ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Finite Element Analysis of Thin Spherical Shells for Different Materials and Geometric Imperfection

V.Prasad
M.Tech (MachineDesign),
Talla Padmavathi College of Engineering,
Somidi, Kazipet, Warangal, T.S, India.

B.Praveen Kumar, M.Tech
Associate Professor,
Talla Padmavathi College of Engineering,
Somidi, Kazipet, Warangal, T.S, India.

ABSTRACT:

In this thesis, finite element analysis is performed on the thin spherical shell geometry under external pressure for different materials & geometric imperfection and compared with that of perfect thin spherical shell. 3D models of perfect and imperfect thin spherical shells are done in Creo 2.0. Static, Modal, Random vibration and Buckling analyses are done on the perfect and imperfect thin spherical shell using different materials Copper, Aluminum alloy 7075 and composite material E– Glass Epoxy. Analysis is done in Ansys 14.5.

INTRODUCTION:

Spherical shells as structural parts are used extensively in several applications, like nuclear, offshore, fossil oil and transport. Because the shells are subjected to varied loading conditions like external pressure, unstable or thermal masses, compressive membrane forces are developed which can cause the shells to fail because of compressive instability. For spherical shells underneath external pressure, comparisons between buckling masses from testing and theoretical concerns have incontestible giant discrepancies. The load that an outwardly pressurised spherical shell will support is considerably below the classical elastic buckling. The discrepancies between check and theory are owing to numerous material and geometric imperfections that arise throughout totally different fabrication procedures. The intense sensitivity to tiny initial imperfections or deviations from the proper geometry is because of the unstable post buckling strength of spherical shells and residual stresses. So as that the shells perform their meant perform adequately, decent style margins against buckling ought to exist.

These style margins are established by means that of theoretical and/or numerical analysis and on comparison with check results. So as to perform a numerical analysis, the data provided to the structural engineer with relevance the important initial geometric imperfectness and residual stresses isn't adequate.

LITERATURE SURVEY:

The work done by N.A. Makhutov[3], the basic industrial and technical areas of applications of pressure vessels and shell structures used are investigated. The design and operation features of the structures for chemical and petrochemical production, metallurgy, thermal and nuclear power engineering, shipbuilding, aviation and rocket-aerospace systems are presented. The specifications and operating conditions of pressure vessels are listed depending on the performance type. The work done by I-Shih[4] the pressure-radius relation of spherical rubber balloons has been derived and its stability behavior analyzed. Here it is showed that those features are practically unchanged for thick spherical shells of Mooney-Rivlin materials. In addition, it is also showed that eversion of a spherical shell is possible for any incompressible isotropic materials if the shell is not too thick.

ANLYSIS OF THIN SPHERICAL SHELL

MATERIAL – E GLASS EPOXY

IMPERFECT THIN SPHERICAL SHELL

The pressure value has been taken from the reference of Pressure vessels and shell structures , N.A. Makhutov and Yu. G. Matvienko specified as [3] in References chapter.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

STATIC ANALYSIS

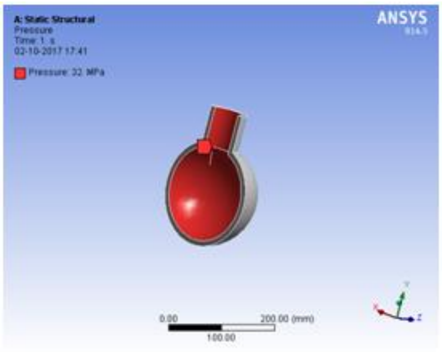

Fig: Pressure is applied inside the shell

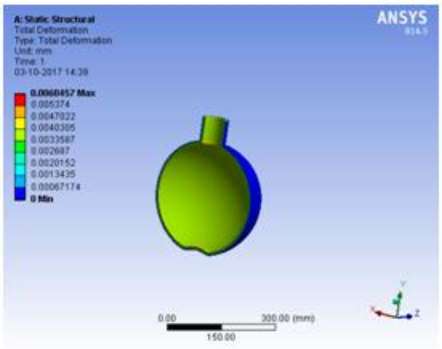

Fig: Deformation of imperfect thin spherical shell using E – Glass Epoxy

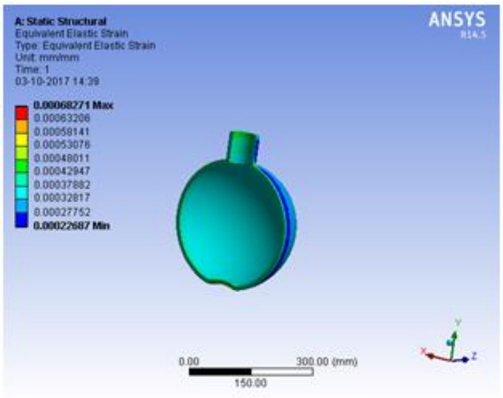

Fig: Strain of imperfect thin spherical shell using E – Glass Epoxy

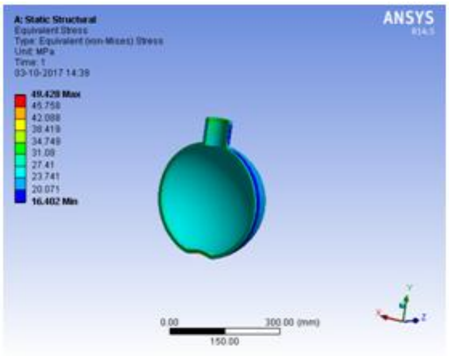

Fig: Stress of imperfect thin spherical shell using E – Glass Epoxy

RESULTS TABLE

Material	Deformation (mm)		Stress (MPa)		Strain	
	Perfect	Imperfect	Perfect	Imperfect	Perfect	Imperfect
COPPER	0.003979	0.0043092	47.007	54.288	0.00048404	0.00050043
ALUMIN MUM 7075	0.0065133	0.0070542	42.564	54.74	0.00079303	0.00082194
E-GLASS	0.0056068	0.0060457	47.473	49.428	0.00064738	0.00068271

By observing the above results, the stresses are increasing by about 13% for spherical shell with imperfection for Copper material, by about 22% for Aluminum 7075 material, by about 4% for E - Glass material and deformations are increasing by 7% when compared with that of spherical shell without imperfection. The stress values are less when E–Glass Epoxy is used. It can be concluded that the perfect shells have more load carrying capacity than the imperfect shells.

MODAL ANALYSIS

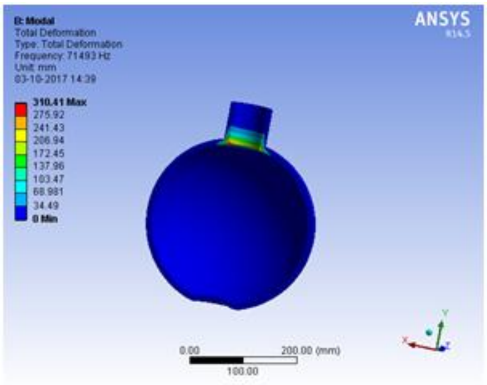

Fig: Mode 1 of imperfect thin spherical shell using E – Glass Epoxy

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

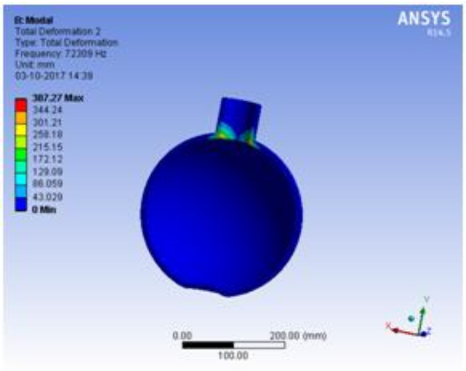

Fig: Mode 2 of imperfect thin spherical shell using E – Glass Epoxy

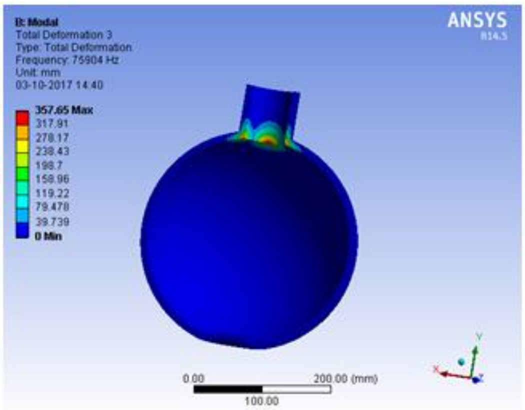

Fig: Mode 3 of imperfect thin spherical shell using E – Glass Epoxy

RANDOM VIBRATIONAL ANALYSIS

Random vibration analysis is done by taking the results from the modal analysis. The results determined are directional deformation, shear stresses and strains.

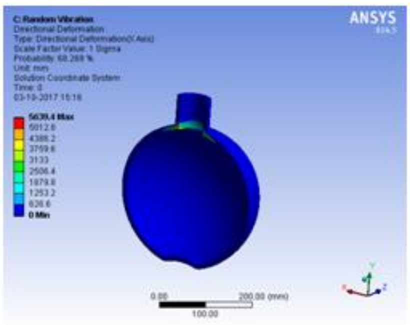

Fig: Directional deformation of imperfect thin spherical shell using E – Glass Epoxy

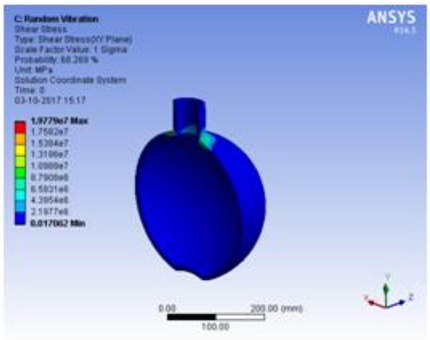

Fig: Shear stress of imperfect thin spherical shell using E – Glass Epoxy

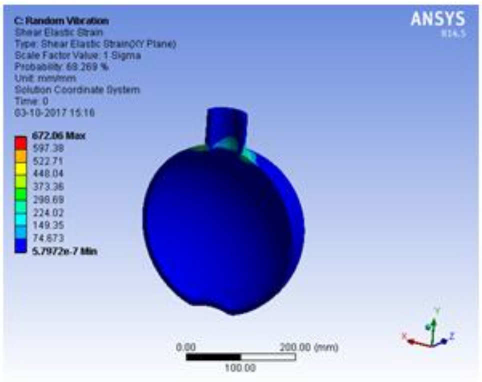

Fig: Shear strain of imperfect thin spherical shell using E – Glass Epoxy

BUCKLING ANALYSIS

Buckling analysis is done to determine the deformations and buckling load factor. From buckling load factor, the buckling load can be calculated.

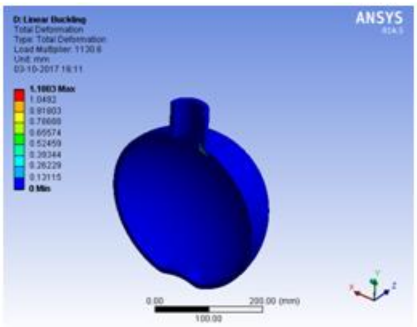

Fig: Mode 1 of imperfect thin spherical shell using E – Glass Epoxy

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

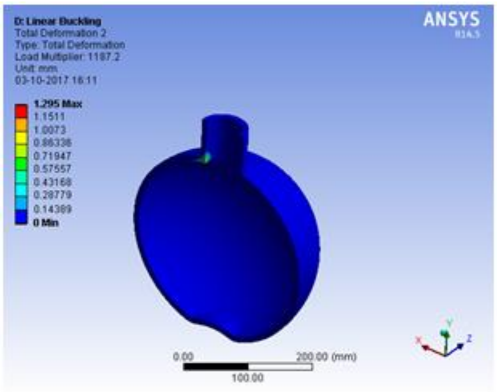

Fig: Mode 2 of imperfect thin spherical shell using E – Glass Epoxy

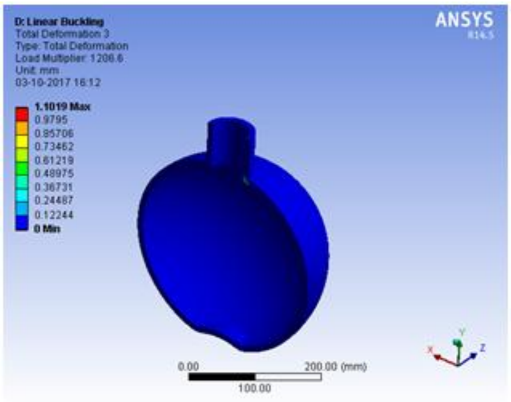

Fig: Mode 3 of imperfect thin spherical shell using E – Glass Epoxy

CONCLUSION

By observing the static analysis results, the stresses are increasing by about 13% for spherical shell with imperfection for Copper material, by about 22% for Aluminum 7075 material, by about 4% for E - Glass material and deformations are increasing by 7% when compared with that of spherical shell without imperfection. The stress values are less when E– Glass Epoxy is used. It can be concluded that the perfect shells have more load carrying capacity than the imperfect shells. Modal analysis results determine the frequencies, which defines the vibrations of the structure. By observing results, the frequencies are reducing for imperfect spherical shell by about 6% when compared with that of perfect spherical shell. So the vibrations are reduced for imperfect spherical shells.

The frequencies and deformations are more when E Glass is used. By observing Random Vibration results, the directional deformations are increasing for imperfect thin spherical shell by 30% when E– Glass Epoxy is used. The stresses are increasing for imperfect spherical shell by 12.7% when E– Glass Epoxy is used. From buckling load factor, the buckling load can be calculated. The buckling load is the load under which the spherical shells fail. So the load factor must be more for more life. By observing Buckling analysis results, the load multiplier is less for imperfect spherical shell. So the imperfect spherical fails faster than for perfect spherical shell. The load multiplier is more when Copper is used. So the life of perfect spherical shell with Copper is more.

REFERENCES

1. Anna Lee, Francisco Lopez Jim, Joel Marthelot, John W. Hutchinson,Pedro M. Reis, The geometric role of precisely engineered imperfections on the critical buckling load of spherical elastic shells
2. Chang-Li Yu, Zhan-Tao Chen, Chao Chen, Yan-ting Chen, Influence of initial imperfections on ultimate strength of spherical shells, International Journal of Naval Architecture and Ocean Engineering
3. N.A. Makhutov and Yu. G. Matvienko, Pressure Vessels And Shell Structures, Mechanical Engineering, Energy Systems and Sustainable Development – Vol. I
4. I-Shih Liu, Stability of Thick Spherical Shells, Continuum Mech. Thermodyn. (1995) 7: 249-258
5. Peter N. Khakina, Buckling Load of Thin Spherical Shells Based on the Theorem of Work and Energy, IACSIT International Journal of Engineering and Technology, Vol. 5, No. 3, June 2013
6. Jens Pontow, Imperfection Sensitivity and Limit Loads of Spherical Shells under Radial Pressure, Proceedings of Mathematics and Mechanics, Volume 5, Issue 1, December 2005, Pages 253–254
7. Ursula Albertin, Walter Wunderlich, Buckling design of imperfect spherical shells, omputational

Methods for Shell and Spatial Structures IASS-IACM 2000

8. Ivana Mekjavić, Buckling analysis of concrete spherical shells, ISSN 1330-3651 UDC/UDK 624.044:624.012.4.074.43
9. G. W. JONES, Axisymmetric buckling of a spherical shell embedded in an elastic medium under uniaxial stress at infinity, New Frontiers in the Mathematics of Solids Mathematical Institute University of Oxford http://www2.maths.ox.ac.uk/oxmos/ June, 2008
10. Nicoleta Teodorescu, Analysis of the Spherical Tanks Shell Stresses Concentration due to the Discontinuous Equatorial Supporting Solutions, Politehnica University of Bucharest, Faculty of Mechanical Engineering and Mechatronics, Process Equipment Department, 313 Splaiul Independenþei, 060042, Bucharest, Romania.