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FEA Analysis Of Shell And Nozzle

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Abstract : *Shell and tube heat exchanger are known as the work horse of the chemical process industry and represent the most widely used vehicle for transfer of heat in industrial applications. In this paper, carried out the analysis of eccentric cone which is weld with the shell on both sides with nozzle. The heat exchanger is proprietary product. Finite element analysis is necessary to check the heat exchanger component like eccentric cone whose half apex angle exceeds more than 30 degree.*
Keywords: *Eccentric cone, FEA, Heat exchanger*.

I. Introduction

The HC Reactor OGR First Stage Chiller is an assembly consisting of a dished ends, shell & cones with tube bundle, tube sheet etc.
Here we have carried out the analysis of eccentric cone which is welds with the shell on both sides with nozzle. The different parts of the assembly are explained in Fig.1

The heat exchanger is proprietary product. F.E.Analysis is necessitated to check the heat exchanger components like eccentric cone whose half apex angle exceeds more than 30 degree.

The analysis objectives, assumptions and the limitations are explained below.

a. To calculate stresses in the following parts and compare them with the code allowable stresses for the design loads:
   - Eccentric Cone
   - Cone with shell at large diameter side
   - Cone with shell at small diameter side
b. Cone is fixed on its both of the sides.

II. Reference Documents and Codes

The following are reference documents, which formed the basis for current analysis:

1. Construction Details are as per **Drg No. B01-611 010 032 Rev.1**, Dated 17/08/2011
2. ASME Sect VIII Div.1 for allowable stresses for different parts.
3. Other relevant standards as mentioned in the drawing.

III. Methodology and F.E. Idealization

The Finite Element model included (Fig.1) shell, eccentric cone etc.

3.1 System of Units:

The following system of units is followed for consistence through out this analysis and results evaluation

Table 1: System of Units

S. No.	Parameter	Units	Conversion Factor used in Analysis
1.	Length	Milimeters	1.0
2.	Force	Newton	1.0
3	Moment	N-mm	1.0

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4.	Mass	Kg	1.0
5.	Pressure, Modulus of Elasticity, Stress	N / mm ^{2}	1.0
6.	Acceleration due to gravity	M / Sec ^{2}	1.0

3.2 Ansys Elements Used

The complete assembly is modeled using ANSYS Element Types as follows:

Table 2: Element types used

Element Type No	Element	ANSYS Element	Parts Modeled
1	3-D Elastic Shell	8 node Shell 93	Shell plate, Cone plate, nozzle and pad etc.
2	Rigid Constraint	MPC-184	Rigid Element

3.3 Material Properties

The Material Properties used for all parts are as follows.
(As per Drawing for all parts MOC is Stainless Steel SA 240 Gr. 304L)

For Design Case:-
Material: Austenitic Stainless Steel. Isotropic
Young's Modulus = 189860 N / mm ^{2}.
Poisson's Ratio = 0.3
Density: 8000 Kg /M ^{3}.

For Hydrostatic Condition Case:-
Material: Austenitic Stainless Steel. Isotropic
Young's Modulus = 195121 N / mm ^{2}.
Poisson's Ratio = 0.3
Density: 8000 Kg /M ^{3}.

IV. Loading (Design Condition)

The Model has been analyzed for combinations one or more of the following loads

1. *Internal Design pressure = 1.96* N / mm ^{2}
2. *External Design Pressure =(F.V.) 0.1013* N / mm ^{2}
3. *Design Temperature = 90˚C*
4. *Hydrostatic Pressure = 2.54* N / mm ^{2}
5. *Hydrostatic Temperature = Ambient*
6. *Forces on Nozzle: Fx=4500N, Fy=3375N, Fz=4500N*
7. *Moments on Nozzle: Mx=675000N-mm, My=878000 N-mm, Mz=1013000 N-mm*

V. Boundary Conditions

The boundary conditions applied on the model are as shown in the enclosed Fig.2

- The model is fixed in all three directions at the end of the cone (Fx=0, Fz=0, Fy =0), and free to move horizontally at other end (Fx=0, Fz=0, Fy free to move). Also model is fixed at saddle.

5.1. FE Model Information:

- Aspect ratio used fro mashing is 10
- Total number of elements are 3508
- Total number of nodes are 10682
- Meshing has done by mapped meshing
- We have taken more shell length and then boundary condition has applied.
- Cone Thickness = 16 mm

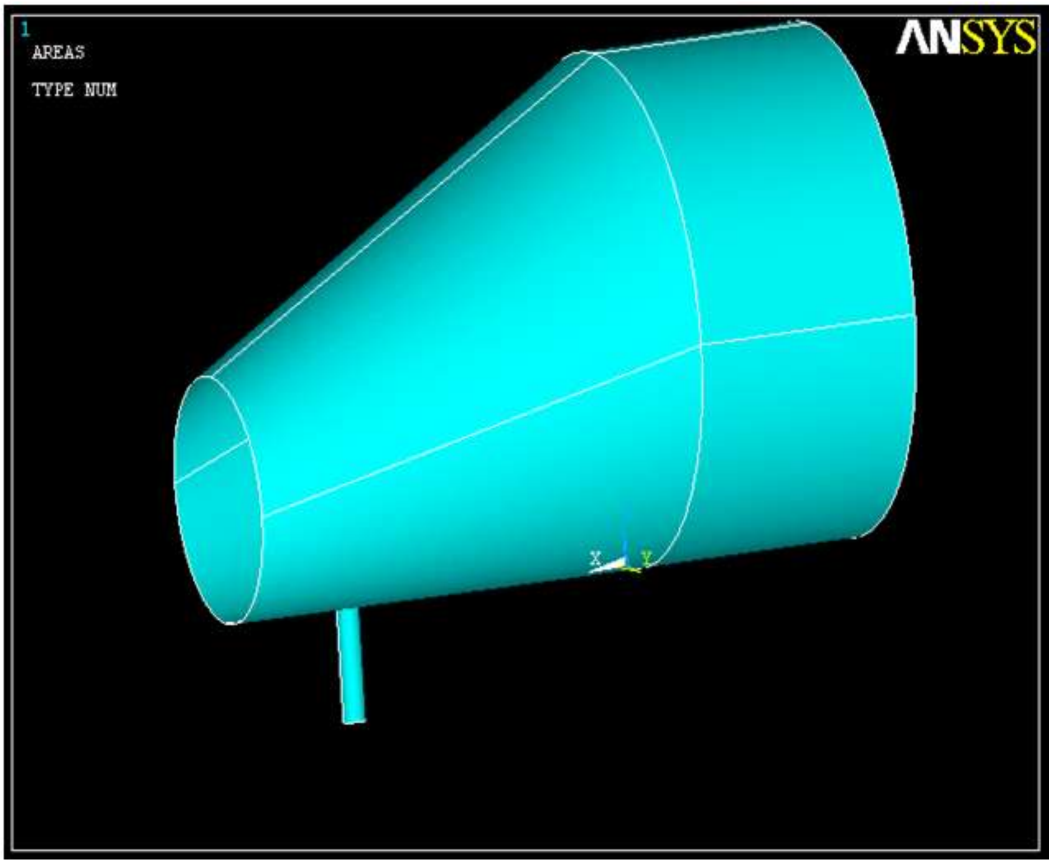

Figure A: Cone Model

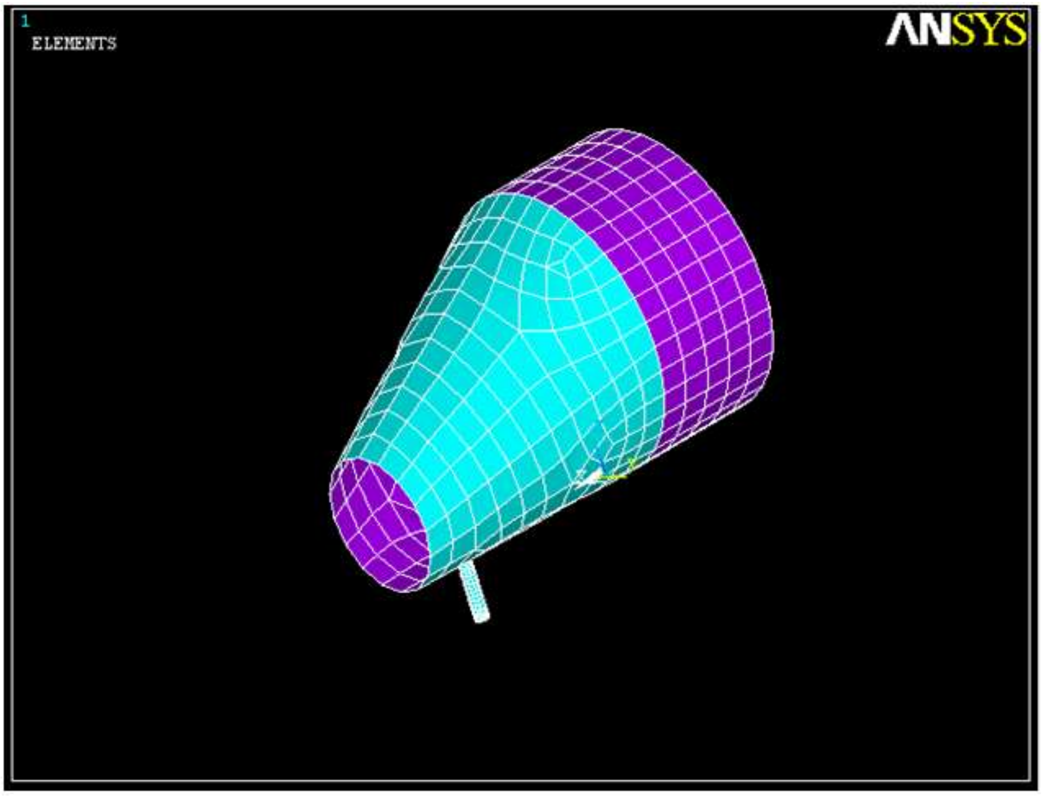

Figure 1: F.E.A. Mesh Model

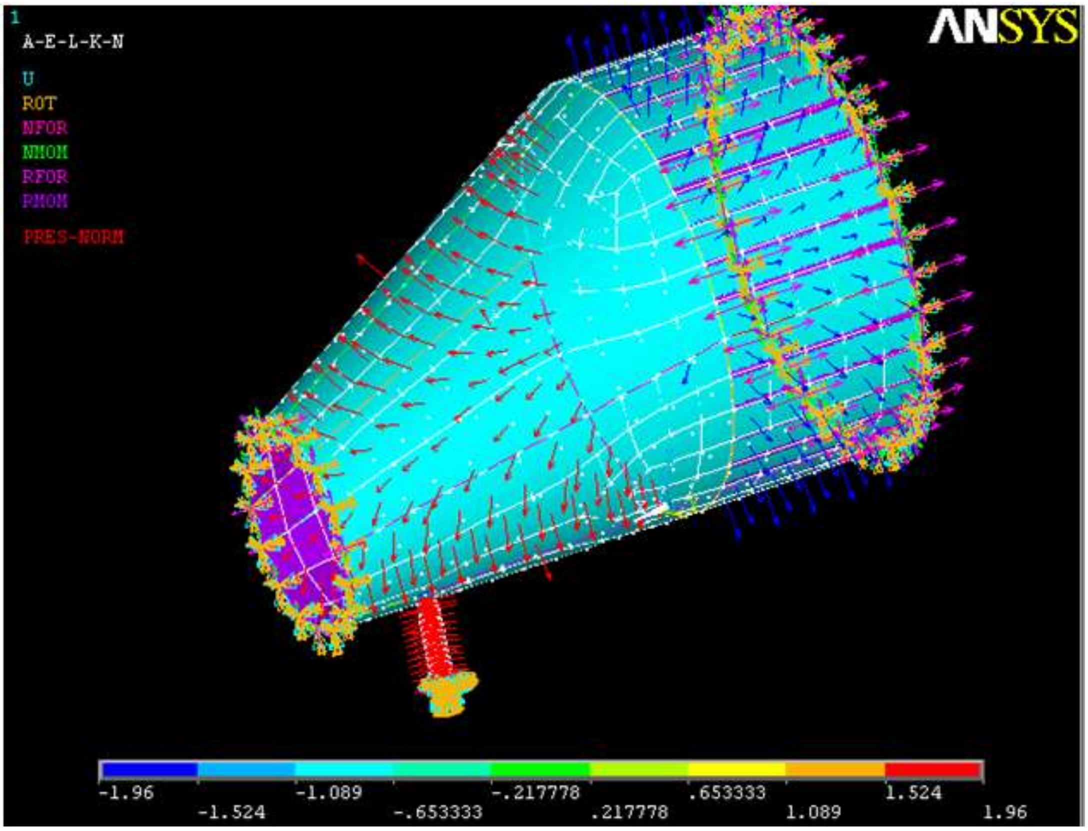

Figure 2: Boundary Conditions for Design Case

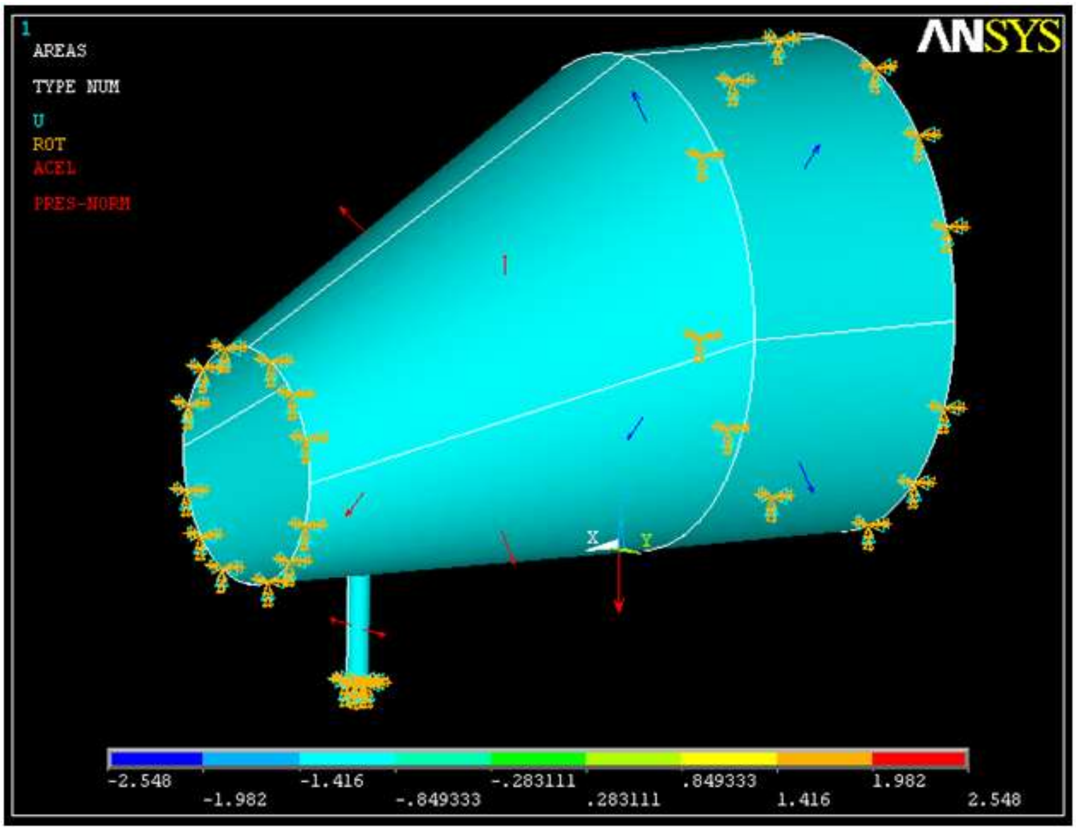

Figure 3: Boundary Conditions for Hydrotest Condition Case

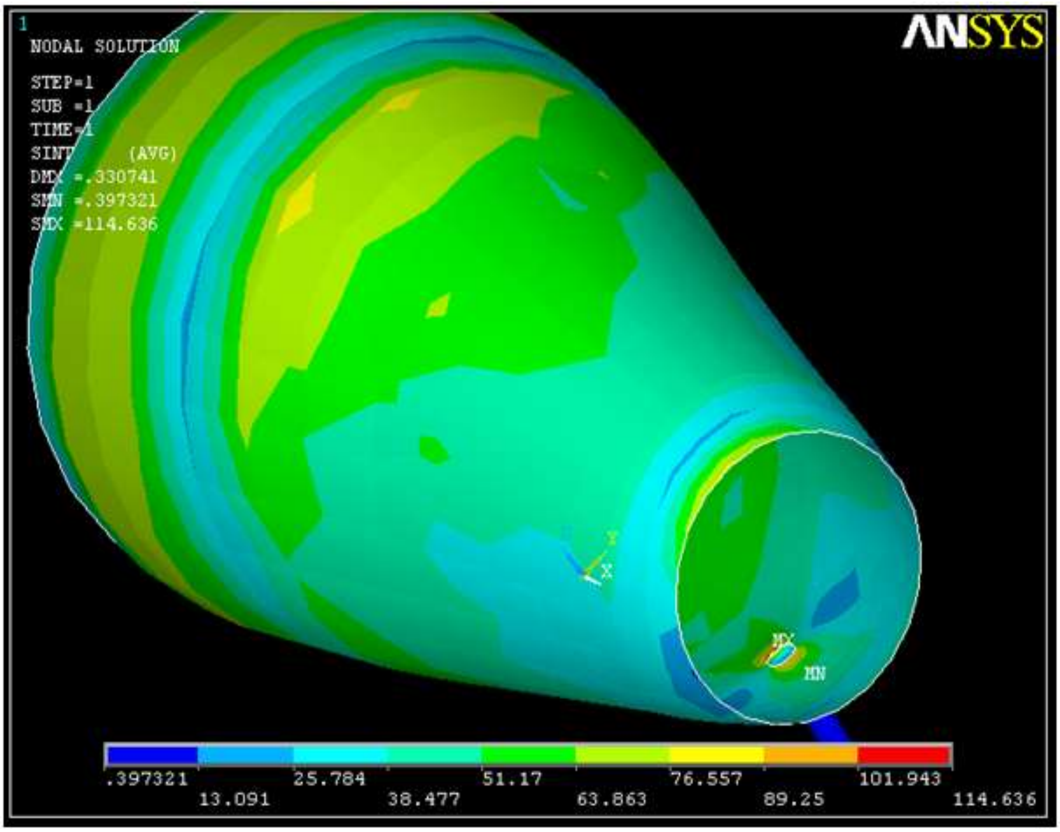

Figure 4: Stress Intensity Plot at Design Condition Without Pad

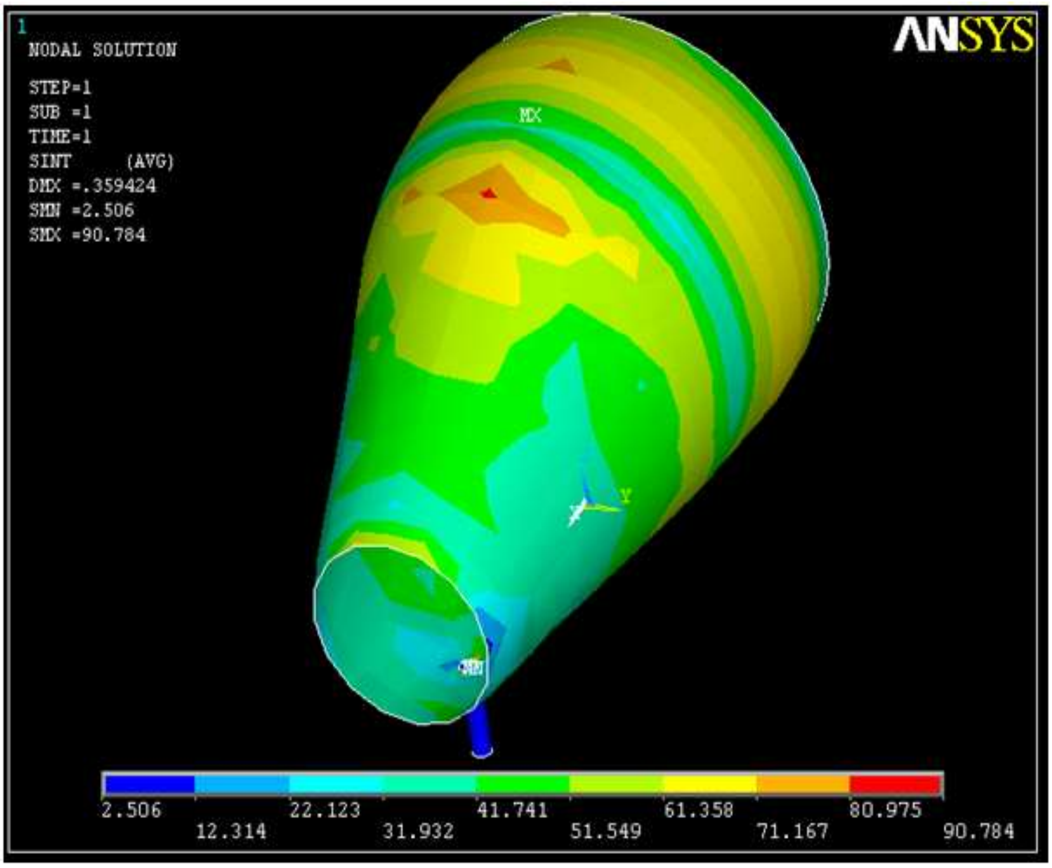

Figure 5: Stress Intensity Plot Of Shell With Nozzle Pad at Design Condition

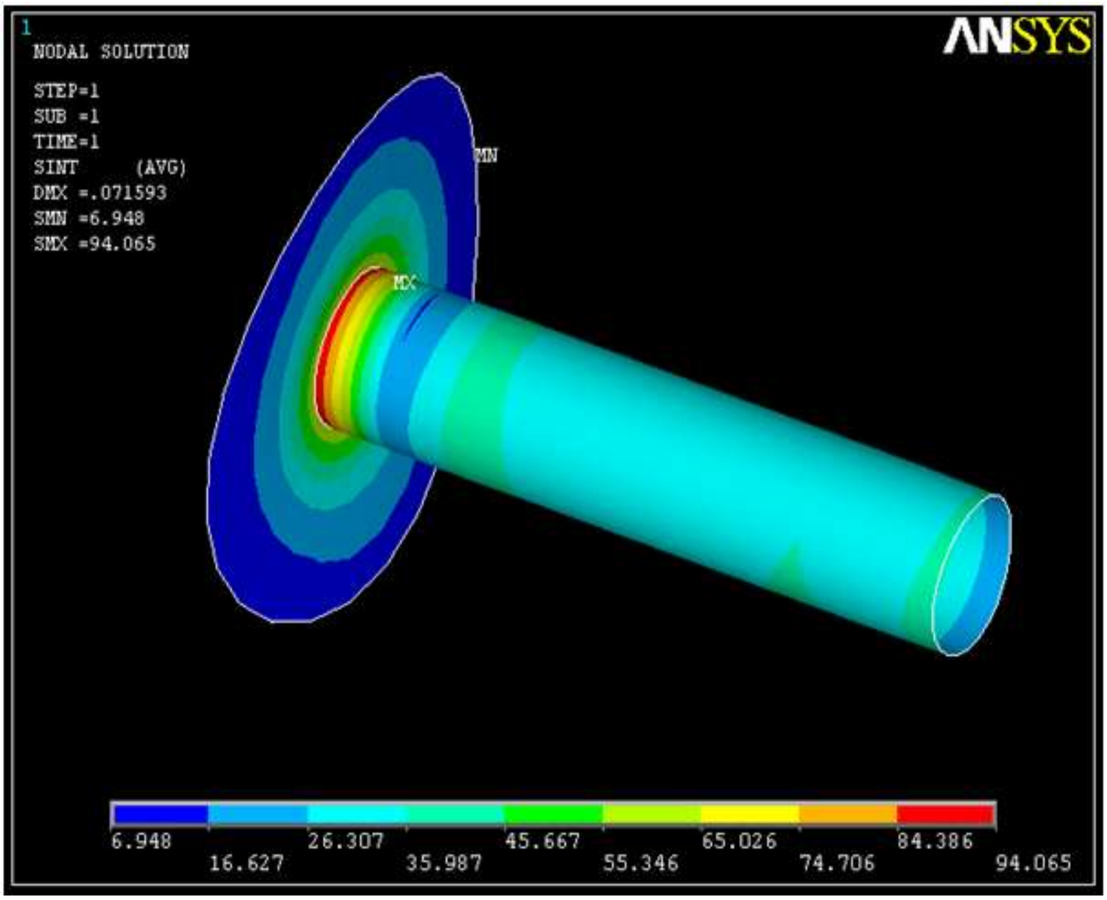

Figure 6: Nozzle Stress Intensity Plot at Design Condition

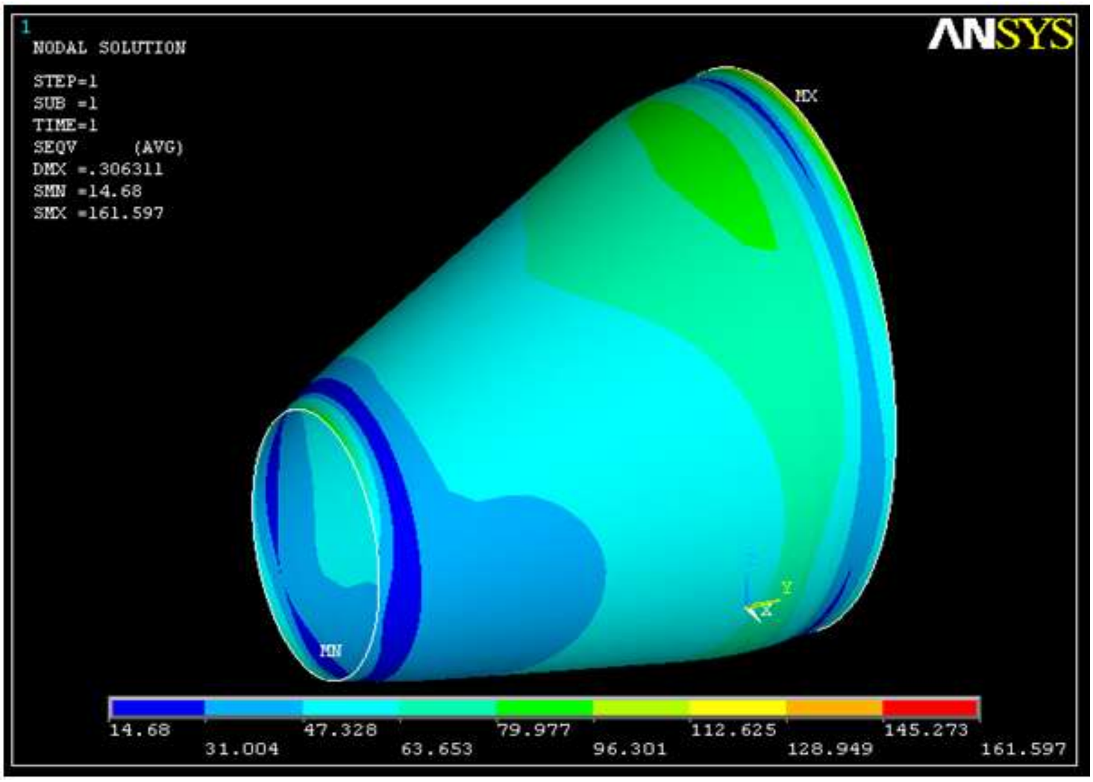

Figure 7: Stress Intensity Plot Of Conical Shell at Hydrostatic Condition

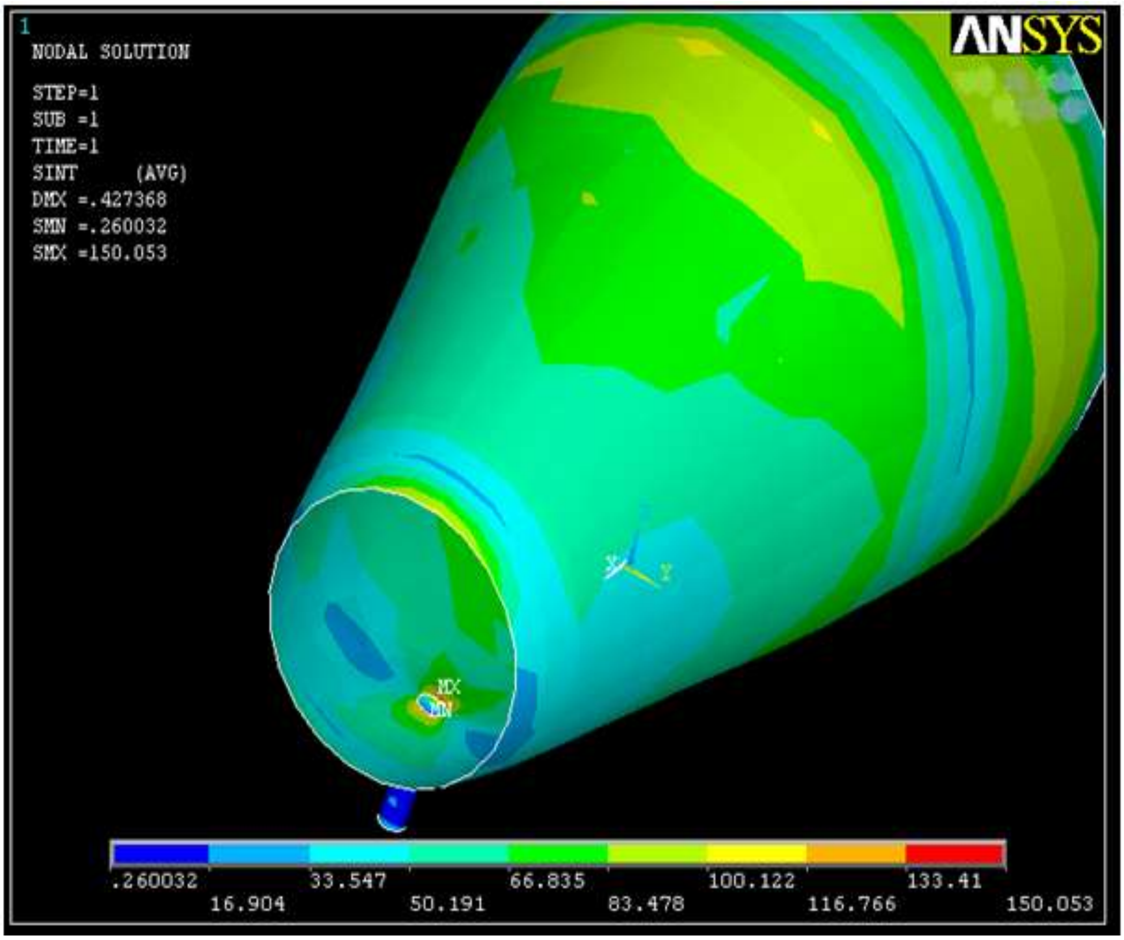

Figure 8: Shell With Nozzle Stress Intensity Plot at Hydrostatic Condition

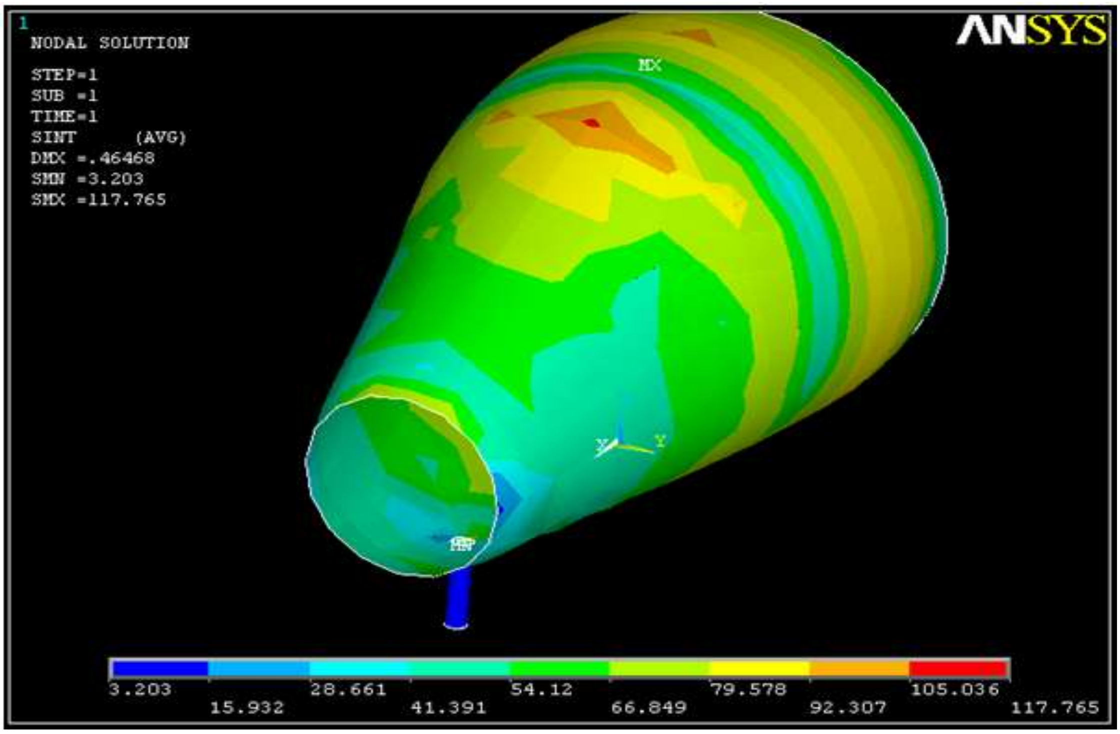

Figure 9: Nozzle with Pad Stress Intensity Plot at Hydrostatic Conditio

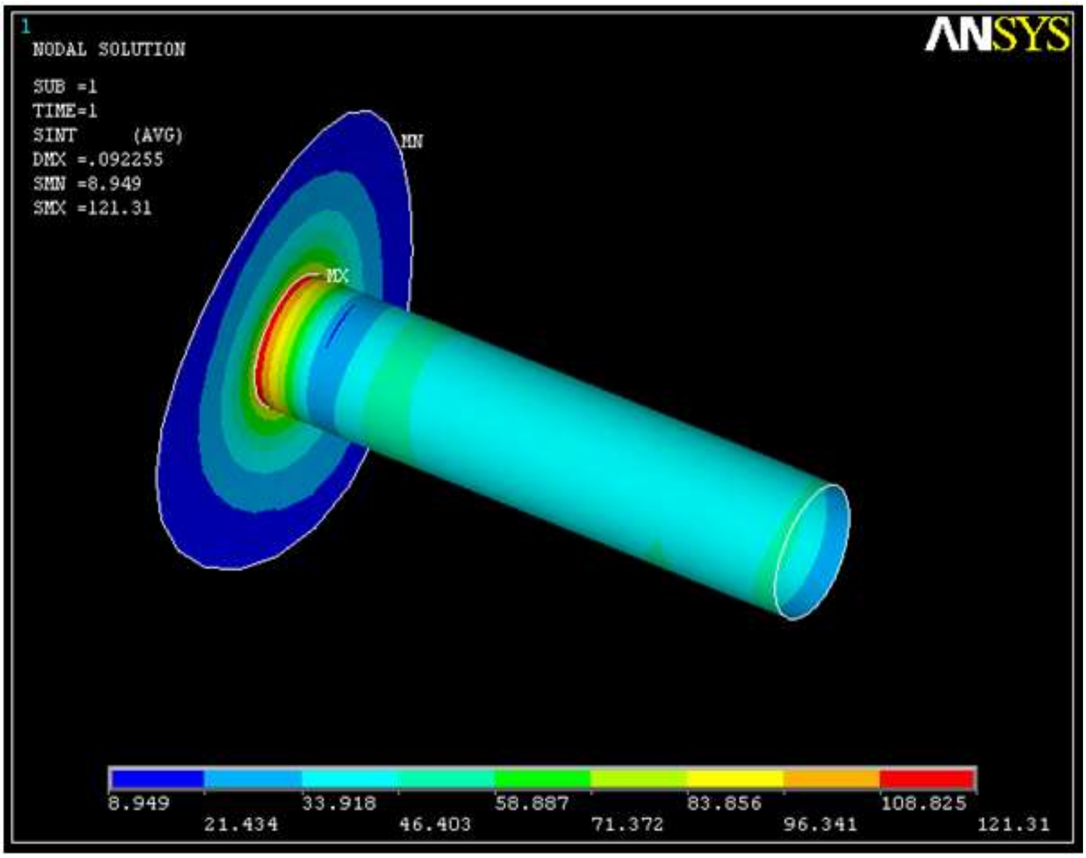

Figure 10: Nozzle Stress Intensity Plot Hydrostatic Condition

VI. Results Interpretation and Code Checking

The stresses for the above mentioned load combinations are summarized and compared with code allowable limits for all critical parts in the following Tables. The stress plots are also enclosed and referred.

Table 3 :Summary of FEA Stresses (Stress Intensity) For Design Condition					
Stress Value \ Member			one	Con e with nozzle	ozzle with pad
Primary Membrane	Middle Layer	Maximum Stress Intensity (N/mm2)	39.57	114. 63	4.065
	Stress Limit	Allowable Stress (N/mm2), S (As per ASME Sec-VIII, Div-2, Clause 4.1.6.1)	15.14	115. 14	15.14

Table 4 : Summary of FEA Stresses (Stress Intensity) For Hydrotest Condition

Stress Value \ Member			Cone	Cone with nozzle	Nozzle with pad
Primary Membrane	Middle Layer	Maximum Stress Intensity (N/mm2)	161.59	150.053	121.31
	Stress Limit	Allowable Stress (N/mm2) (0.95*S_y) (As per ASME Sec-VIII, Div-2, Clause 4.1.6.2)	163.78	163.78	163.78

Note:
1. Allowable stress values for Design case condition are taken from ASME Sec-II Part-D, Table 1A.
2. In this case allowable stress at design temperature as per code = 115.14 N/mm^2
3. Yield Stress (Sy) = 172.4 N/mm^2
4. Nozzle as mentioned above in loading condition has applied on nozzle.
5. Stress at the distance 1.5 Sqrt(RT) is 101 N/mm2 which is less than 1.1Sm (1.1 x 115.4 = 126.9)

VII. Conclusion

This Paper present Finite element analysis of Heat exchanger as a evaporator. The heat exchanger successfully sustain the internal design pressure without leakage, thus mechanical design was sound. Also, Finite element Analysis is done for conical Shell, nozzle and reinforcement pad for design and hydrotest pressure. Analysis shows maximum stress intensity acting on the cone and nozzle is less than allowable stress. Hence cone, nozzle and shell is safe and sound.

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