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Design and Analysis of Container using S-2 Glass for an Automotive

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***Abstract* – The S2 Glass material have been proved their existence in design of automotive structures with their ultimate strength, temperature and performance. It is necessary to identify the effect of buckle on various structures to withstand in the global competition. The reason behind the issue is most of the successful designs fail at the practical application. In this paper, a solid S2 glass structure container various layers has been designed and analyzed thermally its buckling effect with or without a hole using ANSYS and FET. A circular cylindrical shell elliptical headed container is considered due to its outstanding demand in the pressure vessel and automobile engineering. The attention-grabbing stage of buckling phenomena occurs before the deformed or non-deformed and a partial deformed sometimes contour of structure. Finally, concluded with pros and cons of using S2 Glass composites in high temperature environment likewise in automotive industries.**

Keywords – S-2 Glass – buckling – with and without hole/cut –- storage tanks --- finite element technique and elliptical head structure

I. INTRODUCTION

A pressure vessel is a container designed to hold gas or liquid at high pressure at distinct ambient pressure. However, vessels must be designed with a formal code like ASME and BPVC etc., include Storage tanks, glassware, autoclaves, compressed gas cylinders and compressors in refrigerators. However, the most common type of pressure vessel is storage tanks to store liquids and gases for industrial and automotive purposes or processes. Heat exchangers and Process vessels are used to remove, combine, agitate, or break down products in a controlled environment in engineering industry. The pressure tank creates high water pressure using compressed air to open and close the valve by pushing or pulling. The Kevlar is a material that chemically, thermally stable with a high tensile and toughness. It can withstand at a high temperatures in polyamides. It is used as a friction, combustion protector material in the automotive industry and an aerospace industry respectively. Recent researches put forward the usage in advanced and modern technological application Nevertheless of its disadvantages of efficiency quickly absorbs moisture, it is used in both bulletproof and stab proof vests manufacturing. Now days, the material Kevlar weaving is most popular protective tool in defense industry. But Kevlar products are most costly to produce due to difficult process of spin fibers and use of sulfuric acid.

II. LITERATURE REVIEW

A self designed steel structure is modeled using PRO/E and the analysis was done using ANSYS. The result has been concluded that the stress values are decreased for vessel with hole/cut than the vessel without hole/cut and the stresses and displacements are within the range of permissible values for Kevlar material. [7].In a thin laminated composite cylindrical shell a static and buckle analyses is done to determine the stress and deformation fields with an elliptical head without cutout and with cutout is presented. A self designed steel structure is modeled using PRO/E and the analysis is done by using ANSYS. The result has been concluded that the steel displacement without cut is much higher than with cut. The buckling factor is increasing with the increase in displacement [6]. A result is obtained by an analysis that maximum tangential stress resultant concentration near a circular cutout in a tension-loaded, circular, quasi-isotropic shell increases by approximately 18% as the shell radius-to-length ratio decreases. [1]. an efficient finite element model developed based higher order zigzag theory covering different features of laminated composites such as boundary conditions, ply orientations aspect ratio, thickness ratio and loading. A numerical result on buckling responses for different problems defined finite element model for laminated composite plates was capable to the exact solutions and recommended for research and industrial applications [2]. The critical buckling load factor of anti symmetric composite laminates presented on the effect of the skew angle, aspect ratio, length-to-thickness-ratio, fiber orientation angle, numbers of layers in the laminate and laminate sequence on the critical buckling load factor was found to increase with the skew angle depends on the laminate was large, the variation of critical buckling load factor with the number of layers was not appreciable [3]. The study for elastic buckling behavior of laminated composite plates with through-the-width de-laminations are focused on various parameters, such as size of de-lamination, support condition, aspect ratio, width-to-thickness ratio, stacking sequences, and location of de-lamination and multiple de-laminations It was noted that variations in length-to-thickness ratio affects the critical buckling load. The buckling load decreases as the a/t ratio increases. [4] [5].

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III. STRAIN ANALYSIS OF PRESSURE VESSEL WITHOUT CUT

1. Import iges Model from Pro/Engineer

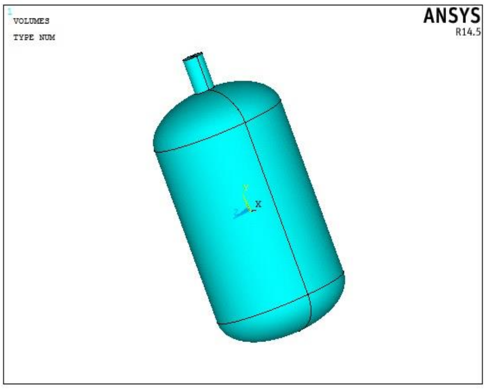

Figure 1. Import iges Model from Pro/Engineer

Pro/EngineerEnter units in command prompt: /units, si, mm, kg, sec, k
Preferences: structural
PREPROCESSOR:
Main Menu> Preprocessor> Element Type> Add/Edit/ Delete
ADD Element Type: solid 20 nodes 95
Material Properties:
Material modals:
Structural Properties: (S2glass)
Density – 0.00000246Kg/mm^3
Young's Modulus – 86900Mpa
Poisson's ratio - 0.23

2. Meshed Model

Generate Mesh

Main Menu> Preprocessor> Meshing> Mesh Tool>Smart size set to7

[Mesh]

[Pick All]

[Close] Warning.

Meshed Model

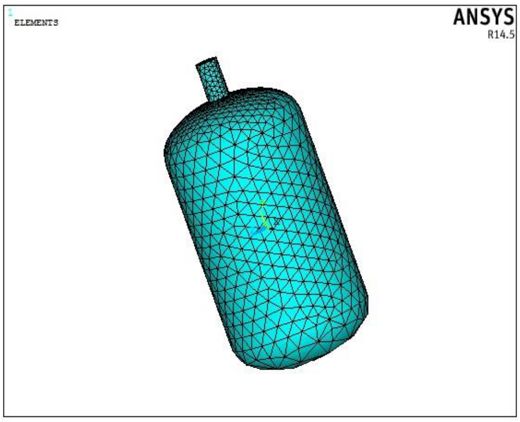

Figure 2. Meshed Model

LOADS

>Apply>Structural>Displacement >On Areas>All Dof >ok

>Apply>Structural>Pressure> On Areas – 21

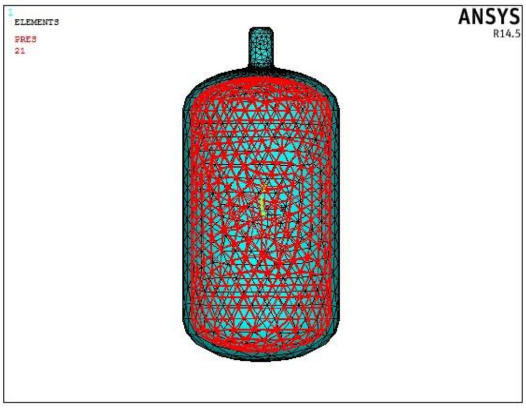

Figure 3. Loads sharing on the container all areas

Solution
Solution – Solve – Current LS – ok
Post Processor:
General Post Processor – Plot Results – Contour Plot - Nodal Solution – DOF Solution – Displacement Vector Sum

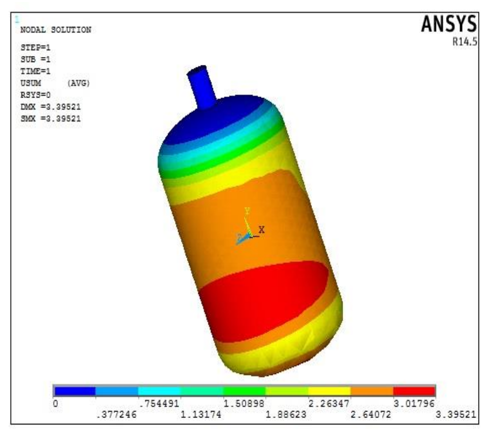

Figure 4. Displacement vector

The maximum displacement is 10.7992mm and the minimum is 1.19991mm.
General Post Processor – Plot Results – Contour Plot – Nodal Solution – Stress – Von Mises Stress

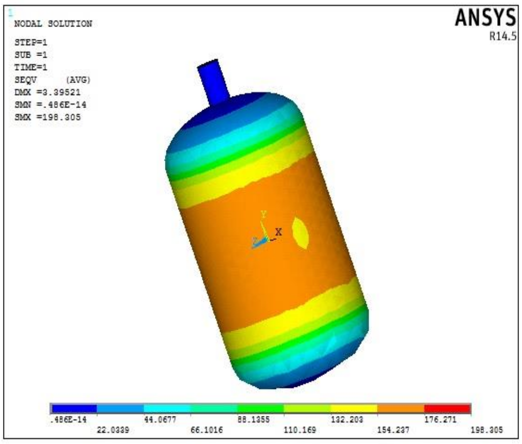

Figure 5. Von Mises Stress

The maximum stress is in the range of 354.763N/mm^2 to 44.3454N/mm^2 which is at the head of the pressure vessel.
General Post Processor – Plot Results – Contour Plot – Nodal Solution – Stress – total mechanical Von Mises Strain

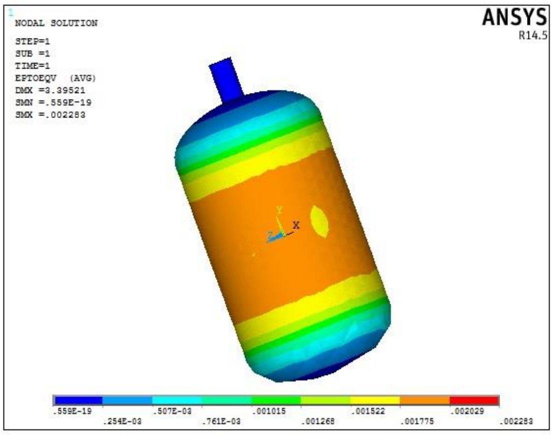

Figure 6. Strain propagation

The maximum strain is 0.005041 and the minimum strain is 0.560e^{-3}

TABLE 1 Displacement stress and strain

Description	S2GLASS
DISPLACEMENT (mm)	3.39521
STRESS (N/mm^2)	198.305
STRAIN	0.002283

S2 Glass Material Properties
Young modulus- 596GPa
Poisson's ratio - 0.23
Density- 1.85g/cc: Displacement vector sum

IV. STRAIN ANALYSIS OF PRESSURE VESSEL WITH CUT

1. Import Model

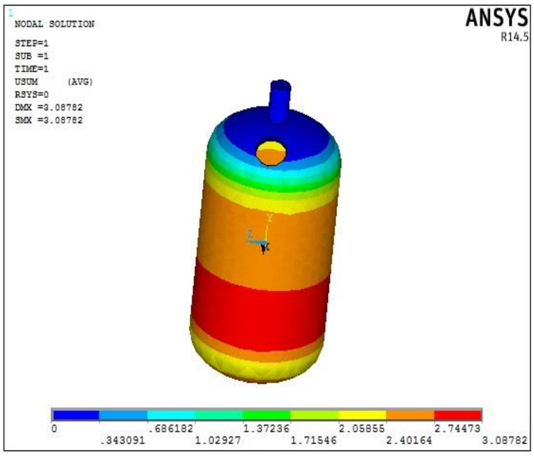

Figure 7. Imported model with cut

The maximum displacement is 2.67429mm and the minimum is 0.297143mm.

Stress

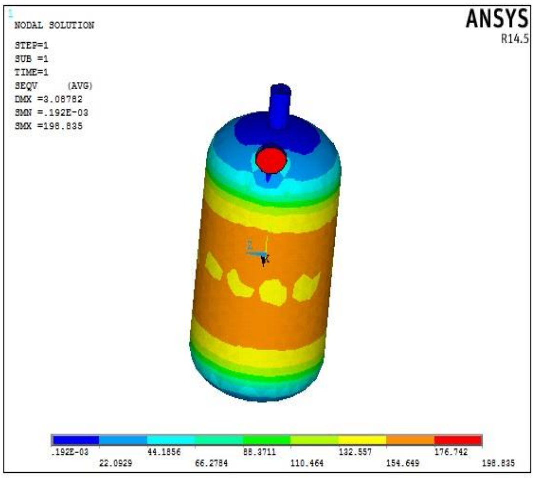

Figure 8. Stress Analysis with cut

The maximum stress is in the range of 140.294N/mm^2 to 166.831N/mm^2 which is near the hole.

STRAIN

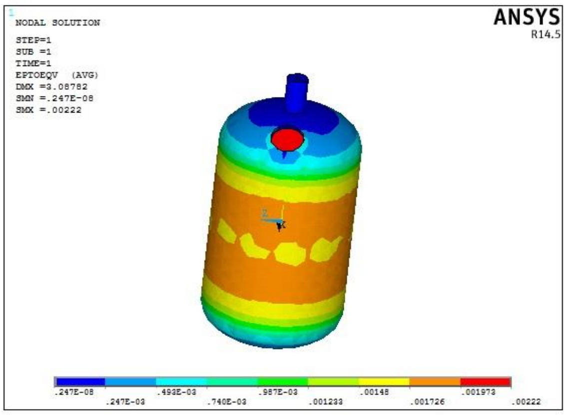

Figure Figure 9. Strain Propagation with cut

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ISSN: 2278-0181
Vol. 9 Issue 11, November-2020

The maximum strain is 0.00192 and the minimum strain is 0.213e^{-3}

S2 GLASS
Young's Modulus – 86900Mpa
Poisson's ratio – 0.23
Density – 0.00000246Kg/mm^3

TABLE 2. Displacement, Stress and Strain with cut

	Displacement(mm)	Stress(N/mm^2)	Strain
S2 GLASS	3.08782	198.835	0.00222

First Set

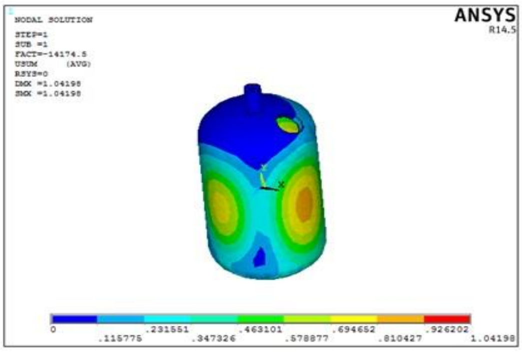

Figure 10. S2 Glass with cut For the first mode, the maximum displacement is 1.04198mm and buckling factor is 14174.5.

Second Set

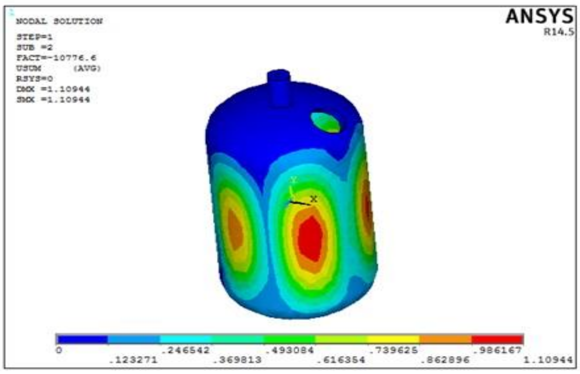

Figure 11. For the second mode, the maximum displacement is 1.10344mm and buckling factor is 10776.6.

Third Set

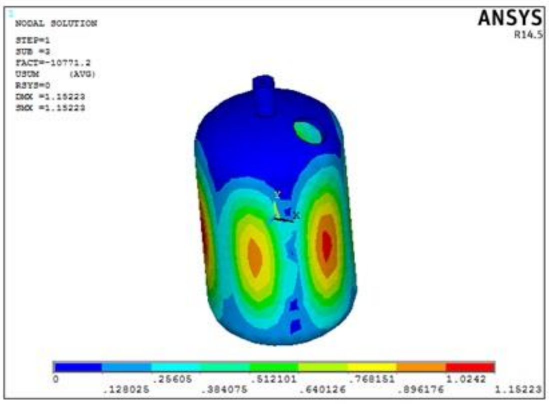

Figure 12. For the third mode, for the third mode, the maximum displacement is a1.15223mm and buckling factor is 10771.2.

V. SHELL ELEMENT - 5 LAYERS

1. Import S2 Glass Material

Preferences>select structural>ok
Preprocessor>element type>add/edit/delete>shell>linear layer99>ok
Real constants>add/edit/delete>enter no of layers 5>ok
Material properties of S2 GLASS
Young's Modulus – 86900Mpa
Poisson's ratio – 0.23
Density – 0.00000246Kg/mm^3
Sections>Shell>lay-up>add/edit>enter thickness>ok
Plot section>range of layers 1-5>ok

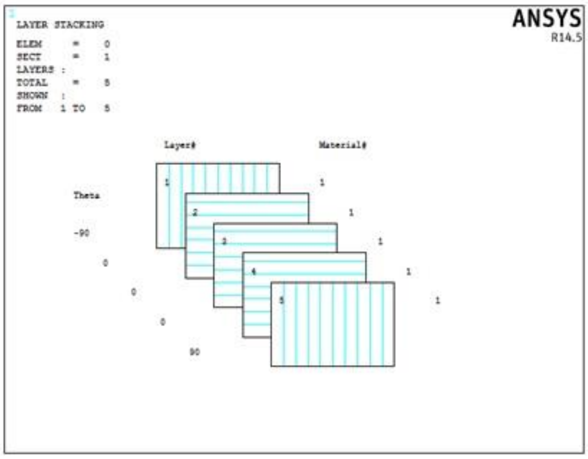

Figure 13. 5 layered S2 Glass Material

TABLE 3. Sets and factors

	First Set		Second Set		Third Set	
	DISP (mm)	FACTOR	DISP (mm)	FACTOR	DISP (mm)	FACTOR
S2 Glass	1.04198	33784.4	1.10944	10776.6	1.18223	14924.3

Meshing>mesh tool>ok

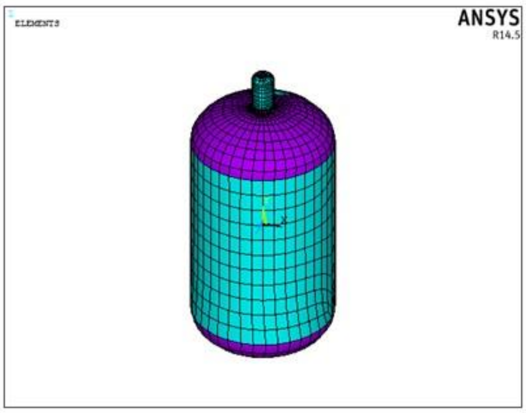

Figure 14. Mesh model S2 Glass Material

Apply loads
Pressure=0.0139MPa
Solution>solve>current ls>ok
General post processor>plot results>counter plot>nodal solution>ok

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 11, November-2020

Displacement>displacement vector sum>ok

DISPLACEMENT

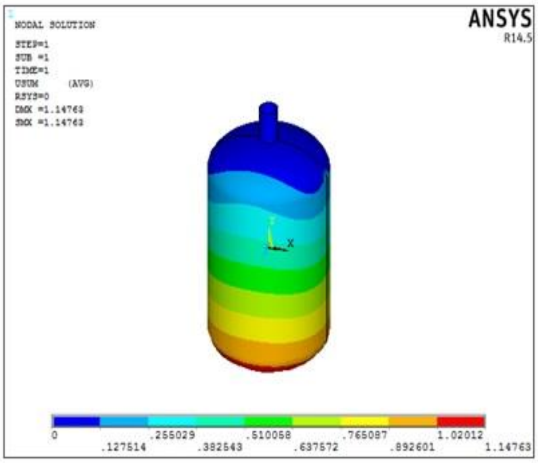

Figure 15. The maximum displacement is 1.14763mm and minimum is 0.127514mm.

STRESS

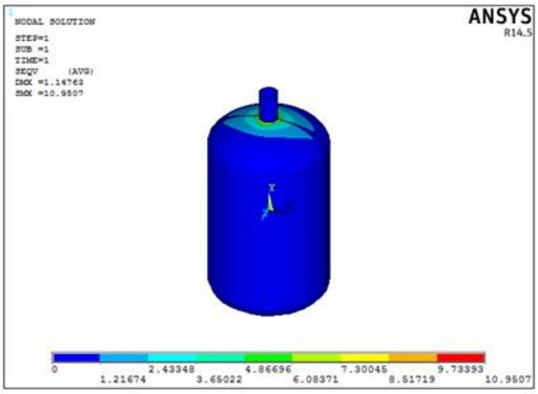

Figure 16. The maximum stress is in the range of 9.73393N/mm^2 to 10.9507N/mm^2

STRAIN

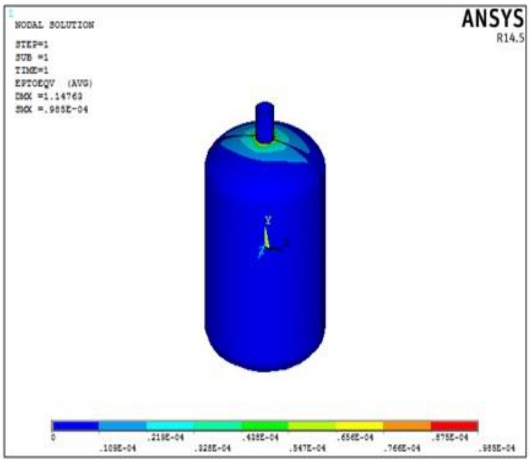

Figure 17. The maximum strain is 0.985e^{-4} and minimum is 0.109e^{-4}.

VI. SHELL ELEMENT - 11 LAYERS

S2 GLASS:

Preferences>select structural>ok
Preprocessor>element type>add/edit/delete>shell>linear layer99>ok
Real constants>add/edit/delete>enter no of layers 11>ok
Material properties of S2 GLASS
Young’s Modulus – 86900Mpa
Poisson’s ratio – 0.23
Density – 0.00000246Kg/mm^3
Sections>Shell>lay-up>add/edit>enter thickness>ok
Plot section>range of layers 1-11>ok

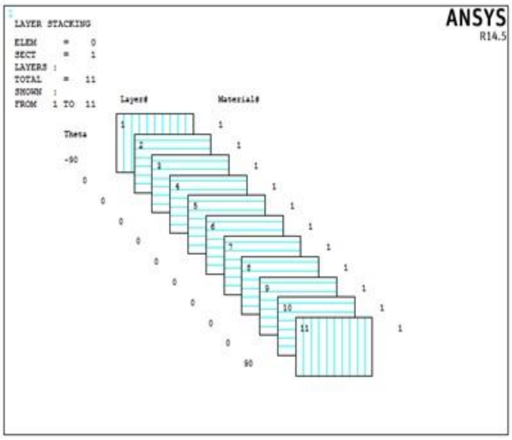

Figure 18. 11 layered S2 Glass Material

Meshing>mesh tool>ok

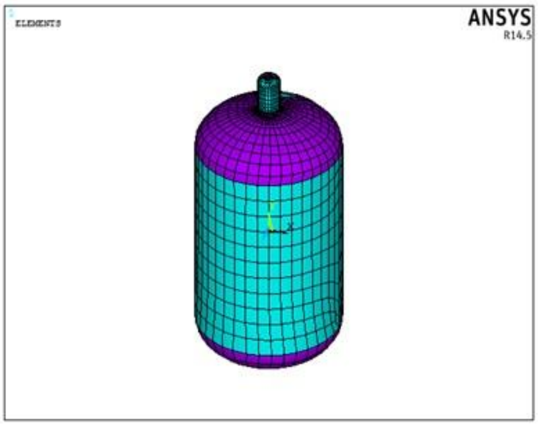

Figure 19. 11 layered meshing S2 Glass Material

Apply loads
Pressure=0.0139MPa
Solution>solve>current ls>ok

General post processor>plot results>counter plot>nodal solution>ok
Displacement>displacement vector sum>ok

DISPLACEMENT

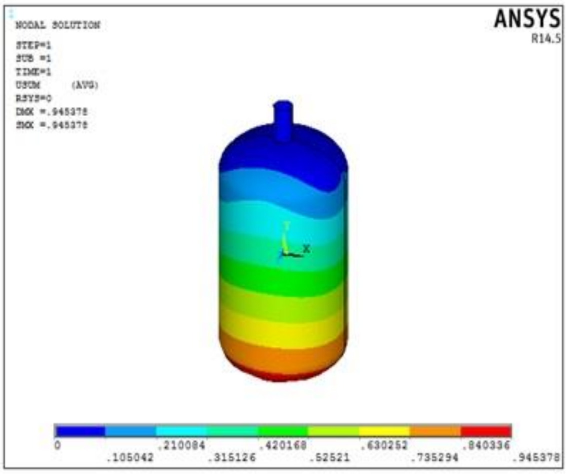

Figure 20. The minimum displacement is 0.945378mm and minimum is 0.105042mm.

STRESS

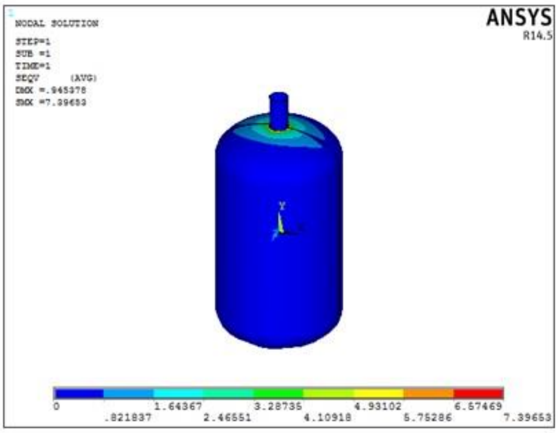

Figure 21. The maximum stress is in the range of 7.39653N/mm^2 to 6.67469N/mm^2

STRAIN

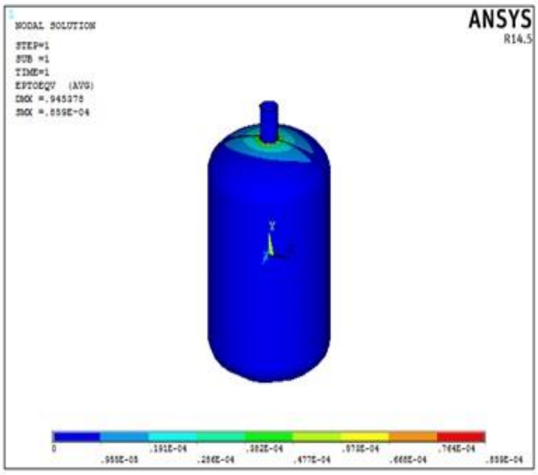

Figure 22. The maximum strain is 0.859e^{-4} and minimum is 0.955

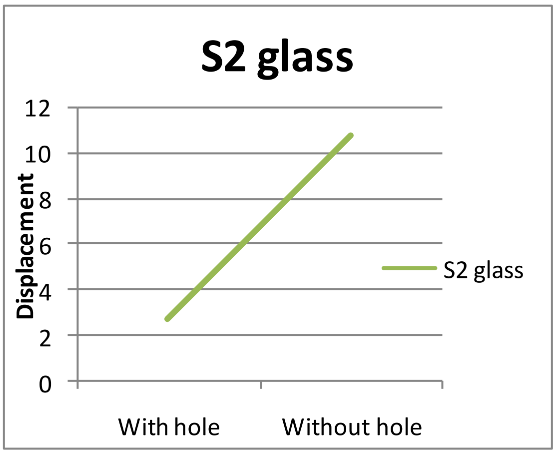

Figure 23. By observing the above graph, the displacement is increasing for without hole.

Table. 4 layer wise analysis

		Displacement(mm)	Stress(N/mm^2)	Strain
S2 Glass	5 layers	1.43482	10.8897	0.127E^{-03}
	11layers	1.14763	10.9507	0.985E^{-04}

VII. RESULTS & DISCUSSION

1. Without & with hole solid structural analysis

TABLE 5. S2 Glass material

	Displacement(mm)	Stress(N/mm^2)	Strain
S2 Glass	2.67429	166.831	0.00192

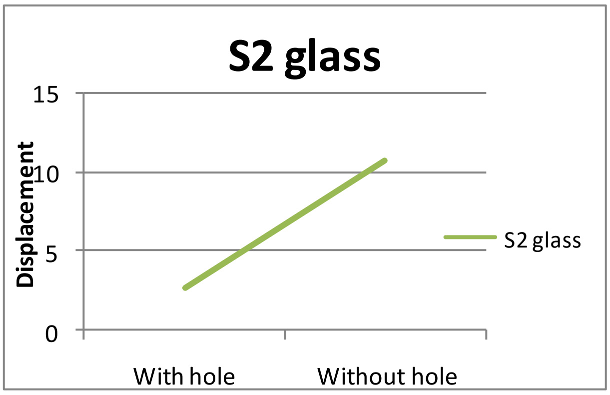

Figure 24. By observing the above graph, the displacement is increasing for without hole and is more.

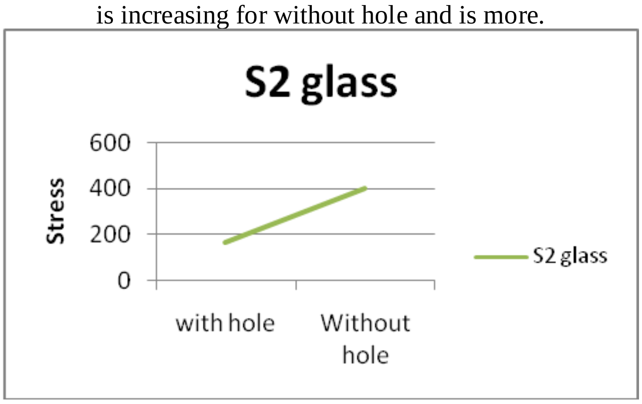

Figure 25. By observing the above graph, the stress is increasing for without hole and is more.

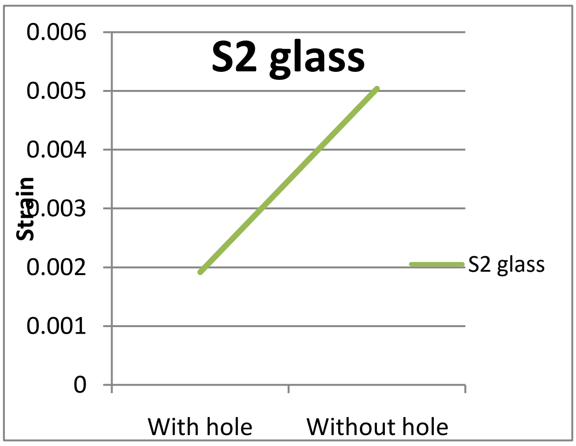

Figure 26. By observing the above graph, the strain is increasing for without hole and is more.

TABLE 6. SHELL ELEMENT

		Displacement(mm)	Stress(N/mm^2)	Strain
S2 Glass	5 layers	1.43482	10.8897	$0.127E^{-03}$
	11 layers	1.14763	10.9507	$0.985E^{-04}$

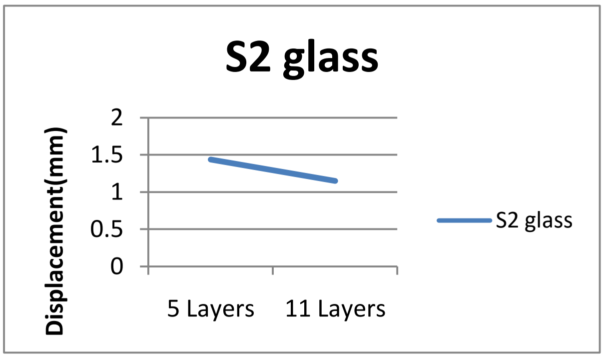

Figure 27. By observing the above graph, the displacement is increasing for 11 layers

The stress is almost same for 5 layers and 11 layers.

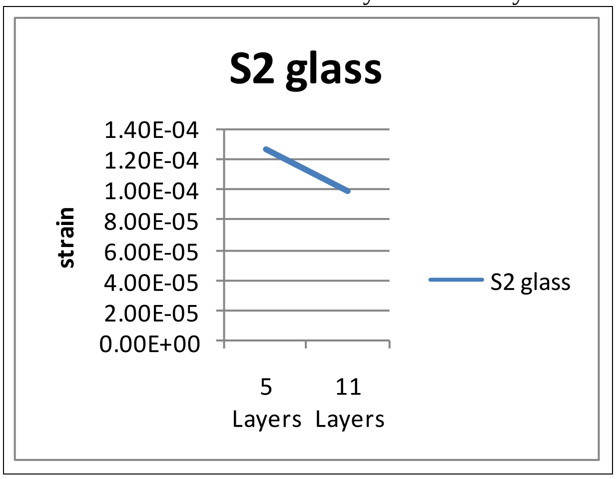

Figure 28. The strain is decreasing for 11 layers

TABLE 7. Buckling Analysis of S2 Glass

	S2 GLASS
DISPLACEMENT (mm)	10.7229
STRESS (N/mm^2)	399.108
STRAIN	0.005041

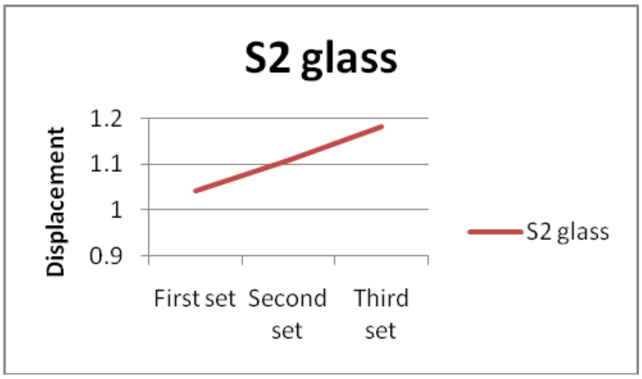

Figure 29. Three Set Displacement

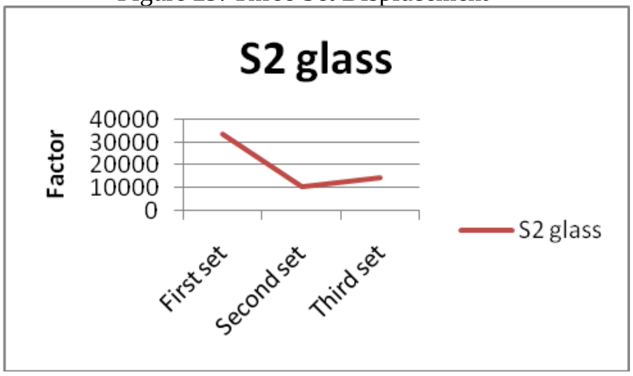

Figure 30. The buckling factor

The bucking factor is more for First set less in second set and moderate in third set.

VIII. CONCLUSION

The elliptical headed laminated cylinders shell has been used for the analysis of static and buckling is done to determine the stress and deformation fields with or without hole/cut using S2 Glass is presented. However, the stress is same in 5 and 11 layers. By observing various the structural analysis results, the displacement, stress and strain is increased for without hole/cut containers. The displacement is increased with increase in layers form 5 to ll. Three set displacement gradually increased with each one to another. The buckling factor in the first is high, second set low and third set is shown as moderate. This result of S-2 glass is best suitable at high temperature environment. Hence, the usage of S-2 material in an automotive industry tremendously is being increased.

IX. REFERENCES

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Dr. Viswa Mohan Pedagopu has vast experience in both teaching and industry. He has worked in central government, private universities in India and abroad. He has many national and international publications with double blinded peer reviewed, UGC approved and Scopus indexed reputed journals. He attended many conferences in national and international conferences in India and abroad. He is an editor, guest editor, and reviewer for many journals. His research interests not limited to but in Computer Integrated Manufacturing, CAPP, advanced manufacturing technologies and flexible manufacturing systems. He has fellow and senior membership in many outstanding institutions like ASME, CSME, MCS, IACSET, FIE, IAEME, FIRAJ and MISTE.