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Finite Element Analysis of LPG Gas Cylinder

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Abstract – The present work involved the Finite Element Analysis of existing LPG gas cylinder to verify the burst pressure. The LPG gas cylinder is manufactured from low carbon steel. The LPG tanks are subjected to incremental internal uniform pressure in the FEA model. 2D nonlinear plane models are developed and evaluated under non-uniform and axis symmetric boundary conditions. For the analysis, the required actual shell properties including weld zone and thickness variation are investigated. Therefore the stress distribution has been analyzed using ANSYS 11 software for which maximum shear stress, equivalent shear stress at critical area has been calculated. Therefore 3D solid model has been chosen in order to predict the detailed stress.

Keywords – *LPG tank, Burst pressure, Nonlinear failure analysis*

I. INTRODUCTION

Liquefied petroleum gas (also called LPG, GPL, LP Gas, autogas, or liquid propane gas) is a flammable mixture of hydrocarbon gases used as a fuel in heating appliances and vehicles. It is increasingly used as an aerosol propellant and a refrigerant, replacing chlorofluorocarbons in an effort to reduce damage to the ozone layer.

With the related literature review and objective of this concern project, we will find relation between input parameters and corresponding output parameters and formulate relation between them to get required result.

This project set out to verify finite element analysis, or FEA, when applied to pressure vessel design. While finite element analysis offers another way to analyze structures, it requires as understanding of the program and subject being modeled. If the operator does not use the correct model, time is wasted and more importantly the data is useless.

The primary problem of the manufacturer is to determine the burst pressures and volume expansions of the LPG tanks whose service and test pressures are known by the definitions of the ECR-R and TS rules.

The service pressure (SP) is the working (operating) pressure where the tanks are filled and used in industrial applications. The test pressure (TP) is a given pressure that is applied and released at which the permanent volume expansions of the tank must exceed 10% of the initial measured volume.

Finite element analysis is a powerful tool in the field of engineering. Initially, finite element analysis was used in aerospace structural engineering. The difficulty is analysis of stress and stress and strain in structural engineering depends on the structure involved. As the structure grows in complexity, so does the analysis. Many of the more commonly used structures in engineering have simplified calculations to approximate stress and strains. However, these calculations often provide solutions only for the maximum stress and strain at certain points in the structure. Furthermore, these calculations are usually only applicable given specific conditions applied to the structure.

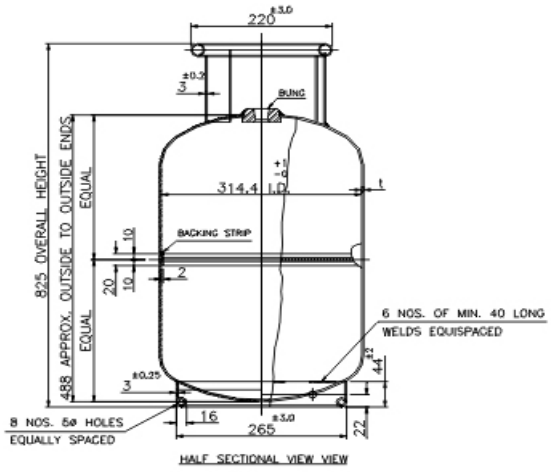


Fig. 1: LPG gas cylinder

Computer aided investigations are carried using ANSYS, finite element computer code, to verify the BP and its location of the to LPG tank. To do this, two different types of non-linear FE models, plane and shell, were developed using 2D axisymmetric finite plane and shell elements, respectively. To create these FE models and simulate the experimental burst, first, shell MPs and thickness variations of the LPG tanks due to spinning processes are investigated and input to the computer modeling processes. Additionally, after selecting the loading and boundary conditions and appropriate finite elements, the nonlinear axisymmetric 2D FE models were generated and simulated in non-uniform and non-homogeneous conditions.

II. ANALYSIS

The following are the basic steps followed in ANSYS software which is use finite element method (FEM) as an analysis tool.

- Building of model : A 3D model of lpg gas cylinder is developed figure 2 shows the assembly of lpg gas cylinder.
- Defining Element Type: each element type had a unique number that define element category in the present work, a structural solid was taken.
- Defining the material properties : Structral steel selected a material of lpg gas cylinder .Its properties are given in Table 1.
- Discretization : the lpg gas model divided into no. of parts using trangular elements.The discretization of lpg gas cylinder is shown in figure. Depending upon the requirements of accuracy of result of fitness of mesh was varying. More finer was the mesh more accurate were the results.
- Boundary condition : the full load was 2.5 mpa applied as shown in figure and it is fixed at bottom support.
- Solver : Solver was used to solve the simultaneous equation that the finite element method generates. The results of the solution were the nodel degree of freedom value which form the primary solution and the derived value, which makes the element solution.
- Postprocessor : Postprocessing means reviewing the result of analysis. It was the probably the most important step in the analysis as it tells how the applied load affects the design, how good is the finite element mesh, the value of the stress in the region.

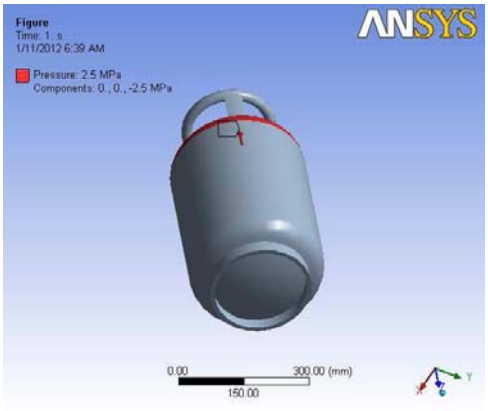
Low Carbon Steel

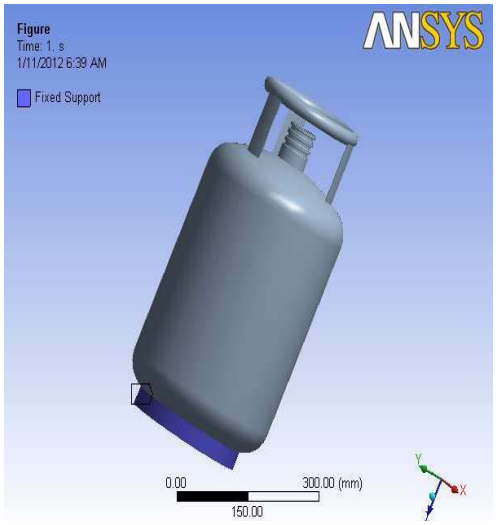
TABLE 1

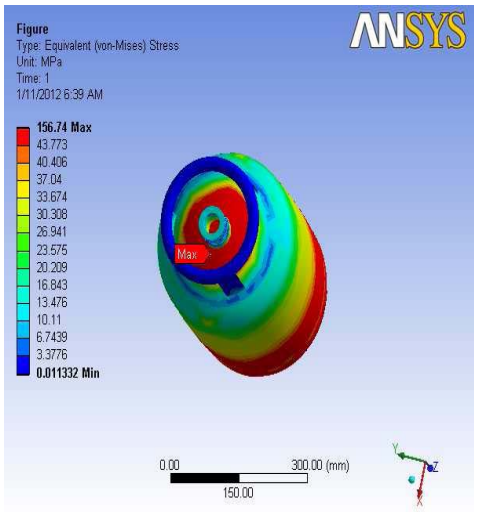
sa20 > Constants

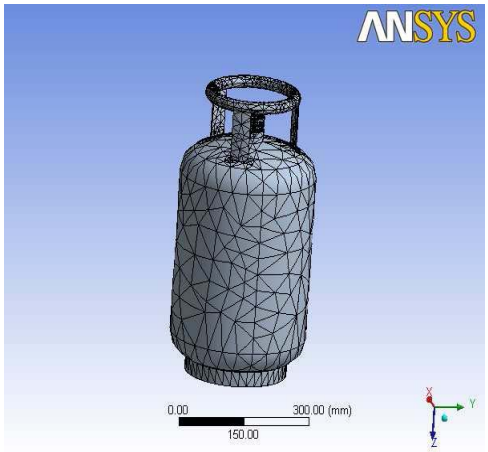
Structural	
Young's Modulus	2.e+005 MPa
Poisson's Ratio	0.3
Density	7.85e-006 kg/mm³
Thermal Expansion	0. 1/°C
Tensile Yield Strength	240. MPa
Compressive Yield Strength	240. MPa
Tensile Ultimate Strength	420. MPa

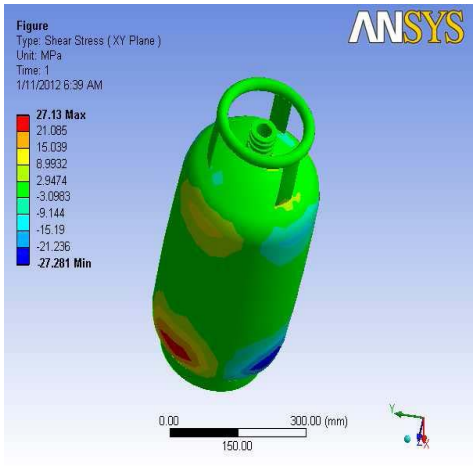
Fig. 2 : Assembly Model

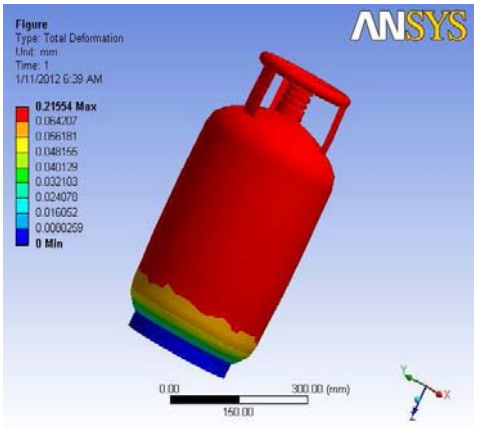












III. RESULT

By comparing the both model of LPG gas cylinder by using Pro-e software and analysis using un the ANSYS 11 software analysis Finite Element Analysis is used to determine equivalent stress, maximum shear stress and deformation.

ultimate tensile strength / max. allowable stress

=420/156.74

=2.67

Hence , as 2.67>1.1

So it will burst at 2.5 Mpa.

IV. CALCULATIONS

LPG Gas Cylinder IS3196

Let

P - Internal or burst pressure of cylinder = 2.5Mpa

t - Thickness of wall cylinder = 2.5 mm

d - Inner dia. of cylinder = 314.4 mm

Circumferential stress (σ)

σ_1= Pd/2t = 157.2 Mpa

Longitudinal stress

σ_2=Pd/4t=78.6 Mpa

Maximum shear (τ_{max})

τ_{max}= Pd/8t = 39.3 Mpa

Equivalent Shear Stress

= $\sqrt{}$ [σ_1^2- σ_1 σ_2. σ_2^2] = 78.6 Mpa

V. CONCLUSION

Name	P= 2.5 Mpa		Hand Calculation
	Max. Mpa	Min. Mpa	Mpa
Equivalent stress	156.74	0.11332	157.2
Shear stress	27.13	-27.281	39.3
Deformation	0.21554mm	0.000 mm	0.006 mm

The burst pressure of LPG gas cylinder has been determined by use of finite element analysis max. and min. equivalent stress, maximum shear stress and deformation at critical area has been calculated . the result of FEA analysis verified with hand calculation

REFERENCES

[1] ANSYS Basic Analysis Procedure Guide Release 5.3 (1996).

[2] Kaptan, A., and Kisioglu, Y., "Determination of Burst Pressures and Failure Locations of Vehicle LPG Cylinders,"

[3] Kisioglu, Y., Brevick, J. R., and Kinzel, G.L., "Determination of Burst Pressure and Locations of the DOT-39 Refrigerant Cylinders", Transactions of the ASME Journal of Pressure Vessel Technology, P.P.123, 240-247, 2001.

[4] Craig, R. (1996). Mechanics of Materials. John Wiley and Sons, New York, New York. P.P.639

[5] Young, W. (1989). Roark's Formulas for Stress & Strain. McGraw-Hill, New York, New York. P.P.763

[6] V.B.Bhandari "Design of machine element",Tata McGraw-Hill,New Delhi p.p.779-780.

[7] Bureu Of Indian Standard.

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