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Thermal Analysis of Shell and Tube Heat Exchanger using ANSYS

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Abstract— ***Heat exchanger plays an important role in all the thermal applications which deals with transfer of the heat energy in different forms. Heat transfer should be optimized to get effective temperature distribution. The objective of this work is to model different segmented baffle configurations of shell and tube heat exchanger using 3D modelling and conducting thermal analysis to find the optimized model which produce effective temperature distribution using ANSYS software.***

Keywords— baffle segments, temperature distribution, ANSYS

INTRODUCTION

Shell and tube heat exchangers (STHEs) are heat transfer devices that are used in the food processing industry, power plants, petroleum refining, marine applications, and transmission coolers, among others. For example, in power plants they are commonly used as condensers or boilers where the steam generated is used to run a turbine and create power. Their design differs from other heat exchangers since they are composed of an outer shell with baffles an inner tube bundle that is housed inside the STHE headers. The outer cylindrical shell design acts as a pressure vessel and allows this kind of heat exchanger to withstand large pressures. One fluid is forced up and down through the outer shell by the baffles, which are intermediate walls that are part of the tube bundle, while another fluid flows through the inside of the tube bundle. The two fluids exchange heat through the conductive tube bundle walls and, as both fluids move along the heat exchanger, one gets cooler while the other one gets hotter or vice versa. The headers could be bolted or welded to the outer shell and serve to distribute the fluid that flows inside the tube bundle. The development of STHE has suffered from a lack of research to study the interconnection between the turbulent fluid flow structures and heat transfer resulting from the effects of the baffles due to the high cost of complex experimental set up and complex modelling geometries. The most used STHE is the segmented baffle shell and tube heat exchanger (SG-STHEs).

LITERATURE REVIEW

S.Rajasekaran, et al (2010), The objective of this paper is to Develop and Test a model of optimizing the early design phase of shell and Tube Heat Exchangers via the application of modified Genetic Algorithm (MGA).The Modified Genetic Algorithm is based on the integration of classical genetic algorithm structure and a systematic neighborhood structure .The MGA model can help the designers to make decisions at the early phases of the design process. With a MGA model, it is possible to obtain an approximately better prediction, even when required information is not available in the design process. This model proved that MGA can provide better solutions with- higher quality even with inadequate data.

Praful Date1, et al (2013).This paper proposed the novel approached toward the heat transfer enhancement of plate and fin heat exchanger using improved fin design facilitating the vortex generation. The vortex generator can be embedded in the plane fin and that too in a low cost with effect the original design and setup of the commonly used heat exchangers. The various design modifications which are implemented and studied numerically and experimentally is been discussed in the paper.

F. Vera-Garcia, et al (2010). In this paper, a simplified model for the study of shell-and-tubes heat exchangers (HXs) is proposed. The model aims to agree with the HXs when they are working as condensers or evaporators. Despite its simplicity, the model proves to be useful to the pre-designment and correct selection of shell-and-tubes HXs working at full and complex refrigeration systems. The heat transfer coefficient and pressure drop correlations are specially selected and treated to implement them into the shell-and-tubes HXs presented. The model is implemented and tested in the modellization of a general refrigeration cycle and the results are compared with data obtained from a specific test bench for the analysis of shell-and-tubes HXs

III.PHASES OF WORK

Modelling of the Shell and Tube Heat Exchanger with the standard Dimensions in CATIA V5

↓

Apply the various Segmented Baffles to the Shell and Tube Heat Exchanger

↓

Import the file into ANSYS workbench, input the Material Properties and apply the boundary conditions, run the solution.

↓

Obtain the temperature distribution and heat flux results, Compare the results to find best and Suitable Model

IV.DESIGN & CALCULATIONS

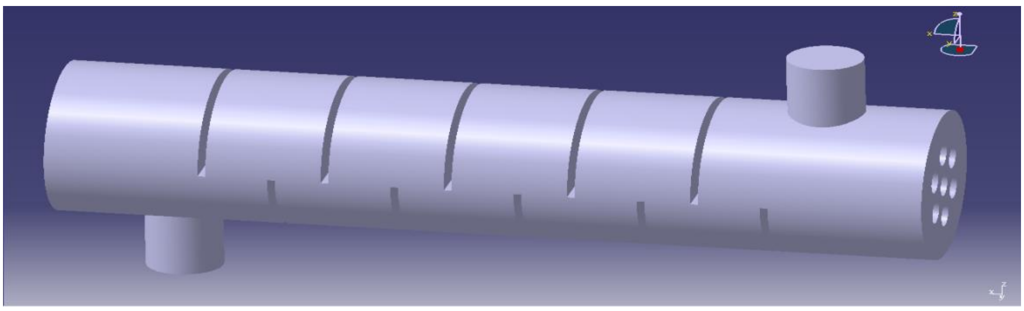
SPECIFICATIONS OF THE DESIGN

1. Shell diameter = 135 mm
2. Length = 500 mm
3. Tube diameter = 20 mm
6. Tube length = 495 mm
7. Tube material = copper
8. Shell material = copper
9. Tube type = triangular pitch
10. Pitch length = 30 mm
11. Total number of the tubes =7
12. Inlet for shell side = Water, mass flow rate = 0.062 kg/sec
13. Inlet for tube side = Water, mass flow rate = 0.318 kg/sec
14. Hot Water Inlet temperature = 363 K
15. Hot Water Outlet temperature = 358 K
16. Cold Water Inlet temperature = 296 K
17. Cold Water Outlet temperature = 303 K
18. Operating pressure = 14.5 kg/cm2

Baffle plates which are going to analysed are:

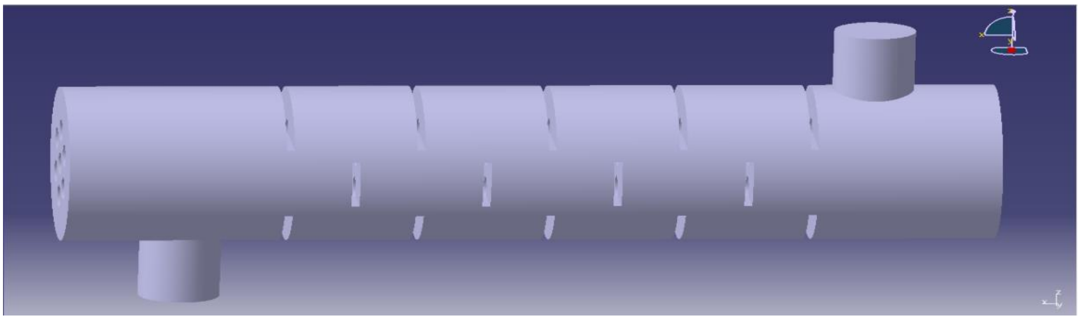
1. Single Segmented Baffles
2. Double Segmented Baffles
3. Triple Segmented Baffles

1. SINGLE SEGMENTED BAFFLE



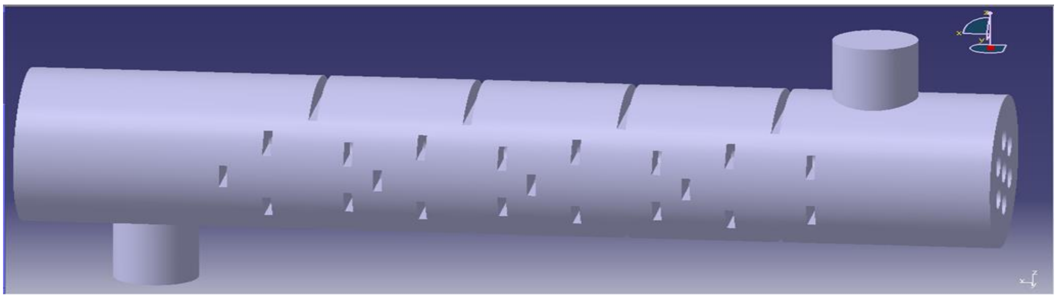
Single segmented baffle shell and tube heat exchanger

2. DOUBLE SEGMENTED BAFFLE



Double segmented baffle shell and tube heat exchanger

3. TRIPLE SEGMENTED BAFFLE

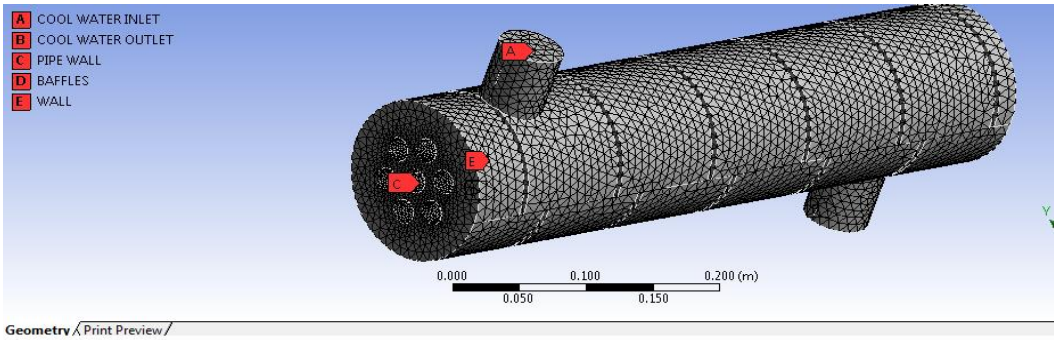


Triple segmented baffle shell and tube heat exchanger

V.THERMAL ANALYSIS

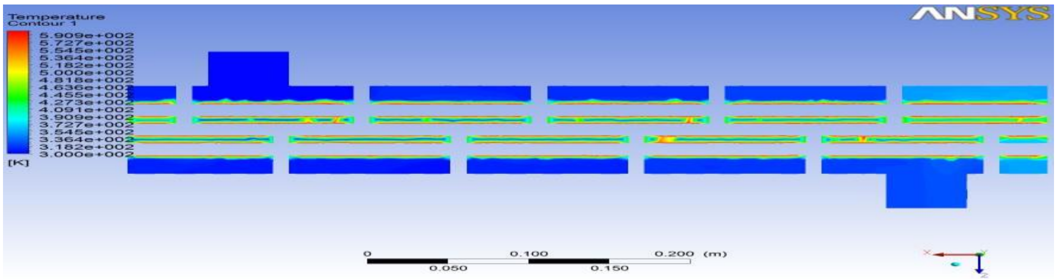
MESH MODEL

Mesh Size	20mm
No. of Elements	64670
No. of Nodes	201181
Mesh type	Tetrahedral



1. **SINGLE SEGMENTED BAFFLES:**

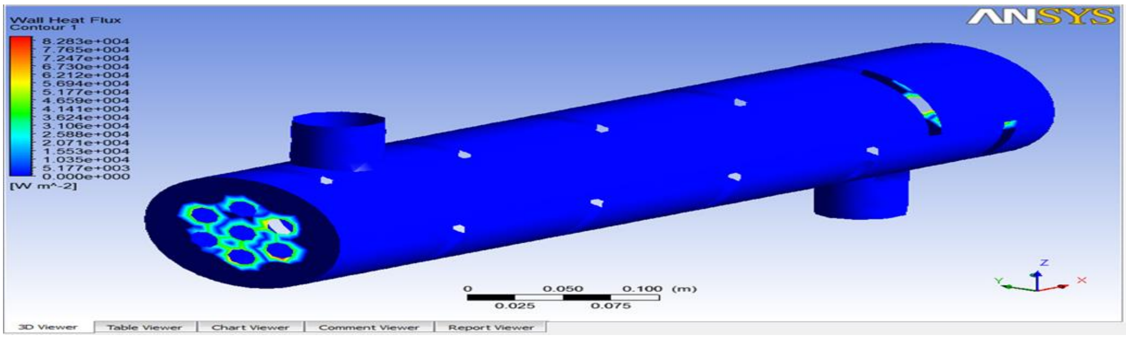
TEMPERATURE DISTRIBUTION



From the above thermal analysis of single segmented Shell and tube Heat Exchanger, we came to know that the temperature distribution is between in the range of following.

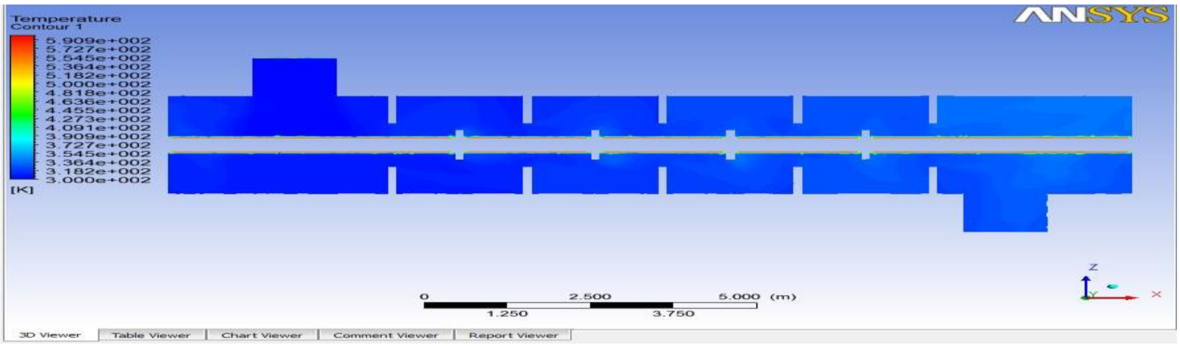
Maximum temperature: 5.909e+002°K
Minimum temperature: 3.000e+002°K

TOTAL HEAT FLUX



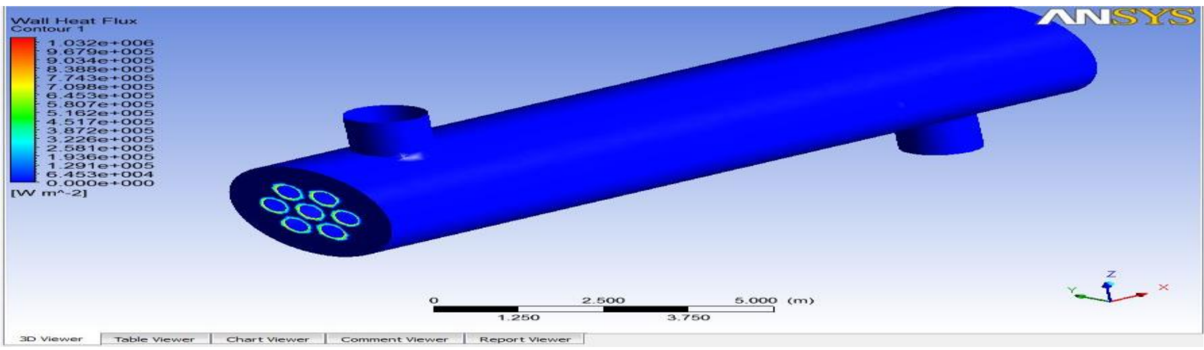
From the analysis the heat flux range in the single segmented shell and tube heat exchanger is found to be:
Maximum heat flux : 8.283e+004 W/m^2
Minimum heat flux : 1.035e+004 W/m^2

2. DOUBLE SEGMENTED BAFFLES:
TEMPERATURE DISTRIBUTION



From the above thermal analysis of double segmented Shell and tube Heat Exchanger, we came to know that the temperature distribution is between in the range of following.
Maximum temperature: 5.909e+002°K
Minimum temperature: 3.000e+002°K

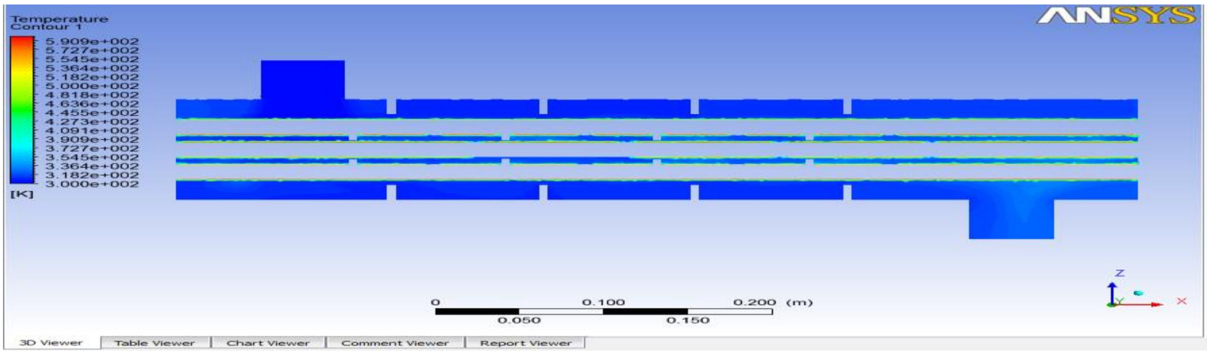
TOTAL HEAT FLUX



Obtaining the total heat flux range inside the double segmented shell and tube heat exchanger we get
Maximum heat flux: 1.032e+006 W/m^2
Minimum heat flux: 6.453e+004 W/m^2

3. TRIPLE SEGMETED BAFFLES:

TEMPERATURE DISTRIBUTION

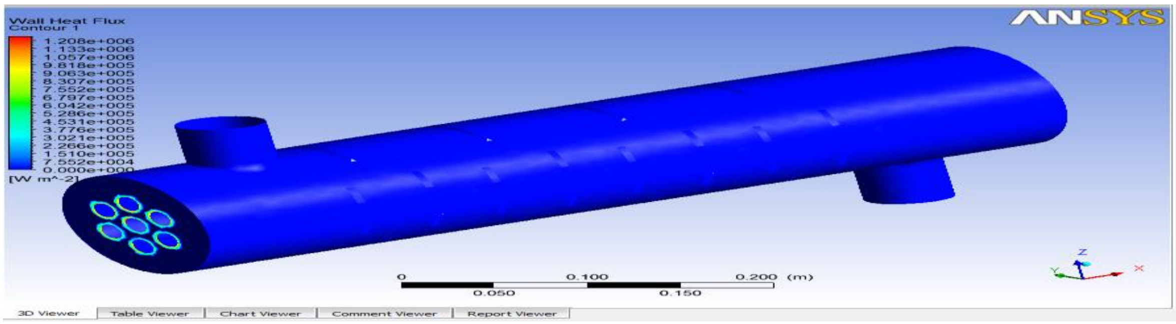


From the above thermal analysis of triple segmented Shell and tube Heat Exchanger, we came to know that the temperature distribution is between in the range of following.

Maximum temperature: 5.909e+002°K

Minimum temperature: 3.000e+002°K

TOTAL HEAT FLUX



Obtaining the total heat flux range inside the double segmented shell and tube heat exchanger we get

Maximum heat flux: 1.208e+006 W/m^2

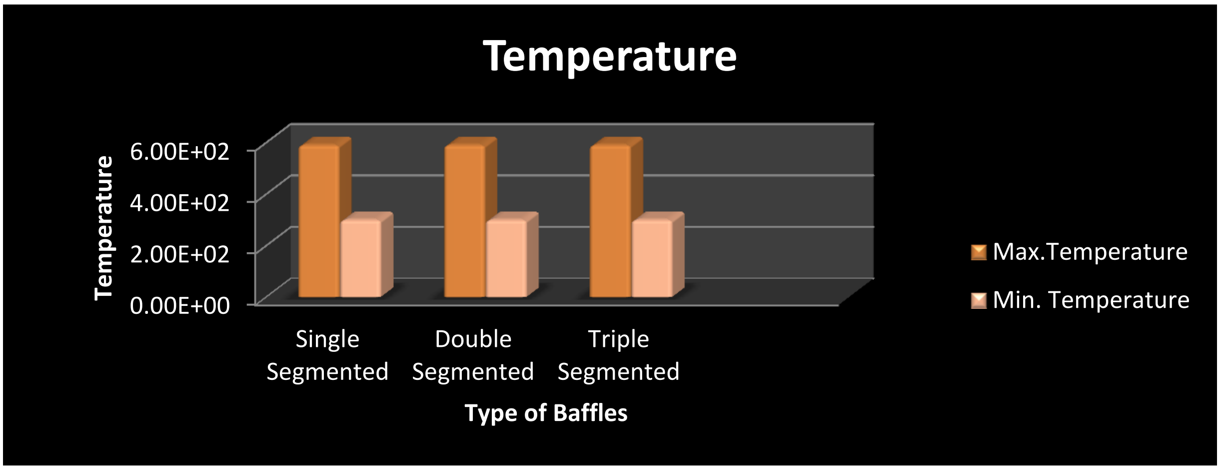
Minimum heat flux: 7.552e+004 W/m^2

VI.RESULT ANALYSIS

TEMPERATURE DISTRIBUTION

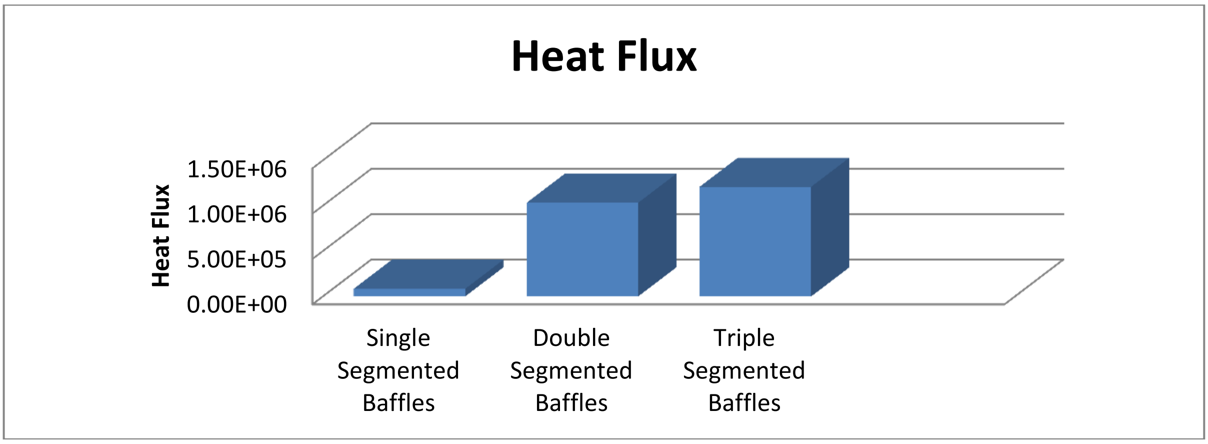
Most effective temperature rise is studied which also contributes to the selection of the optimum baffle configuration from the following analysis

Sl. No	Type of Segmented Baffles	Max. Temp	Min. Temp
1.	Single Segmented Baffles	5.909e+002	3.00e+02
2.	Double Segmented Baffles	5.909e+002	3.00e+02
3.	Triple Segmented Baffles	5.909e+002	3.00e+02



TOTAL HEAT FLUX

Sl. No	Type of Segmented Baffles	Max. Heat flux W/m^2	Min. Heat flux W/m
1.	Single Segmented Baffles	8.283e+004	1.035e+004
2.	Double Segmented Baffles	1.032e+006	6.453e+004
3.	Triple Segmented Baffles	1.208e+006	7.552e+004



VII. CONCLUSION

From the above result analysis it is found that the model with Triple Segmented Baffles exhibits much better results than other segmented baffles. It is almost at same temperature but it gets reduced and it exhibits the **highest total heat flux rate**. So the Triple Segmented Baffles shell and tube heat exchanger is better than other segmented baffles.

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