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A Novel Numerical Study of Influencing Parameter of Imperfections on Thin Short Carbon Steel Cylindrical Shell under Axial Compression

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Abstract

Thin cylindrical shell structures have big variety of applications attributable to their favorable stiffness-to-mass quantitative relation and under axial compressive loading, these shell structures fail by their buckling instability. Hence, their load carrying capability is decided by its buckling strength that successively preponderantly depends on the geometrical imperfections gift on the shell structure. The most aim of the current study is to work out the lot of influential geometrical parameter out of 2 geometrical imperfection parameters particularly, "the extent of state gift over a surface area" and its "amplitude". To account for these geometrical parameters at the same time, the state pattern is assumed as a dent having the form of extent of surface area as a virtually sq.. The facet length of extent of expanse is thought of as proportional to extent of state present over a neighborhood and therefore the dent depth is thought of as proportional to amplitude of imperfections. For the current numerical study, metallic element models of skinny short steel excellent cylindrical shells with completely different sizes of dent are generated at 1/3rd and 0.5 the peak of cylindrical shells and analyzed exploitation ANSYS non-linear metallic element buckling analysis.

Introduction

Thin cylindrical shell structures are generally extremely economical structures and that they have wide applications within the field of mechanical, civil, aerospace, marine, power plants and organic compound industries etc. the skinny cylindrical shell structures are prone to an outsized variety of imperfections, because of their producing difficulties. These imperfections have an effect on the load carrying capability of these shells. The imperfections that have an effect on the strength of skinny cylindrical shells are sorted into 3 major classes. They are, geometrical (for example, out-of-straightness, initial ovality and geometrical eccentricities, dents, swells, disk shape, cylindricity etc.), structural (small holes, cut outs, rigid inclusions, residual stresses and material in homogeneities) and loading imperfections (non-uniform edge load distribution, fortuitous edge moments, load eccentricities and cargo misalignments in addition as imperfect boundary conditions). Out of of these imperfections, the geometrical imperfections are a lot of dominant in deciding the load carrying capability of skinny cylindrical shells. Reliable prediction of buckling strength of those structures is very important because the buckling failure is harmful in nature.

Literature Review

The classical elastic buckling theory predicts the bifurcation buckling load of good cylindrical shell underneath uniform axial compression is given in Timoshenko and Gere (1965). Geometrical imperfections may be classified as distributed and native geometrical imperfections. One in every of the foremost common approaches to model the distributed geometrical imperfections is mistreatment the imperfections information taken from actual take a look at specimens. These measured imperfections area unit typically regenerate into a modal or Fourier series illustration which may be simply used for analysis or style. Since the knowledge needed on the precise size and form of the imperfections for modeling is obtained realistically, this approach provides reliable results. Similar approach was followed by many researchers. for instance on skinny gold-bearing shells, Arbocz& Babcock

(1969),Abramovich, & Singer (1987), Schneider (1996)and Athiannan&Palaninathan (2004). for instance on composite skinny cylindrical shells, Chryssanthopoulos et al (1999 & 2000), Spagnoli et al (1999), Carvelli et al (2001), Bisagni&Cordisco (2003). within the different approach, if measured imperfections data isn't obtainable, it's usually counseled that the imperfections pattern may be taken as initial Manfred Eigen mode form and amplitude of imperfections may be elite relying upon the producing method adopted. For instance, Featherston (2001&2003), Teng and Song (2001), Kim and Kim (2002) and Khelil (2002), in their work, had taken the primary Manfred Eigen mode form, called initial Manfred Eigen Affine Mode form state Pattern (FEAMSIP), obtained from the linear Manfred Eigen buckling analysis as worst imperfection form and superimposed on the right pure mathematics to form imperfect structures. This approach is employed to see the state sensitivity of the shell structure.

Studies involving the result of native geometrical imperfections on the buckling of cylindrical shells area unit restricted in variety as mentioned by Shen and Li (2002). varied researchers studied however the buckling strength of skinny cylindrical shell structures area unit influenced by the presence of native geometrical imperfections like axisymmetric trigonometric function formed dimple imperfections, [Hutchinson et al (1971)], diamond formed dimple imperfections [Krishnakumar& Forster (1991)], axisymmetric planoconcave and convexo-convex ring formed imperfections [Schneider (2006)], axisymmetric triangular or rippling type [Pircher (2001), Limam Ali et al (2010) and Bahaoui et al (2010)]weld iatrogenic axisymmetric imperfections [Pircher et al (2001)] and dents [Gavrilenko (2004), Prabu et al (2007,2009 & 2010)].

Athiannan and Palaninathan (2004) dole out numerical and experimental studies on buckling strength of skinny stainless-steel cylindrical shell underneath axial compression and direct shear loading and one in every of the conclusion derived is that “The extent of imperfection (imperfections gift over AN area) instead of the magnitude of state (the highest worth in a very model) is important in assessing the buckling load”. Hence, during this work to verify this conclusion, efforts area unit created to see the lot of influential geometrical parameter out of 2 geometrical state parameters particularly, “the extent of state gift over a surface area” and its “amplitude”. To account for these geometrical parameters at the same time, the state pattern is assumed as a dent having the form of extent of expanse as a virtually sq.. The scale of extent of expanse (Sd) may be considered as proportional to extent of state gift over a part and also the depth of dent (td) may be thought of as proportional to amplitude of imperfections. For the current numerical study, metallic element models of skinny short steel good cylindrical shells with totally different sizes of dent area unit generated at 1/3rd and [*fr1] the peak of cylindrical shells. The scale of cylindrical shell taken for study is: D = 700mm with varied shell thicknesses (t) of zero.9,1.25 and a couple of millimetre and varied length (L) of 350mm and 700mm . the scale of extent of expanse (Sd) is varied as eighty seven.5, 112.5 and 137.5 millimetre and depth of the dent (td) varied as zero.625, 1.25, 2.25 3.25 and 5mm. These metallic element models area unit analyzed mistreatment ANSYS non-linear buckling analysis.

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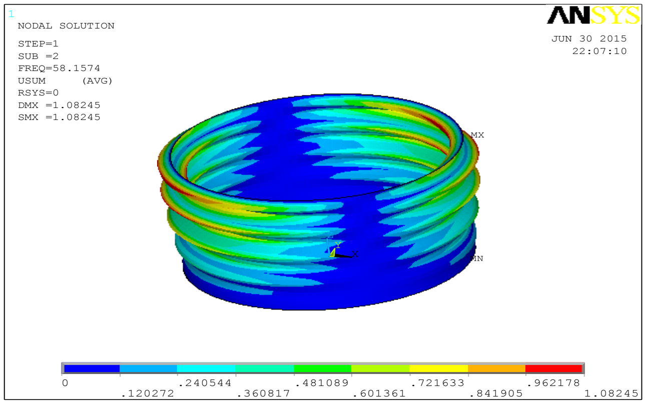
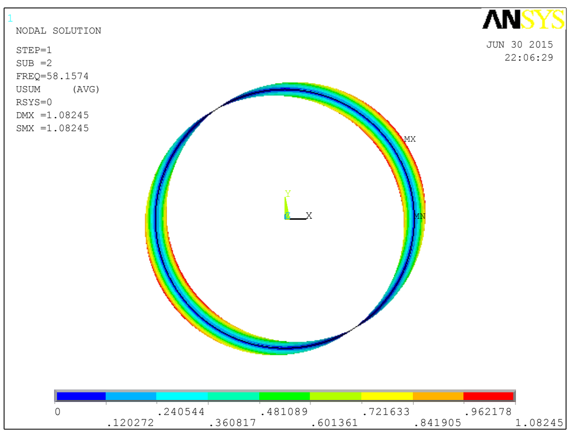
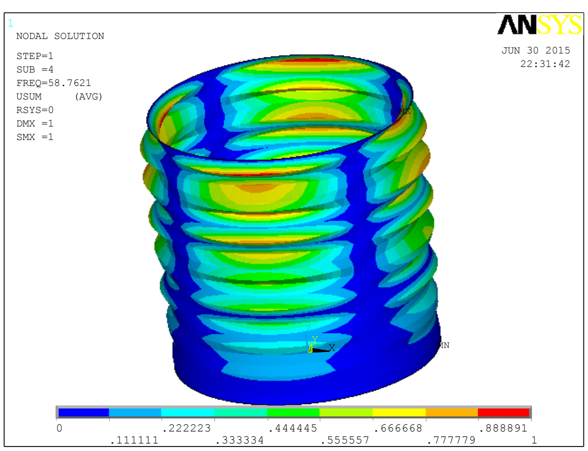


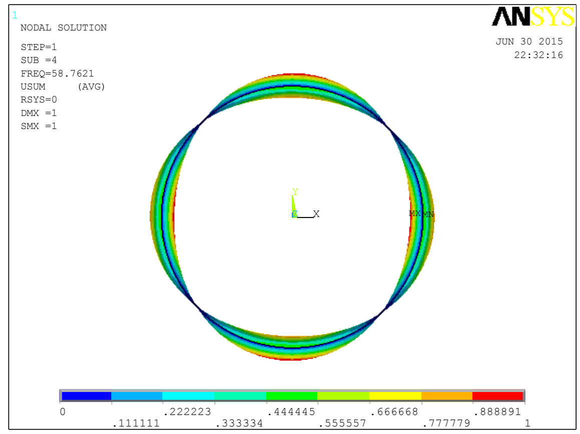
Displacement Vector Sum (isometric-view) for a length of L=340



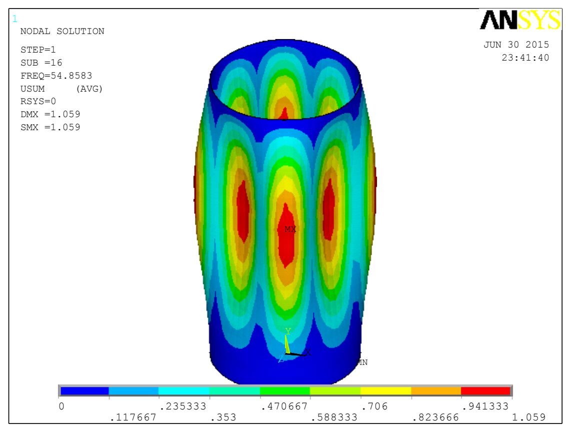
Displacement Vector Sum (top-view) for a length of L=340



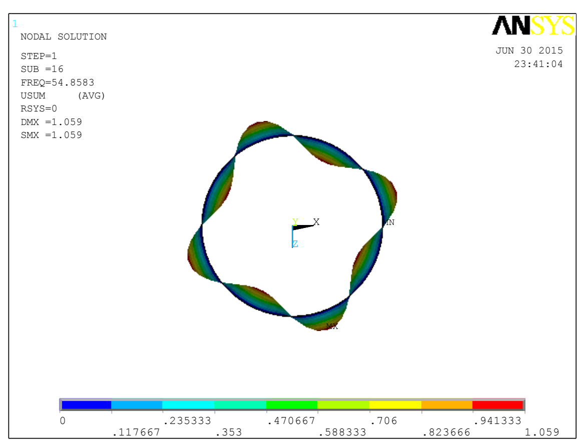
Displacement Vector Sum (Isometric-view) for a length of L=700



Displacement Vector Sum (Top-view) for a length of L=700



Displacement Vector Sum (isometric-view) for a length of L=1500



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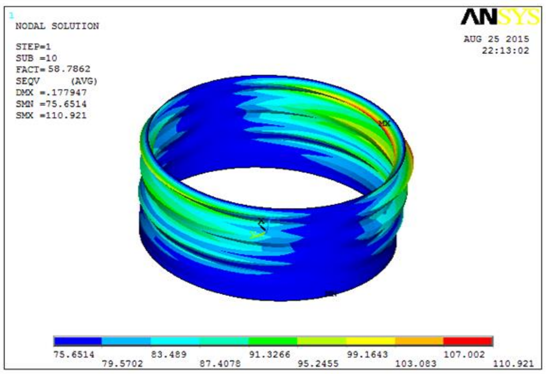
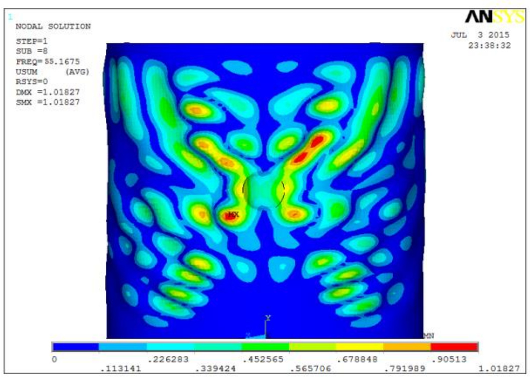
Displacement Vector Sum (top-view) for a length of L=1500

Displacement vector sum for a length of L=700 with circular dent



Stress distribution in the shell for length L=340

Analysis of Imperfect shells



VALIDATION FOR PERFECT SHELLS

The results obtained by analytical solution are compared with ANSYS for perfect shells and are validated here in the Table 4.10. The validation is done for three different lengths and the results obtained by both theoretical and numerical technique are almost equal.

Table 4.10 Comparison of theoretical frequency with ANSYS for perfect shells

Sl. No	n	Length (mm)	Theoretical solution	ANSYS solution	Error (%)
1	1	340	56.07	58.157	3.58
2	2	700	55.96	58.76	4.76
3	4	1500	55.81	54.85	2

As per previous studies, the similarity between the analytical and numerical solutions were about 65-85%. It is shown that the buckling characteristics of thin cylindrical shells can be predicted with less than 5% error [25]. The results from this study indicate that numerical modeling can be used to evaluate the buckling strength accurately, provided the material properties and initial imperfections are properly modeled.

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OBSERVATIONS

1) The deformation is maximum at dent geometry and the displacement below the dent gradually becomes zero towards supporting edge.
2) Comparing the above results we observe that the frequency values gradually increases with the increase in the circumferential nodes n.
3) The variation of length and thickness of the shell will definitely have an effect on the load carrying capacity as shown in the graphs.
4) The slenderness also increases the effect of reducing the Buckling Strength.

CONCLUSIONS

From the analysis of thin stainless steel dented cylindrical shells taken for study, the following conclusions are derived on the basis of the parameters considered in the study. The buckling criterion is the most decisive as far as the resistance of a compressed cylindrical shell is concerned. In the calculation of theoretical buckling load of perfect shell, it was found that as the length of the cylinder varies from 340mm to 1500mm, the buckling load gradually tend to reduce due to the increase in slenderness. The critical load obtained in such a way should be significantly reduced due to presence of unavoidable geometrical imperfections. The buckling phenomenon varies even for perfect shells with thickness as well as length. It is also found that buckling strength of perfect cylindrical shell is higher compared to cylindrical shell having dents**.** From the analysis it is found that when the maximum amplitude of imperfections is present, the pattern gives out the lowest critical buckling Load when compared to the other imperfection patterns considered. When the amplitude of imperfections is minimum, the pattern gives out the highest critical buckling load when compared to the other imperfection patterns considered. The buckling or collapse strength of dented cylindrical shell decreases with increase in both diameter and depth of the dent. Further, this decrease in strength increases with increase in depth of dent.

References

[1] Abramovich, Yaffe R. and Singer (1987), 'Evaluation of stiffened shell characteristic from imperfection measurements', Journal of strain analysis, Vol.22 (1), pp. 17-23.

[2] ANSYS 12 Reference Manual.

[3] Arbocz Johann and Babcock Charles D. Jr. (1969), 'The effect of general imperfection on the buckling of cylindrical shells', Journal of Applied Mechanics-Transactions of ASME, Vol. 36, pp. 28-38.

[4] Athiannan K. and Palaninathan R., (2004), 'Experimental investigations on buckling of thin cylindrical shells under axial compression and transverse shear', Sadhana, Vol. 29(1), pp. 93-115.

[5] Bahaoui JE,, Khamlichi A, Bakkali LE and Limam A (2010) 'Reliability Assessment of Buckling Strength for Compressed Cylindrical Shells with Interacting Localized Geometric Imperfections' American J. of Engineering and Applied Sciences, Vol.3 (4), pp.620-628

[6] Bisagni Chiara and CordiscoPotito (2003), 'An experimental investigation into the buckling and post buckling of CFRP shells under combined axial and torsion loading', Composite Structures, Vol.60 (4), pp. 391-402.

[7] Cai M., Mark J., Holst F.G. and Rotter J.M., (2002), 'Buckling strength of thin cylindrical shells under localized axial compression', EM2002, 15th ASCE Engineering Mechanics Conference, Columbia University, NewYork.

[8] Carvelli V., Panzeri N. and Poggi C. (2001), 'Buckling strength of GFRP under-water

vehicles', Composites Part B: Engineering, Vol. 32(2), pp. 89-101.

[9] Chryssanthopoulos M.K., Elghazouli A.Y and Esong I.E. (2000), 'Validation of FE models for buckling analysis of woven GFRP shells', Composite Structures , Vol. 49(4), pp. 355-367.

[10] Chryssanthopoulos M.K., Elghazouli A.Y. and Esong I.E. (1999), 'Compressiontests on antisymmetric two-ply GFRP cylinders', Composites Part B, Vol. 30, pp. 335-350.

[11] Featherston C.A., (2001), 'Imperfection sensitivity of the flat plates under combined compression and shear', International Journal of Non-Linear Mechanics, Vol. 36 (2), pp. 249-259.

[12] Featherston C.A., (2003), 'Imperfection sensitivity of curved panels under combined compression and shear', International Journal of Non-Linear Mechanics, Vol.38 (2), pp. 225-238.

[13] Gavrilenko GD., (2004), 'Stability and load-bearing capacity of smooth and ribbed shells with local dents', International Applied Mechanics Vol. 40(9), pp. 970–93.

[14] Han H., Cheng J., Taheri F. and Pegg N., (2006) 'Numerical and experimental investigations of the response of aluminum cylinders with a cutout subject to axial compression', Thin-Walled Structures, Vol. 44(2), pp. 254-270.

[15] Hutchinson J.W., Tennyson R.C. and Muggeridge D.B., (1971), 'Effect of local axisymmetrical imperfection on the buckling behavior of a circular cylindrical shell under axial compression', AIAA Journal, Vol. 9, pp. 48-52.

[16] Jullien J.F. and Limam A., (1998), 'Effect of openings on buckling of cylindrical shells subjected to axial compression', Thin-Walled Structures, Vol. 31(1-3), pp. 187-202.

[17] Khelil (2002), 'Buckling of steel shells subjected to non-uniform axial and pressure loadings', Thin Walled Structures, Vol. 40(11), pp. 955-970.

[18] Kim Seung-Eock and Kim Chang-Sung (2002), 'Buckling strength of the cylindrical shell and tank subjected to axially compressive loads', Thin Walled Structures, Vol. 40(4), pp. 329-353.

[19] Krishnakumar S. and Forster C.G., (1991), 'Axial load compatibility of cylindrical shells with local geometric defects', Experimental Mechanics, Vol. 31, pp. 104-110.

[20] Limam Ali, El Bahaoui Jalal, KhamlichiAbdellatif, El BakkaliLarbi (2011), 'Effect of multiple localized geometric imperfections on stability of thin axisymmetric cylindrical shells under axial compression', International Journal of Solids and Structures, Vol 48(6), pp. 1034–1043

[21] Pircher M., Berry P.A., Ding X.L. and Bridge R.Q., (2001), 'The shape of circumferential weld induced imperfections in thin walled steel silos and tanks', Thin-Walled Structures, Vol. 39(12), pp. 999-1014.

[22] Prabu B., Bujjibabu N., Saravanan S. and Venkatraman A., (2007), 'Effect of a dent of different sizes and angles of inclination on buckling strength of a short stainless steel cylindrical shell subjected to uniform axial compression', Advances in Structural Engineering, Vol. 10(5), pp. 581-591.