		
Type	Temperature	Total Heat Flux
By	Time	
Display Time	Last	
Calculate Time History	Yes	
Identifier		
Suppressed	No	
Results		
Minimum	110.63 °C	7.9493e-004 W/mm²
Maximum	120. °C	8.9392e-004 W/mm²
Information		
Time	1. s	
Load Step	1	
Sub step	1	
Iteration Number	2	
Integration Point Results		
Display Option		Averaged

Table 7: Model > Steady-State Thermal > Solution > Results



Import Data to Ansys

Model > Steady-State Thermal > Solution > Temperature > Figure

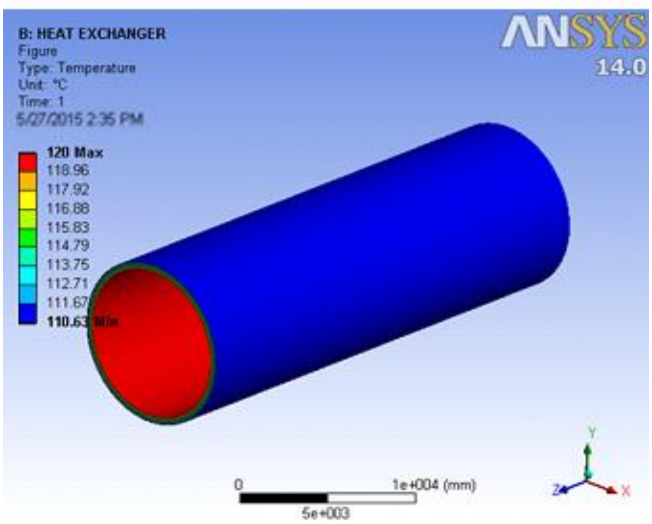


Fig 3: Heat Exchanger showing different temperatures

Model > Steady-State Thermal > Solution > Total Heat Flux > Figure

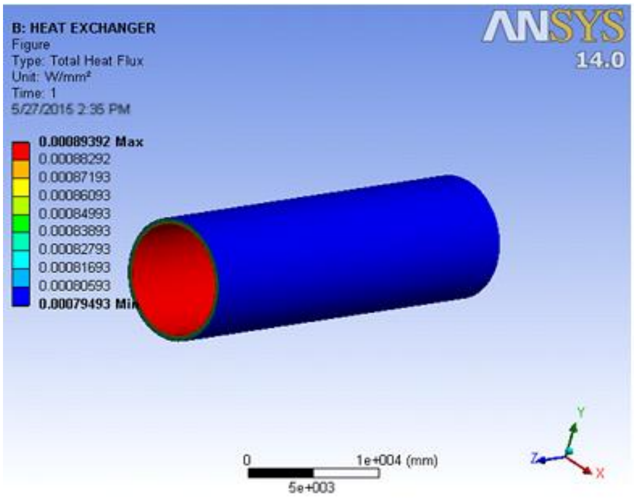


Fig 4: Heat Exchanger showing total heat flux

VII. CONCLUSION

After performing all the analysis work for shell & tube heat exchangers the following observation had been done. From the study of the result as mentioned in table 1 , after performing the calculation the fluid water for bass output temperature is 310 °k which is nearer to the value mentioned in output temperature of ansys. As we change the tube material from the brass to the copper, temperature difference between output temperature of copper & brass had been varied. Analysis has been done by varying the tube materials and it is found that copper material gives the better heat transfer rates than the brass material.

1. Rate of heat transfer can be improved by varying the tube diameter, length and no of tubes.
2. By changing the pitch lay out rate of heat transfer can be improved.
3. By changing the temperature of tubes and medium rate of heat transfer can be improved.

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