Proceedings of the International Conference on Applied Mechanical Engineering Research (IC-AMER2019)
NIT Warangal, India – May 02-05, 2019
Paper No. XXX (The number assigned when the papaer is accepted)

STRESS ANALYSIS OF CYLINDRICAL SHELL WITH INTEGRATED CORRUGATED CORE UNDER UNIFORM EXTERNAL PRESSURE

Vallawai Vamshi[a], Rabindra Kumar Behera[b]
[a]*Department of mechanical engineering, Nit Rourkela 769008, Odisha, India*
[b]*Department of mechanical engineering, Nit Rourkela 769008, Odisha, India*

* Email: vamshivallawai1449@gmail.com

Stress is an internal resistance that occurred in a body when external forces are applied on it. The Intension in work is to analyse a multi-layered cylindrical shell with the corrugated core which is integrated to adjacent layers. The corrugated core has two layers which are identical and placed in opposite phase angle. The shell is externally loaded with uniform pressure on the outer most layer. Design and Analysis have been done using ABAQUS with different dimensions of length. Stresses developed for different dimensions are calculated and coMPared with the equivalent single layered cylindrical shell. Performance of the Shell having corrugated core takes over the equivalent single layered shell with better stress values and deformations. The results are also displayed in graphs.

***Keywords*:** Stress, ABAQUS, Integrated, Corrugated core.

1. Introduction

Shells are the structural members used instead of conventional members having the advantage of strength to weight ratio. Study and research on shells and their structures are going on for years and taking great advancement every year. The membrane behaviour of shell gives the positive side in the performance. Shells are used in different applications in Civil and Mechanical industries like containment shells, pressure vessels, storage tanks and domes structures. The type of material to use is also a big factor in this study. The stability, imperfections, Nonlinear Deformation, Buckling, Multi-layered shells are some of the studies that are made on shells using Numerical methods, ANSYS, ABAQUS, MATLAB,.. etc.

The structures are made of sandwich models in the early years. Marek MALINOWSKI, Tomaz BELICA and Krzysztof MAGNUCKI made an investigation on Buckling analysis of cylindrical sandwich shell with three faced corrugated main core [1]. Marek MALINOWSKI, Tomaz BELICA and Krzysztof MAGNUCKI, investigated on the buckling and post-buckling shells [2]. Lokesha, Chandan R, Byregowda K C, designed the cylindrical shell and carried FE analysis by using ABAQUS.

The subject of the current paper is the stress analysis on the multi-layered cylindrical shell with integrated corrugated core on which external uniform pressure is acting. The corrugated core is having two layers in a trapezoidal shape and placed in opposite phase angle with same pitch value, On the application of uniform pressure the deformations and stress values are found out using ABAQUS and are coMPared to Equivalent single layered Cylindrical shell.

2. Structure of cylindrical shell

2.1. Multi-layered cylindrical shell

The shell is having eight faces/layers in which corrugated core is integrated to adjacent upper and lower layer so looks like a single layer. Finally, shell behaves like five layered cylindrical shell. The outer-most and inner-most layers are named as t_{f1}, the next to those are t_{c1}, the innermost layer is corrugated core structure of two layers of thickness t_0, and the layers between both t_{c1} and core are named as t_{f2}.

2.2. Equivalent single layered shell

The equivalent diameter of the shell is found considering equivalent volume by calculating equivalent thickness.

The thickness is given by

$$t_{eq} = 2tf1 + 2tf2 + 2tc1\,(\rho c1/\rho s) \tag{1}$$

3. Design of structure

The shell is made of two different materials like Steel Metal Foam and Stainless-steel sheet metal. The Properties of materials are

3.1. Material properties

Sheet metal:

Elastic Modulus (E_s)=200Gpa;

Density (ρ_s) = 8000kg/m^3;

Poisson ratio (υ_s) = 0.3

Metal foam:

Elastic Modulus (E_f)==3150MPa;

Density (ρ_f)=145kg/m^3;

Poisson ratio (υ_f)=0.05

3.2. Geometry of structure

t_{f1}=1mm; t_{f2}=0.8mm; t_{c1}=15mm;

t_0 =0.3mm; b_0=80mm; b_1=30mm; R=2m;

3.3. FEM Modelling

- Multi-layered shell is taken as the shell-solid structure and built using FEM. All the layers mentioned above with dimensions are developed. The mid-surfaces of outer most, innermost with core structures are considered as shell elements and a metal foam is considered as a solid structure. Using ABAQUS the Numerical model is developed.

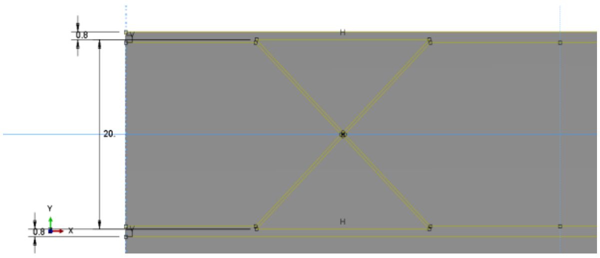

Fig. 1. Core structure

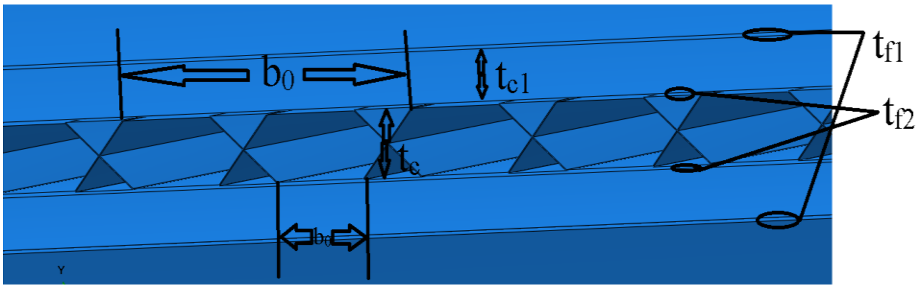

Fig. 2. A sectional view of Multi-layered shell

- For the structural reasons stiffening rings are placed on the outer edge of the shells. Edges of the multi-layered cylindrical shell are constrained by stiffening rings such that deformation towards the direction is resisted. The interactions between the layers are given as surface to surface contact. On the circular lateral edge the shell is simply supported with the radius R. At the supported edge, the radial and circumferential displacements are blocked. Only the longitudinal displacement and all rotations are allowed. In the symmetry plane of the shell, the longitudinal displacements are blocked

4. Stress Analysis

The stress of Multi-layered cylindrical shells is calculated for all the values of L. The variable values of L are (3, 4, 6, 8 and 16). Geometric data like the mid-plane radius of the multi-layered cylindrical shell is 2m; the entire shell wall thickness t is 53.6 mm. i.e ($t = 2\,(t_{f1}+t_{f2}+t_{c1}) + t_{core}$). The pressure of 1.6MPa is applied on the outermost surface of the shell[2]. The total number of finite elements has been established by the mesh convergence analysis. On varying meshing values, it is observed that the output doesn't deviate more than 1%.

The results obtained and are plotted in graphs.

Table 1. stresses and deformation varying upon the length

O/p \ L	Von-mises stress (MPa)	Max principal stress (MPa)	Deformation (mm)
L = 3	1022	81.22	10.76
L = 4	1021	77.86	10.75
L = 6	1019	74.4	10.73
L = 8	1019	72.72	10.73
L = 16	1019	70.33	10.73

4.1. Results and discussions

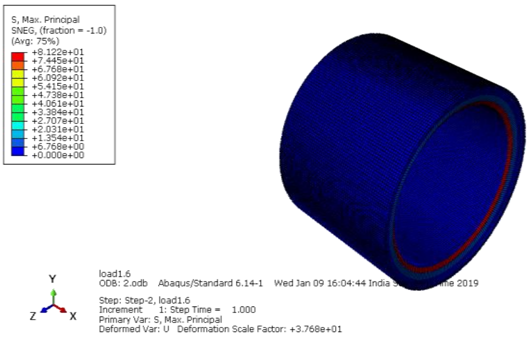

Fig. 3. Max principal stress of Multi-layered Shell

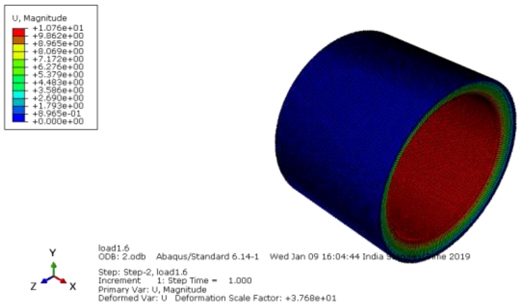

Fig. 5. Deformation of Multi-layered Shell

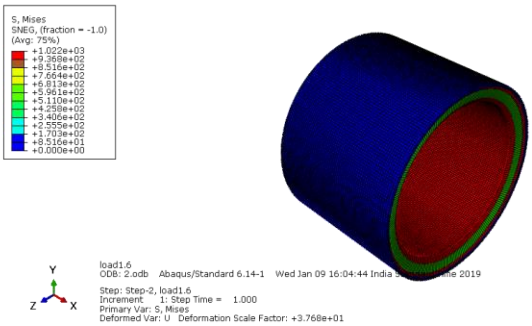

Fig. 4. Von-mises stress of Multi-layered Shell

Stresses induced in the multi-layered shell are much lower coMPared to the single-layered shell. The change of stress under the same pressure on varying length is shown under in graphs.

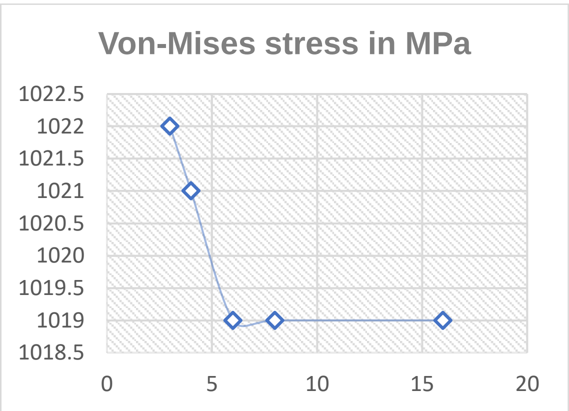

Fig. 6. Von-mises stress of Multi-layered Shell vs length

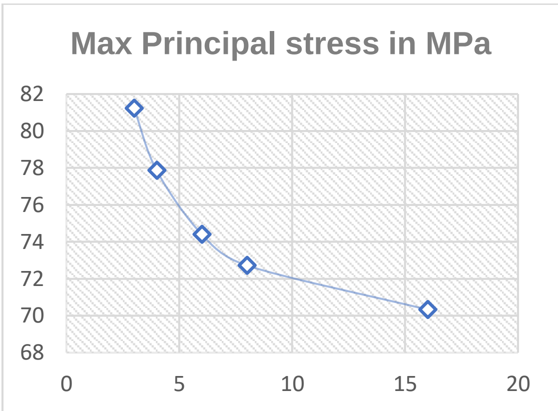

Fig. 7. Max principal stress of Multi-layered Shell vs length

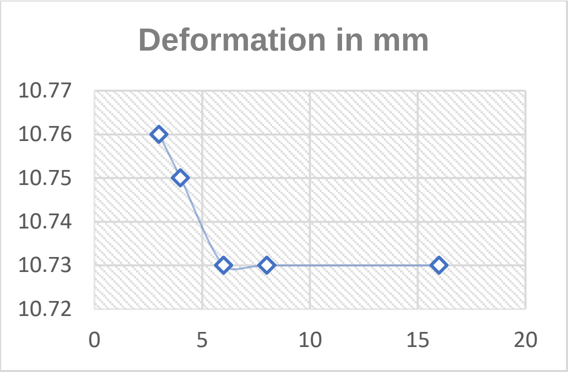

Fig. 8. Deformation of Multi-layered Shell vs length

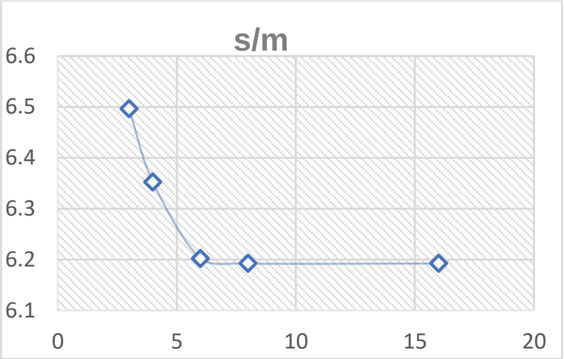

Fig. 9. Stress ratio of equivalent single shell to Multi-layered Shell vs length

5. Conclusion

The cylindrical shell with multi-layers having integrated corrugated core is performing better than the equivalent cylindrical shell.

Upon increasing the length stress values and deformation values are coming down.

The ratio of stress induced in multi-layered shell vs equivalent single layered shell is also displayed in the graph. It is obtained that stress developed in a multi-layered shell is six times lower than the equivalent single layered shell.

References

1. Journal article

M. Malinowski, T. Belica, K. Magnucki, Buckling of a sandwich cylindrical shell with corrugated main core and three-layer faces, Appl. Comput. Sci. 10 (4) (2014) 18–25.

M. Malinowski, T. Belica, K. Magnucki, Buckling and post-buckling behaviour of elastic seven-layered cylindrical shells–FEM study, Thin-Walled Structures. *94*, (2015) 478-484.

Lokesha, Chandan R, Byregowda K C, Design and Structural Analysis of Cylindrical Shells, International Research Journal of Engineering and Technology (IRJET). 04 (2017) 158-162.