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Design Modification and Analysis of Toroidal Pressure Vessel

Ms T.E.Niharika
Assistantt Professor
Department of Mechanical Engineering
Ellenki College of Engineering and Technology
Patelguda(V), Near BHEL, Hyderabad - 502319

Mr. Prashanta Devangada
M.Tech - CAD/CAM
Department of Mechanical Engineering
Ellenki College of Engineering and Technology
Patelguda(V), Near BHEL, Hyderabad – 502319

ABSTRACT

The main of this thesis is to compare the deformations, stresses, frequency values, directional deformations and shear stresses for Conventional Toroidal Pressure vessel and Filament wound Pressure Vessel used to store CNG. The Toroidal Pressure vessel and Filament wound Pressure Vessel are modeled in 3D modeling software Creo 2.0. Static, Modal analyses and Random Vibration analysis are performed on Toroidal Pressure vessel and Filament wound Pressure Vessel and compared for the results. The analysis is done in Ansys.

Indroduction

The main of this thesis is to compare the analytical results for Conventional Toroidal Pressure vessel and Filament wound Pressure Vessel used to store CNG. The Toroidal Pressure vessel and Filament wound Pressure Vessel are modeled in 3D modeling software Creo 2.0. Static, Modal and Random Vibration analyses are performed on Toroidal Pressure vessel and Filament wound Pressure Vessel and compared for the deformations, stresses, frequency values, directional deformation and shear stress values. The analysis is done in Ansys.

MODELING OF TOROIDAL AND FILAMENT WOUND TOROIDAL PRESSURE VESSEL IN CREO 2.0

TOROIDAL PRESSURE VESSEL

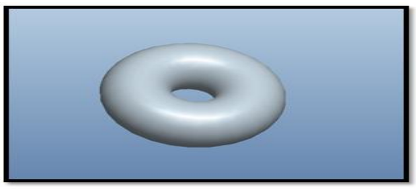

Fig 1 - Final model

FILAMENT WOUND TOROIDAL PRESSURE VESSEL

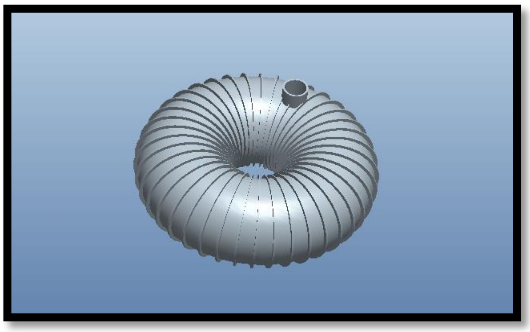

Fig 2 – Final Model of Filament wound pressure vessel

ANALYSIS OF TOROIDAL AND FILAMENT WOUND TOROIDAL PRESSURE VESSEL

BOUNDARY CONDITIONS

The pressure vessel is analyzed for an internal pressure of 25 MPa. The value is taken from the journal paper, “CNG: Always been in pursuit of energy to meet his ever increasing demand”, by Vikas Sharma as specified in references [11].

STRUCTURAL ANALYSIS OF FILAMENT WOUND TOROIDAL PRESSURE VESSEL

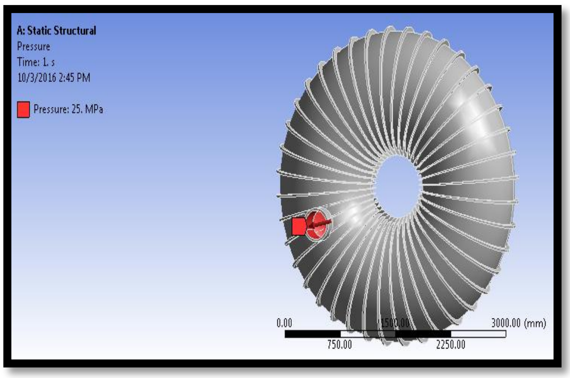

Fig 3 – Pressure is applied inside the pressure vessel

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MATERIAL- KEVLAR

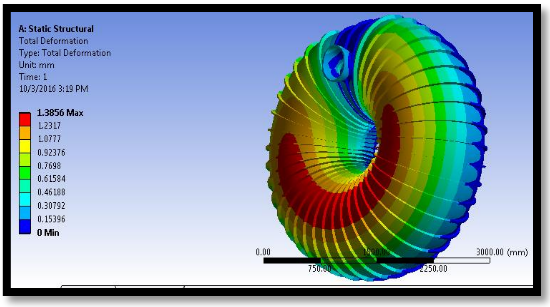

Fig 4 – Total Deformation for Kevlar

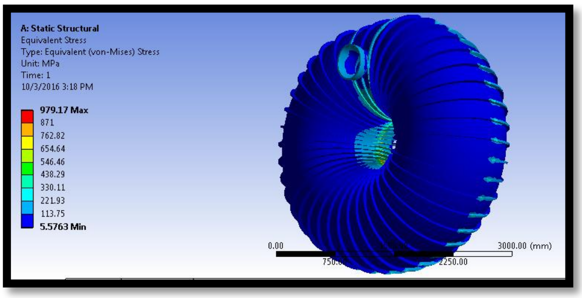

Fig 5 – Equivalent Stress for Kevlar

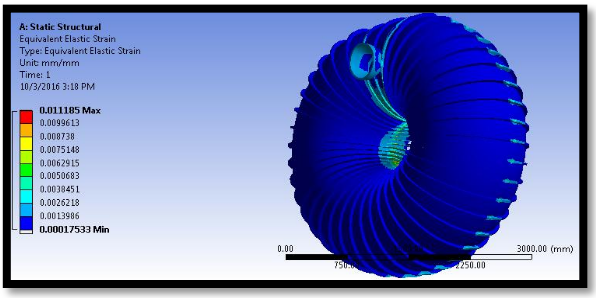

Fig 6 – Equivalent Elastic Strain for Kevlar

MODAL ANALYSIS OF FILAMENT WOUND TOROIDAL PRESSURE VESSEL

MATERIAL- KEVLAR

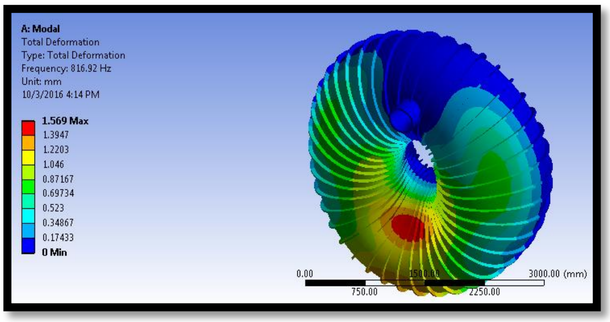

Fig 7- mode -1 for Kevlar

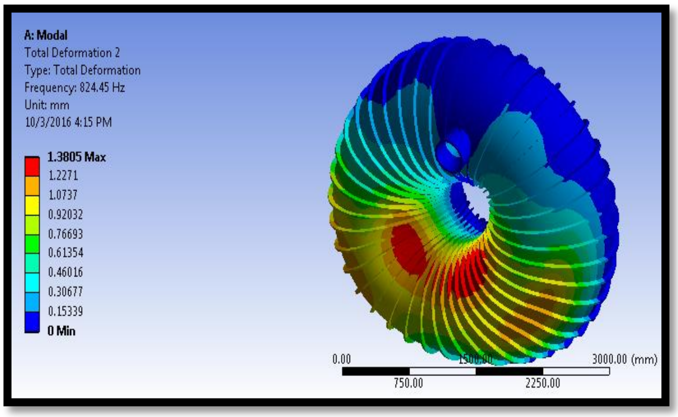

Fig 8 –mode -2 for Kevlar

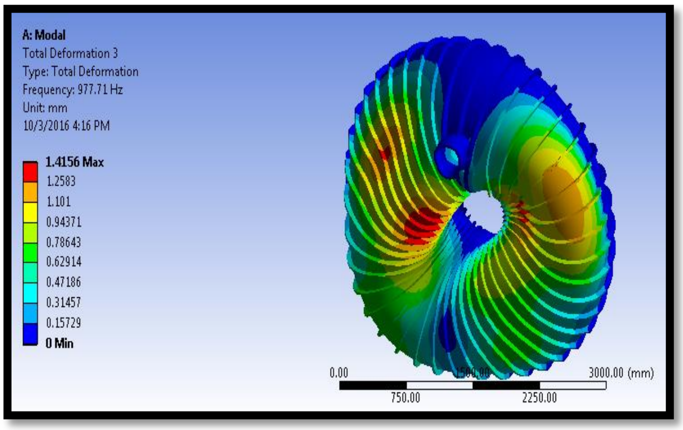

Fig 9–mode -3 for Kevlar

RANDOM VIBRATION ANALYSIS OF FILAMENT WOUND TOROIDAL PRESSURE VESSEL

The result of frequency values from modal analysis are taken as input for random vibration analysis

MATERIAL- KEVLAR

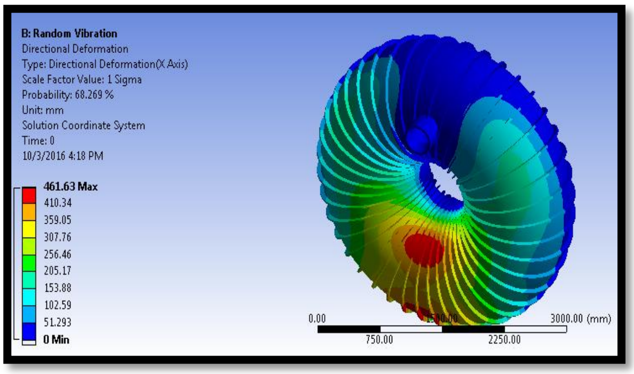

Fig 10 – Directional Deformation for Kevlar

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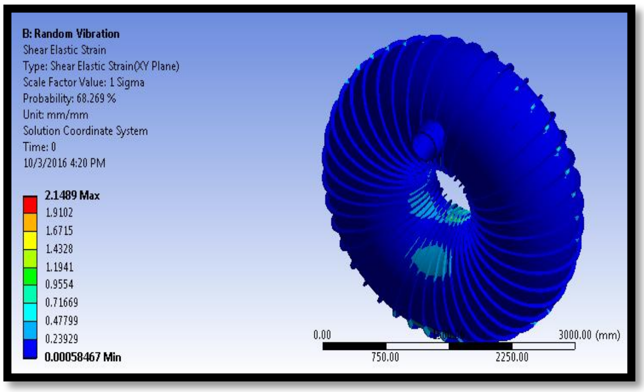


Fig 11 – Shear Elastic Strain for Kevlar

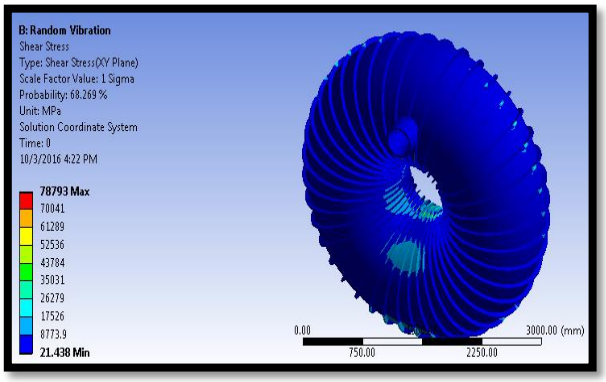


Fig 12– Shear Stress for Kevlar

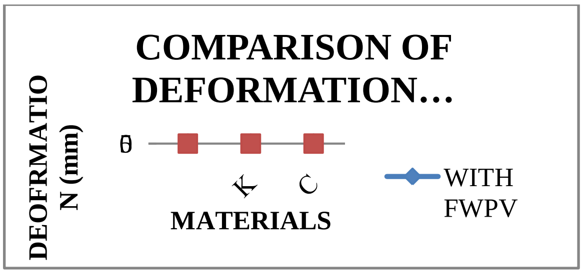
RESULT & DISCUSSIONS
STATIC ANALYSIS

MATERIALS	DEFORMATION (mm)	STRESS (MPa)	STRAIN
STEEL	0.69285	1020.5	0.0058
KEVLAR	1.3856	979.17	0.011185
CARBON FIBER	2.0191	1089.3	0.01775

Table 1 – Static analysis results of Filament wound toroidal pressure vessel

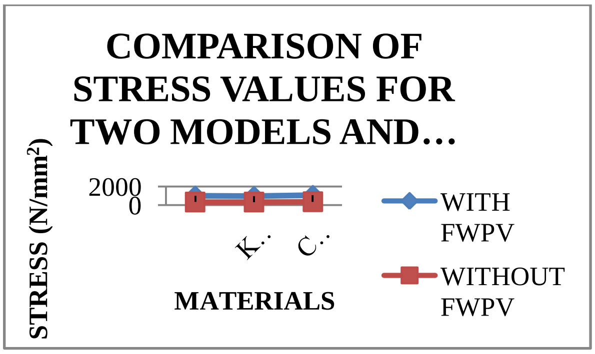
MATERIALS	DEFORMATION (mm)	STRESS (MPa)	STRAIN
STEEL	0.59447	352.69	0.0019564
KEVLAR	1.176	340.08	0.0037774
CARBON FIBER	1.7652	371.76	0.0059636

Table 2 – Static analysis results of Toroidal pressure vessel



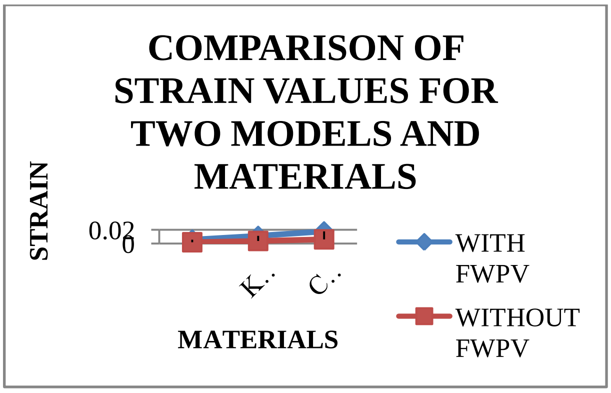
Graph 1 – Comparison of Deformation values for two models and different materials

From the above graph it is observed that the total deformation is less for toroidal pressure vessel than Filament wound pressure vessel and it is less for Steel material.



From the above graph it is observed that by using steel for filament wound pressure vessel fails because the stress values are more than its allowable strength but for Kevlar and Carbon Fiber the stress values are less than their respective allowable strength values.

The stress value is less for Toroidal pressure vessel than Filament wound pressure vessel and it is less for Kevlar material.



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From the above graph it is observed that the strain is less for toroidal pressure vessel than Filament wound pressure vessel and it is less for Steel material.

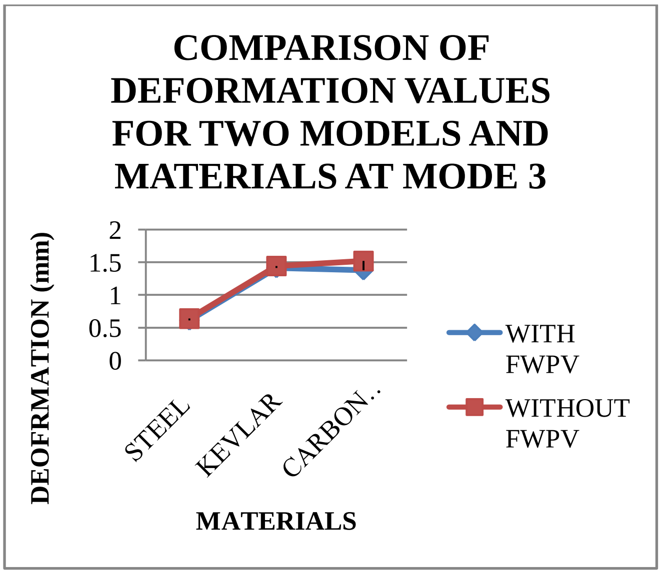
MODAL ANALYSIS

MATERIALS	VARIABLES	MODE1	MODE2	MODE3
STEEL	Deformation (mm)	0.67752	0.59607	0.61335
	Frequency (Hz)	498.4	502.66	595.85
KEVLAR	Deformation (mm)	1.569	1.3805	1.4156
	Frequency (Hz)	816.92	824.45	977.71
CARBON FIBER	Deformation (mm)	1.5142	1.3328	1.3815
	Frequency (Hz)	655.18	660.08	782.15

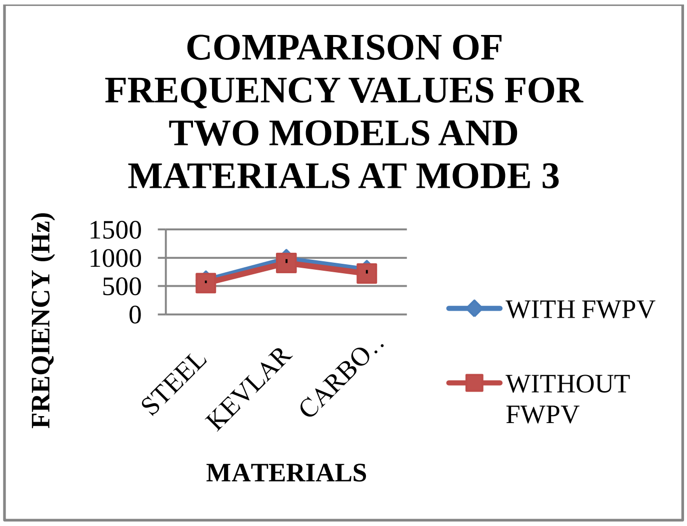
Table 3 –Modal results of Filament wound toroidal pressure vessel

MATERIALS	VARIABLES	MODE1	MODE2	MODE3
STEEL	Deformation (mm)	0.55965	0.5491	0.63891
	Frequency (Hz)	542.12	543.08	553.04
KEVLAR	Deformation (mm)	1.2673	1.2874	1.4431
	Frequency (Hz)	885.79	887.15	908.91
CARBON FIBER	Deformation (mm)	1.3761	1.2871	1.5196
	Frequency (Hz)	715.26	717.14	723.45

Table 4 – Modal results of Toroidal pressure vessel



From the above graph it is observed that the deformation is less for toroidal pressure vessel than Filament wound pressure vessel and it is less for Steel.



From the above graph it is observed that the frequency values are more for filament wound toroidal pressure vessel than toroidal pressure vessel, so vibrations are more for filament wound pressure vessel and it is less for Steel.

RANDOM VIBRATION ANALYSIS

MATERIALS	DIRECTIONAL DEFORMATION (mm)	SHEAR STRESS (MPa)	STRAIN
STEEL	176.26	63876	0.83039
KEVLAR	461.63	78793	2.1489
CARBON FIBER	405.75	55778	1.9283

Table 5 – Random analysis results of Filament wound toroidal pressure vessel

MATERIALS	DIRECTIONAL DEFORMATION (mm)	SHEAR STRESS (MPa)	SHEAR STRAIN
STEEL	138.77	16466	0.21406
KEVLAR	283.82	16077	0.43846
CARBON FIBER	211.3	9262.1	0.3202

Table 6 – Random analysis results of Toroidal pressure vessel

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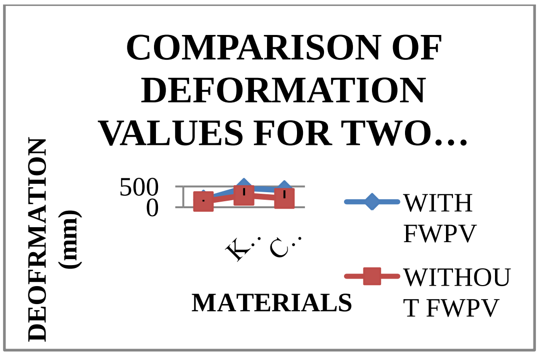
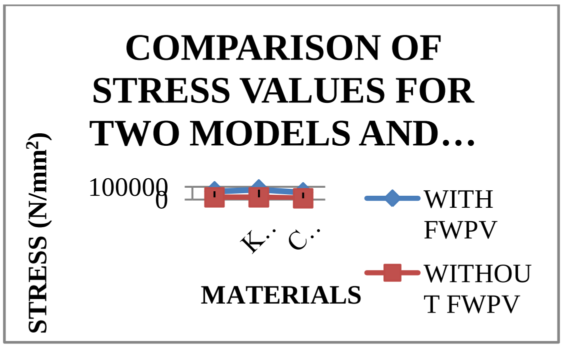
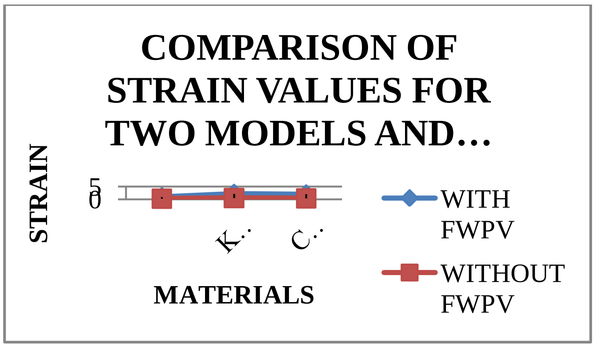


Graph – Comparison of Deformation values for two models and different materials

From the above graph it is observed that the total deformation is less for toroidal pressure vessel than Filament wound pressure vessel and it is less for Steel material.



From the above graph it is observed that by using steel for filament wound pressure vessel fails because the stress values are more than its allowable strength but for Kevlar and Carbon Fiber the stress values are less than their respective allowable strength values. The stress value is less for toroidal pressure vessel than Filament wound pressure vessel and it is less for Carbon Fiber material.



From the above graph it is observed that the strain is less for toroidal pressure vessel than Filament wound pressure vessel and it is less for Steel material.

CONCLUSION

Theoretical calculations are done to determine stress and displacement values for toroidal pressure vessel. By observing the calculations, the displacement is less for Carbon Fiber than Kevlar and Steel. The values are similar with that of analytical results.

By observing the static analysis results, the total deformation is less for toroidal pressure vessel than Filament wound pressure vessel and it is less for Steel material. From the stress results it is observed that by using steel for filament wound pressure vessel fails because the stress values are more than its allowable strength but for Kevlar and Carbon Fiber the stress values are less than their respective allowable strength values. The stress value is less for toroidal pressure vessel than Filament wound pressure vessel and it is less for Kevlar material.

By observing the modal analysis results, the deformation is less for toroidal pressure vessel than Filament wound pressure vessel and it is less for Steel. The frequency values are less for wound toroidal pressure vessel than toroidal pressure vessel, so vibrations are more for filament wound pressure vessel and it is less for Steel.

By observing the Random Vibration analysis results, the directional deformation values toroidal pressure vessel than Filament wound pressure vessel and it is less for Steel material. The stress value is less for toroidal pressure vessel than Filament wound pressure vessel and it is less for Carbon Fiber material.

REFERENCES

[1] J Blachut and OR Jaiswal, On Buckling of Toroidal Shells under External Pressure, Computers and Structures, 2000, 77, 233-251.

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

[2] Rakendu R, MK Sundaresan and Pinky Merin Philip, Finite Element Analysis of Toroidal Pressure Vessels Using FEASTSMT/PreWin, European Journal of Advances in Engineering and Technology, 2015, 2(11): 62-68, ISSN: 2394 - 658X

[3] Lei ZU, Design and optimization of filament wound composite pressure vessels, ISBN: 978-90-8891-382-2, Printed in the Netherlands by Uitgeverij BOXPress, Oisterwijk

[4] Calum Fowler - Rmit University Melbourne, Australia Review of Composite Toroidal Pressure Vessel Research, Design And Development For On-Board Cng And Hydrogen Storage

[5] Vladan Veličković, Stress and Strain States in the Material of the Stressed Toroidal Container for Liquefied Petroleum Gas, Scientific Technical Review, 2007, LVII, No.3-4,94-104.

[6] H.J. Zhan, Static and dynamic analysis of toroidal LPG tanks, UNIVERSITY OF OTTAWA, Canada, 2008

[7] Avinash Kharat and V V Kulkarni, Stress Concentration at Openings in Pressure Vessels- A Review, International Journal of Innovative Research in Science, Engineering and Technology,2013,2(3), 670-677.

[8] SUTCLIFFE,W.J,: Stress analysis of toroidal shells of elliptic cross ssection, Int. J. Mech. Sci., 1971, 13, pp. 951-958.

[9] YAMADA,G., KOBAYASHI,Y., OHTA,Y., YOKOTA,S.: Free vibration of a toroidal shell with elliptical cross-section, J. Sound. Vibr., 1989, 135, 411-425.

[10] Pravin Narale and PS Kachare, Structural Analysis of Nozzle Attachment on Presure vessel Design, International Journal of Engineering Research and Applications, 2012, 2(4), 1353-1358.

[11] Vikas Sharma, Aniket Kumar, Anshika Yadav, CNG: Always been in pursuit of energy to meet his ever increasing demand, International Journal of Science, Technology & Management http://www.ijstm.com, Volume No.03, Issue No. 07, July 2014 ISSN (online): 2394-1537