Scientific Journal of Impact Factor(SJIF): 3.134
e-ISSN(O): 2348-4470
p-ISSN(P): 2348-6406
International Journal of Advance Engineering and Research Development
Volume 2, Issue 5, May -2015

DESIGN AND STRUCTURE ANALYSIS OF LOX TRANSPORT TANK USING FINITE ELEMENT METHOD

NITESH R. CHAUDHARY[1], PROF. U.V. SHAH[2]

[1]*Student of M.E. (CAD/CAM)* [2]*Associated Professor, L.D. College of Engineering Department of mechanical engineering Ahmedabad 380015*

***Abstract**: In modelling of LOX tank with its frame structure. After that it may include FEA the rmalanalysison the base of Extraction of heat loadand temperaturepr ofile. It also included Structural analysis due to self-weight of vesseland LOX weight. In this study it may covered operating pressureanalysisofLOXtankwiththehelpofFEA.thispresentstudy coverspropertiesandapplicationofLOX.Itcoversthedesigno fLOX tankusing ASME CODE.*

Keywords: Liquid Oxygen Storage vessel, FEA, Heat load

1.0 INTRODUCTION

Liquid oxygenhasadensityof1.141g/cm^3 (1.141kg/Lor1141kg/m^3) and freezing point of 54.36K (−361.82°F, −222.65°C)andaboilingpointof90.19K(−297.33°F,−182.96 °C)at 101.325 kPa (760 mmHg). Oxygenwithanatomicnumberof16hasthreestableisotopesofmass numbers 16, 17, and 18. It is generally found in aircraft, iron industries, in medical purpose.

2.0 DESIGN OF LOX TANK

2.1 Input Data For design calculation:

Material of construction =304L
DesigncodeASME SEC.VIIDIV.I
Fluid stored =Liquid Oxygen
P_0=OperatingPressure(fordesign)= 1.5 MPa
P_e=External vacuum=0.100 MPa
Di=Inside diameter =1850 mm
c1 =Positive toleranceon insidediameter=3 mm
Ls =W.L. to W.L. length=3000 mm
L=Inside crown radius=0.9 ×D=1665 mm
r=Inside knuckle radius=0.17 ×D_i =314.5 mm
S.F. =SafetyFactor S. F.of dished ends =50 mm
p_s=Sp. gravityof vesselmat =8
p =Sp. gravityofLOX=1.141
Maximumdesign Temp. = 77^{0}C
Minimumdesign Temp. = -183^{0}C
S=At design temp. allowable stressfor Dish=140 MPa
S_a=At test temp allowable stress forDish=140 MPa.

2.2 output data and heat load calculation:

ts_1= Providedshellthickness= 14 mm
t_h nom. =Provided nominal thickness for bottom and upward diameter = 16 mm
V_{netf} = finalgrosscapacityofInner Vessel= 1000 L
H= Overall height of I.V. = 4038 mm

Heat load:
l =Length of support = 2200 mm

b =Width of support = 300 mm
t = Thickness of support=15 mm
n =No. ofsupports =3
k =Conductivity=0.96W/mK
A = areaof support =b×t = 0.03 x 0.15 = 0.45 m^2

$$Q = \frac{kA\,(T_o - T_i)}{dx} = \frac{0.97 \times 0.0045\,(308-91)}{2.2}$$

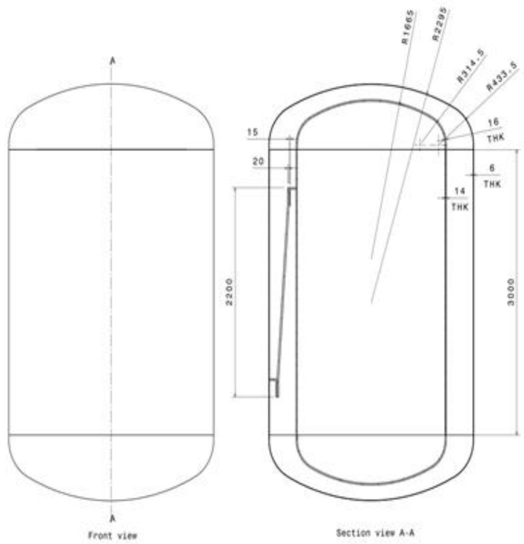
= 0.4305 w

Now, Total heat load through 3 supports

$Q_{total} = n \times Q$
=3 ×0.4305
=1.2916 W ……………………………………………………………………………………….. (1)

3.0 FEA SETUP OF LOX TANK

In figure 1 2D diagram of LOX tank and in Figure 2 support frame structurewith inner vessel and outer vessel are shown. Here in support frame G10 material is used instead of 304L. Here model is made in CATIA v5. Whole mode with outer support is than imported into ANSYS 14.0 workbench.



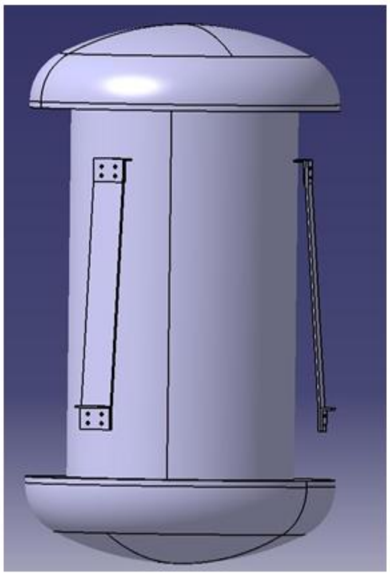


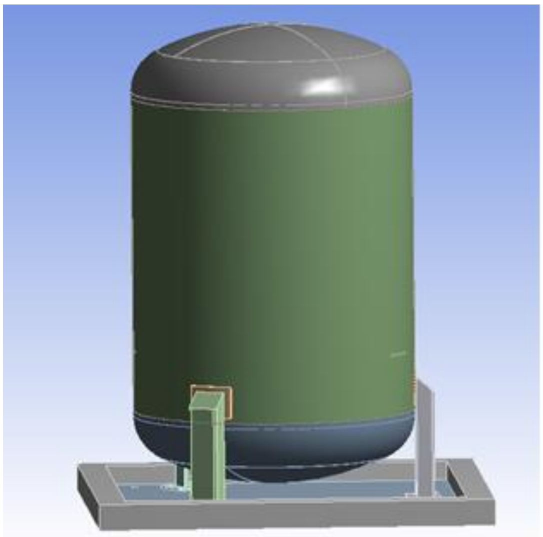
Figure 1 2 D modelling of LOX Tank **Figure 2 Frame structure with I.V. and O.V.**

4.0 MATERIAL PROPERTIES AND MESHING

For Inner vessel, outer vessel and external support Elastic modulus = 210000 N/mm^2, Poisson modulus = 0.3 and Density 7.850 x 10^{-6} kg/$mm^3$are taken. Whereas for Inner support material Elastic modulus in X direction 30500 N/mm^2, in Y direction 26700 N/mm^2 and in Z direction 15900 N/$mm^2$are taken. Poisson modulus 0.29-XY, 0.32YZ and 0.06-XZ are taken. Whereas Density in 1.9 x 10^{-6} is taken.For meshing purpose SOLID 186 and SOLID 187 types are used. Total no of nodes are 336410 where total no. of elements are 88523 are consider. Whole model which is imported in ANSYS 14.0 workbench and meshing are shown in figure 3 and figure 4 respectively. There are no. of contacts between outer vessel and external supports, shell and dish end of outer vessel, shell and dish end of inner vessel, contact between shell and lug and lug and strips.

5.0 HEAT LOAD BY FEA

In FEA heat load as per design parameter temperature is taken and temperature profile and heat load result is shown in figure 5 and figure 6 respectively.



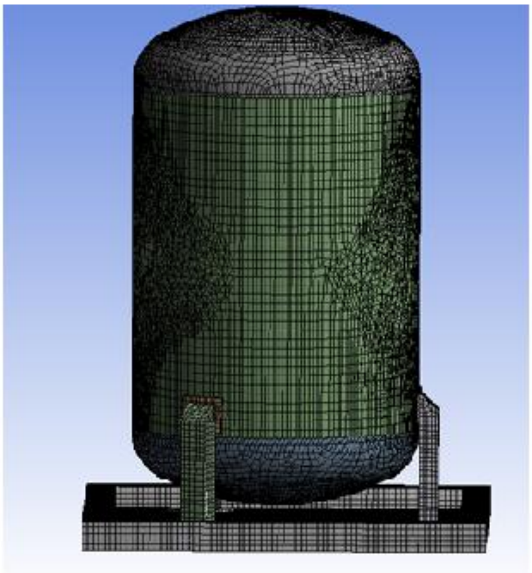
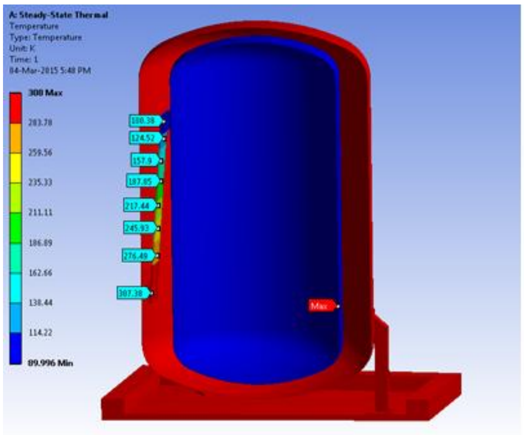


Figure 3 LOX transport tank **Figure 4 Meshing of LOX Tank**



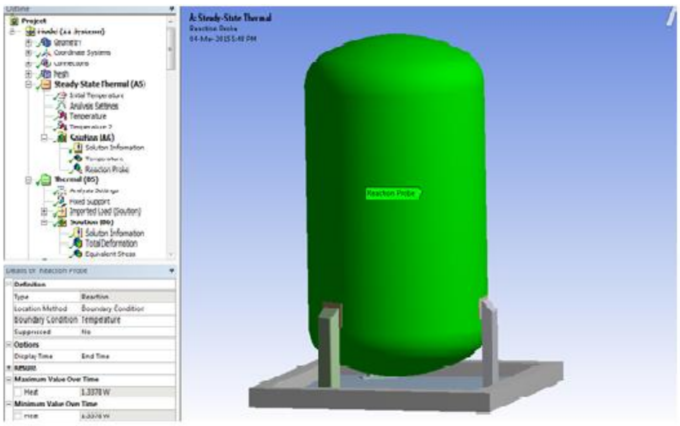
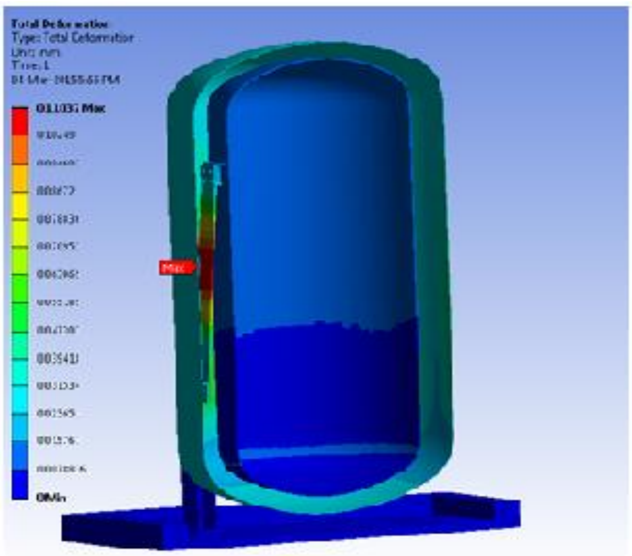


Figure 5 Temperature profile **Figure 6 Heat load**



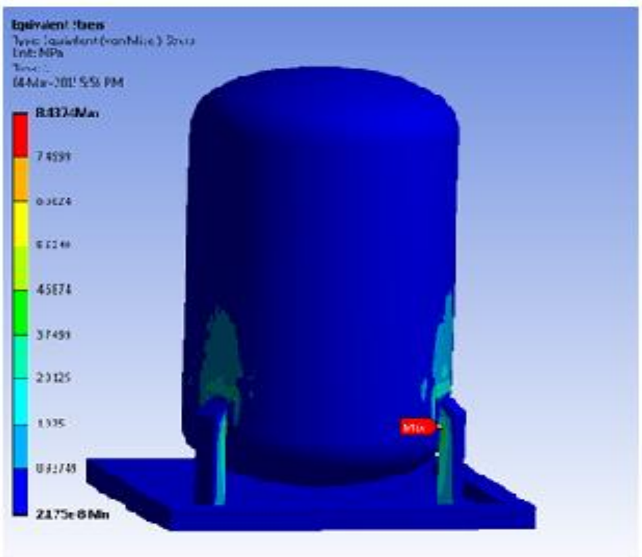


Figure 7 Total deformation **Figure 8 Equivalent stresses**

6.0 STRUCTURAL ANALYSIS OF LOX TANK

In structural analysis of self weight for lox tank is taken and fixed support in bottom of the LOX Tank is applied. Now total deformation and stresses are generated which is shown in figure7 and figure 8 respectively. Also max. principal stresses and min. principal stresses for this load case is shown in figure 9 and figure 10 respectively.

7.0 FEA IN OPERATING CONDITION

In this load case fixed in bottom surface of LOX Tank is applied. Pressure for inside vessel is 1.5 MPa and for also vacuum between outer vessel and inner vessel is applied. Now result of total deformation, equivalent stresses and max and min principal stresses are shown in figure 11 to 14 respectively.

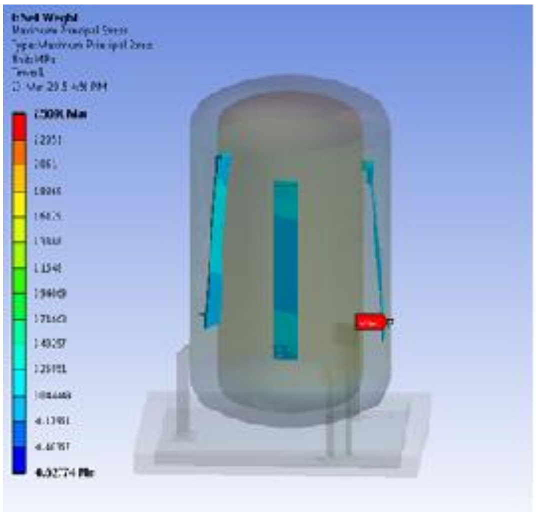


Figure 9 Max principal stresses

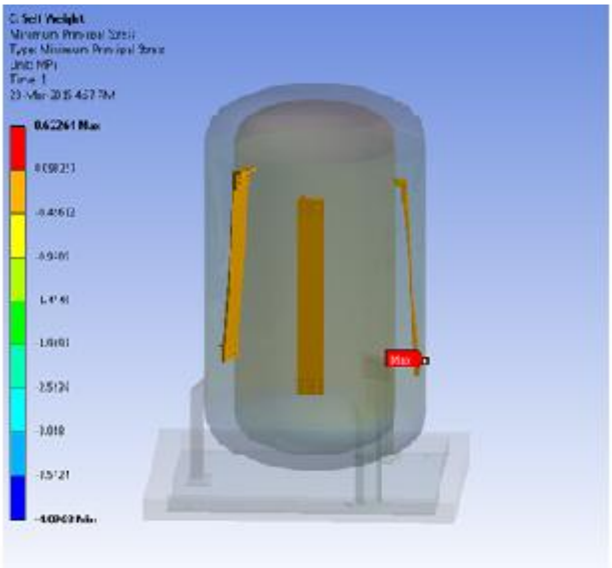


Figure 10 Min Principal stresses

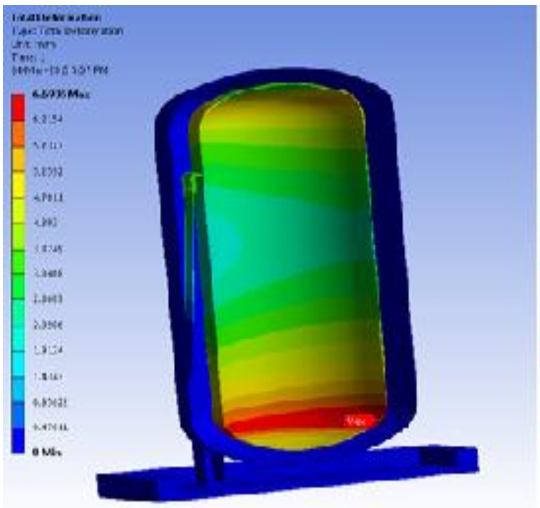


Figure 11 Total deformations

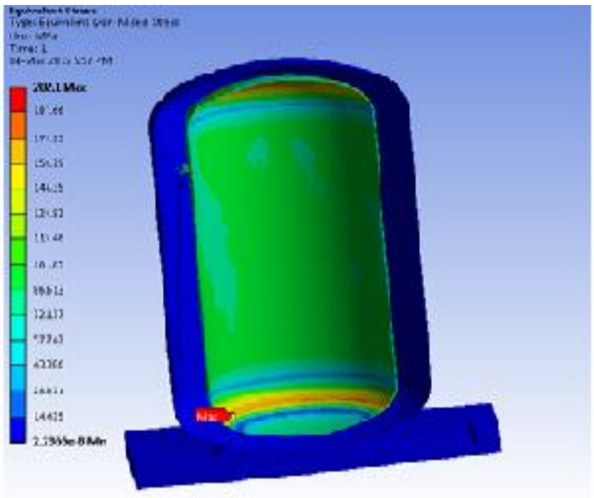
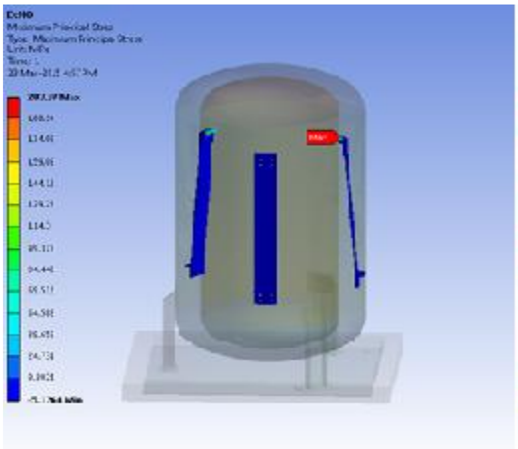


Figure 12 Von misses stresses

8.0RESULT AND CONCLUSION

As per the design parameter heat load generated and by FEA heat load is almost same for variation of 3.57%. So it can be accepted. Now For structure analysis heat total deformation is 0.1137 mm and von misses stresses and max principal stresses are well within criteria. According to 304L material FOS as 1.5 and for G10 material is taken as 2.0 as FoS. So it can be accepted. There is some point where stress are concerned which can be neglected.



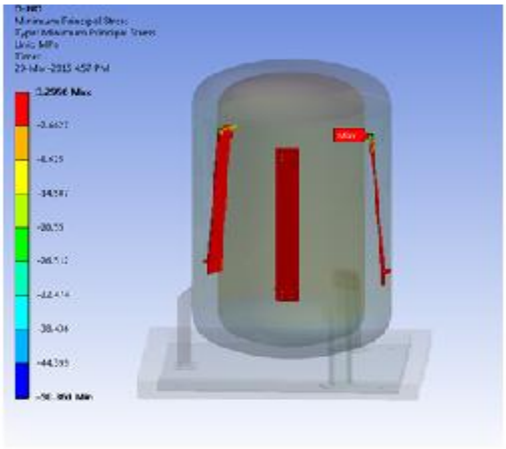


Figure 13 Max principal stresses **Figure 14 Min Principal stresses**

9.0 REFERENCES

1. ShafiqueM.A.Khan,"STRESSDISTRIBUTIONSINAHORIZONTALPRESSUREVESSELAND THESADDLESUPPORTS",InternationalJournalofPressureVesselsandPiping.p.p. 239-244, 2010.
2. S.M.AcevesandG.D.Berry,"ANALYTICALANDEXPERIMENTAL EVALUATION OF PRESSURE VESSELS FOR CRYOGENIC HYDROGEN STORAGE",LawrenceLivermoreNationalLaboratory, USA.
3. Mr.AbdulSayeedAWShaikhandProf.P.T.Nitnaware,"MODELINGANDFEA BASEDANALYSISOF VACUUMCHAMBERFORBUCKLING FAILURE",International JournalofEngineeringResearch&Technology(IJERT),Vol.1Issue10,2012.
4. Design of vessel supportp. 185-297
5. http://en.wikipedia.org/wiki/Heat_transfer
6. Cokorda Prapti Mahandari and Dani Kurniawan," Mechanical design of vertical pressure vessel for air receiver using software", Prosiding KNEP III , p. 233-240, 2012.