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

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Abstract: In modelling of LOX tank with its frame structure. After that it may include FEA the rmalanalysism the base of Extraction of heat loadand temperament profile. It also included Structural analysis due to self-weight of vesseland LOX weight. In this study it may covered operating pressureanalysis of LOX tank with the help of FEA. this present study covers properties and application of LOX. Its coversthe design of LOX tank using ASME CODE.

Keywords: Liquid Oxygen Storage vessel, FEA, Heat load

1.0 INTRODUCTION

Liquid oxygen has a density of 1.141 g/cm³ (1.141 kg/L or 1.141 kg/m³) and freezing point of 54.36 K (−361.82° F, −222.65° C), and a boiling point of 90.19 K (−182.96° F, −125.9° C) at 101.325 kPa (760 mm Hg). Oxygen with an atomic number of 8 has two stable isotopes of mass 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
Design code ASME Sec. VI-DIV.I
Fluid stored = Liquid Oxygen
Ps = Operating Pressure (for design) = 1.5 MPa
Pc = External vacuum = 0.100 MPa
Di = Inside diameter = 1850 mm
ci = Positive tolerance on inside diameter = 3 mm
Ls = W.L. to W.L. length = 3000 mm
L = Inside crown radius = 0.9 x Di = 1665 mm
r = Inside knuckle radius = 0.17 x Di = 314.5 mm
S.F. = Safety Factor. S.F. of dished ends = 50 mm
pX = Sp. gravity of vessel mat = 8
p = Sp. gravity of LOX = 1.141
Maximum design Temp. = 77° C
Minimum design Temp. = −183° C
S = At design temp. allowable stress for Dish = 140 MPa
Sd = At test temp. allowable stress for Dish = 140 MPa.

2.2 output data and heat load calculation:

ts = Provided shell thickness = 14 mm
iₙom = Provided nominal thickness for bottom and upward diameter = 16 mm
Veₙf = final gross capacity of Inner 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. of supports = 3
k = Conductivity = 0.96 W/mK
A = Area of support = b x t = 0.03 x 0.15 = 0.45 m²

\[ Q = \frac{d(T_e - T_i)}{k d} = \frac{0.097 x 0.045(988 - 91)}{22} = 0.4305 \text{ W} \]

Now, Total heat load through 3 supports

\[ Q_{total} = n \times Q = 3 \times 0.4305 = 1.2916 \text{ W} \]

3.0 FEA SETUP OF LOX TANK

In figure 1 2D diagram of LOX tank and in Figure 2 support frame structure with 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 model with outer support is than imported into ANSYS 14.0 workbench.

4.0 MATERIAL PROPERTIES AND MESHING

For Inner vessel, outer vessel and external support Elastic modulus = 210000 N/mm², Poisson modulus = 0.3 and Density 7.850 x 10⁻⁶ kg/mm³ are taken. Whereas for Inner support material Elastic modulus in X direction 30500 N/mm², in Y direction 26700 N/mm² and in Z direction 15900 N/mm² are taken. Poisson modulus 0.29-XY, 0.32-YZ 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 considered. 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
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 figure 7 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.

8.0 RESULT 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.
9.0 REFERENCES


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