FINITE ELEMENTAL STRESS ANALYSIS OF NTIW HEAT EXCHANGER

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Abstract

The increased size of the power plants needs to handle large steam at higher loading condition for the heat exchanger. Due to this overall diameter of the heat exchanger is to be increased. This may results in the flow induced vibrations and reduced pressure drop. To maintain pressure drop and to reduce flow induced vibrations, NTIW tube sheets are preferred. The various design codes like ASME, TEMA are available for design of the heat exchanger. This paper is intended towards the method used for analysis of heat exchanger with NTIW configurations.

Keywords: *Finite elemental Analysis, No tubes in window, ASME, TEMA.*

Introduction

In today's world, the process industry is the fastest growing industry. Boiler and heat exchangers are the main process equipment's used in this industry. The shell and tube heat exchangers are mainly used type of heat exchanger. They are used in the petrochemical plants, nuclear power plants, and food and beverage plants. In the late 60's through early 80's, the size of such power plants grown up drastically. This needs to handle larger steam which resulted in the requirement of larger diameter of the heat exchangers. To maintain flow velocities with same tube diameter, baffle spacing is to be increased. Due to this, soon failures start occurring as a result of flow induced vibrations. To maintain high pressure with reduced flow induced vibrations, special arrangement of tubes over tube sheet is required. The design of such special non habitual tube-sheet is not covered in the design codes like ASME and TEMA [1] [3]. Design by analysis can be used for such cases [4].

NTIW Tube-sheet

In order to maintain the pressure drop and to mitigate the vibrations some portion of the tube sheet is kept un-tubed. Such arrangement in the shell and tube heat exchanger is called as 'No Tubes in Window' (NTIW) configuration. The NTIW zone design provides an improved level of the performance of multi zoned feed water heaters at the overload at upset working conditions of the plant [5]. The figure 1 shows the typical NTIW tube-sheet. The window may be kept at upper half or lower half or at middle portion also.

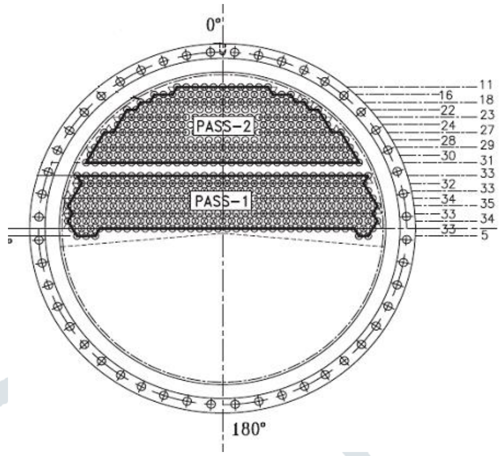

Fig. 1 Tube-sheet with NTIW Configuration Fig. 2 NTIW tube-sheet used

Need of FEA

It has been observed that, the standard design methods and codes are available for uniformly tubed tube-sheet. It is observed those inadequate research articles are available related to special arrangement of the tubes on the tube-sheet. The only method available for the design of NTIW configuration of the heat exchanger is design by analysis [1] [2]. The design by analysis method is used for the non-habitual tube sheets.

Finite Elemental Analysis

The study is conducted to determine the stress levels in shell, channel and tube-sheet of the heat exchanger. 3D CAD Solid model is generated as per geometric details. CAD model consists of shell, channel shell, shell side nozzles, tube-sheet. Finite element model consists of Solid 186 element is used for analysis. Tetrahedral and hexahedral elements are used for the meshing. In order to reduce the node count, the hexahedral elements are preferred. Minimum 2 to 3 elements are maintained across the thickness of each component in order to achieve accurate results at critical locations.

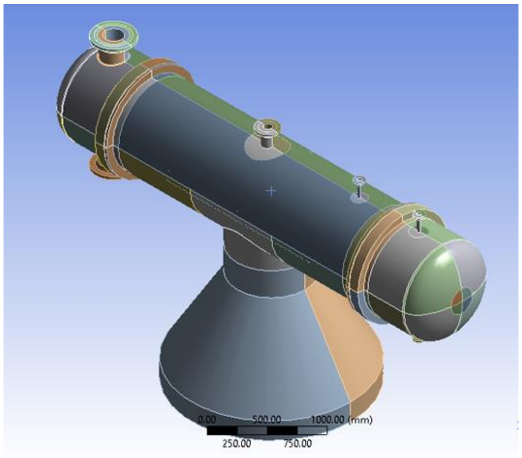

Fig. 3 CAD Model of Heat Excanger

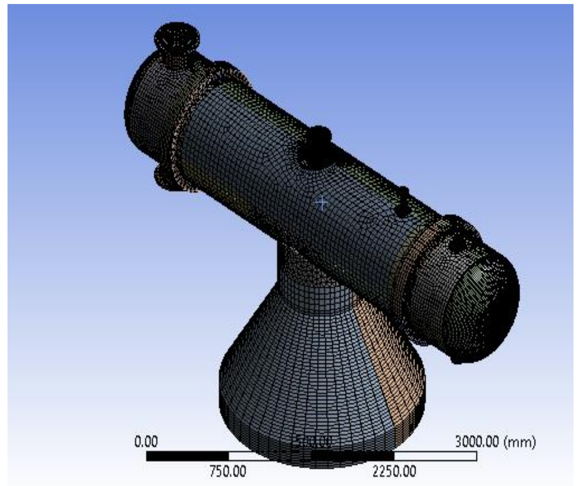

Fig. 4 Meshed model of heat exchanger

The slice method is preffered for the better meshing in the critical areas. The element size varies from slice to slice. Overall mesh quality checks are as below.

Table 1 Overall mesh quality

Quality Check	Acceptable Value	Achieved Valve
Aspect Ratio	< 5	3.35
Jacobian Ratio	> 0.5	0.93
Skewness	< 0.70	0.36

Total numbers of elements in model - 323615

Total numbers of nodes in model – 130925

Boundary and loading condition

The first loading condition to be considered is operating weight. Operating weight is considered as gravity load in downward direction. Shell side internal design pressure is applied on internal faces of shell, shell side face of both tube-sheets, tube outer faces. Thrust due to internal pressure is applied shell side nozzle flange faces. Nozzle process loads are applied on shell side nozzle to shell junction. Displacement boundary condition is applied on bottom face of middle saddle. Baffles have not been modeled in FE Model though effect of the same is considered in FEA Analysis. Displacement Boundary condition is provided at baffle locations such that it is free to move in longitudinal direction and its movement in other two directions is constrained.

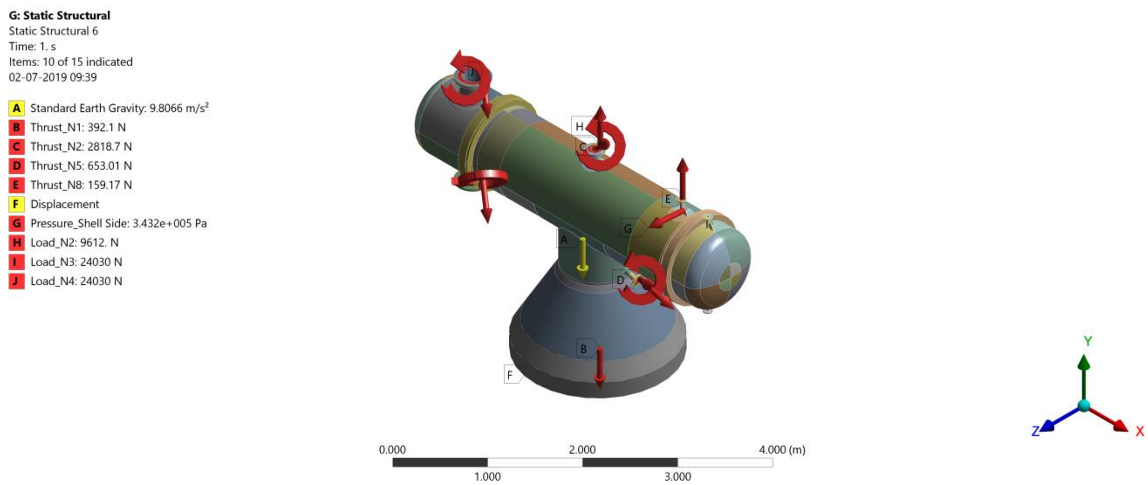

Fig. 5 Nozzle Process Loads

Results and discussion

The stresses for the applied loading condition are observed as follows

Location	PL (MPa)	PL+Pb+Q (MPa)	Pm(MPa)
At maximum stress location (At Nozzle to shell junction)	133.73	218.54	79.64
At maximum stress location of Tube-sheet	15.30	50.83	
At Tube-sheet to channel junction	15.57	129.37	

Results for design pressure conditions are compared with ASME Section VIII, Division 2, Part 5. Stress comparisons are made as per ASME Sect VIII, Div. 2 (Ed.2017).The Stresses are compared and validated by using following methodology.

1. PL + Pb + Q are compared with Sps.
2. PL is compared with S_{PL}
3. Pm is compared with S,

Where S = allowable stress for material

S_{PL} = 1.5*S or S_y (1.5*S shall be used when the ratio of the minimum specified yield strength to ultimate tensile strength exceeds 0.70)

Sps = allowable stress for primary and secondary stresses (ASME Sect VIII, Div. 2, Part 5.E)

References

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