International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue-17
December 2017

Design and Finite Element Analysis of Vertical Pressure Vessels Subjected To Applied Forces

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ABSTRACT

Vertical pressure vessels consist of a cylindrical shell and dished bottoms. They are placed on three welded legs. The size and positioning of the filler necks is adjusted according to the customer requirements and accordance with the relevant European standards. The pressure vessels can be produced from ferrous or austenitic steel.In this thesis, a vertical pressure vessel is designed subjected to different loads internal pressure and external pressure by theoretical calculations. The models are done in Creo 2.0.Static, Modal and Random vibration analysis are done on the model to determine displacements, stresses, frequencies, directional deformations and shear stresses. Analysis will be done in Ansys 14.5.

INTRODUCTION TO PRESSURE VESSEL

A pressure vessel is a closed container designed to hold gases or liquids at a pressure substantially different from the ambient pressure.Cylinders are widely used for storage due to their being less expensive to produce than spheres. However, cylinders are not as strong as spheres due to the weak point at each end.This weakness is reduced by hemispherical or rounded ends being fitted. If the whole cylinder is manufactured from thicker material than a comparable spherical vessel of similar capacity, storage pressure can be similar to that of a sphere.Main pressure vessel components

1.Shell, 2.head, 3.nozzle, 4.supports, 5.saddle supports, 6.leg supports, 7.lug supports, 8. Skirt supports

LITERATURE REVIEW

In the paper by **Mane S.S**[1], deals with vessels that are subjected to various applied forces acting in combination with internal or external pressure as well as concerned with the vibration of vertical pressure vessels known as columns or towers. The type of vessels considered is cylindrical shells with the longitudinal axis vertical. The procedure for estimating the period of first mode of vibration for columns which are the same diameter and thickness for their entire length is outlined. A method for designing vessels considered as dynamic structures is described as well as a detailed procedure for estimating the period of vibration of multi thickness (stepped shell) vessels and/or vessels built to two or more diameters with conical transitions where the difference in diameter is small. The design procedure outlined will be useful to the practical vessel designer confronted with the task of investigating vibration possibilities in vertical pressure vessels.In the paper by **V. P. Gawade** [2], The pressure vessel is designed for internal pressure using ASME Codes. The components of the pressure vessel are designed by calculating the factors like thickness of the shell, head, stress analysis etc. To validate the design result the pressure vessel is modeled and analyzed in ANSYS. The preferred method to conduct the analysis is FEA. In the paper by **A. DEVARAJU** [3], The main objective of this paper is to design the standard cylindrical pressure vessel and calculate the stresses induced in the various part of the vessel by manually and compare these results with the ANSYS results.

Pressure Calculations of Pressure vessel for internal forces

$(\boldsymbol{tr}) = PRi$ / (SE-0.6P)

Where

Internal design pressure = p
Maximum allowable stress value = S
Weld joint efficiency = 1
Corrosion allowance = C.A = 1.5
Total shell thickness = tr+ C.A

Total shell thickness = 50.8
$\boldsymbol{tr} = PRi$ / (SE-0.6P)

Pressure Calculations of Pressure vessel for external forces

$r = \frac{We1}{We}$

$r = \frac{n2-1}{n2-1+m}$

$m = \pi^2 R^2/2L^2$

$S_b = \frac{4We}{\pi D^2 t}$

$S_b = \frac{4M}{\pi D^2 t}$

Where,

M = bending moment due to horizontal loads

n = number of lobes into which shell may buckle

^{We1}= collapsing pressure for external pressure acting on sides and

Ends of vessel, psi

We= collapsing pressure for external pressure acting on sides of

Vessel only, psi

R = outside radius of shell

Sb = bending stress on outermost fiber, psi

BOUNDARY CONDITIONS

The reference journal for modeling and analysis are taken from following journal "The Design Of Vertical Pressure Vessels Subjected To Applied Forces And Vibrational Conditions by Maane S.S, Prof. Wankhede P.A" specified as [1] in References chapter.

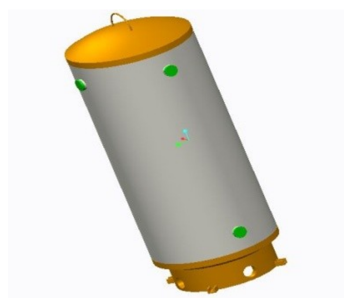

Fig – Assembly of vertical pressure vessel

ANALYSIS OF VERTICAL PRESSURE VESSELS

MATERIAL - HIGH CARBON STEEL

STATIC STRUCTURAL, MODAL AND RANDOM VIBRATION ANALYSIS

APPLYING INTERNAL PRESSURE

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p-ISSN: 2348-795X
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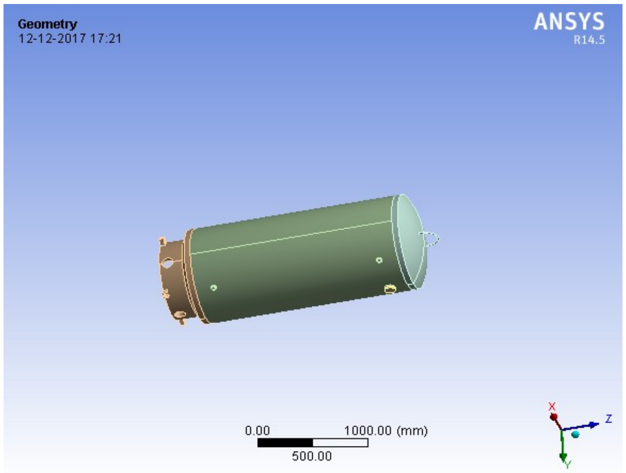

Fig: Imported Geometry of Vertical Pressure Vessel

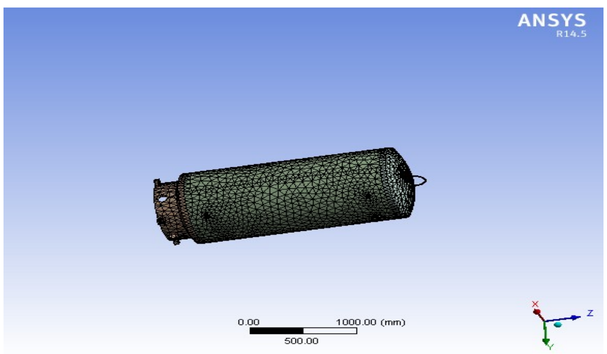

Fig: Meshed model of Vertical Pressure Vessel

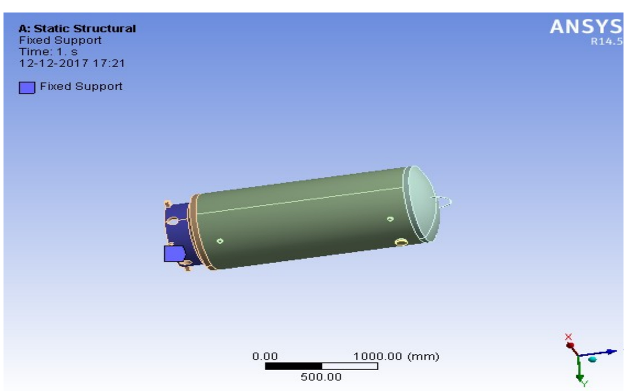

Fig: Fixed support applied at bottom of vessel

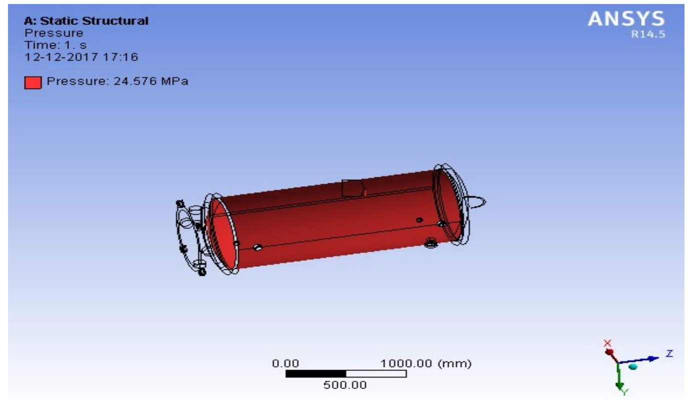

Fig: Pressure is applied insidevessel

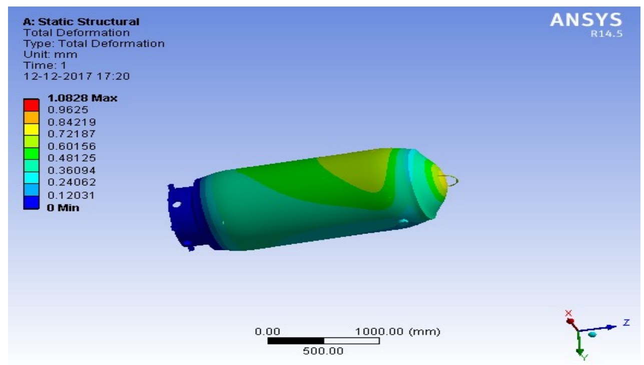

Fig: Total deformation of Vertical Pressure Vessel using High Carbon Steel by applying internal pressure

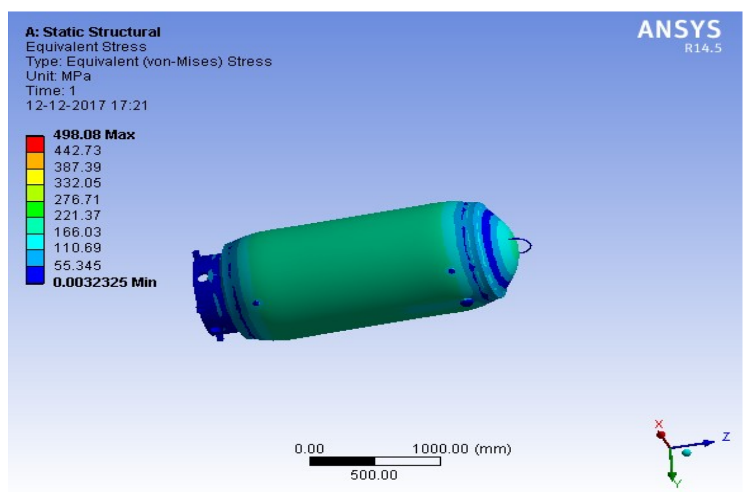

Fig: Stress of Vertical Pressure Vessels using High Carbon Steel by applying internal pressure

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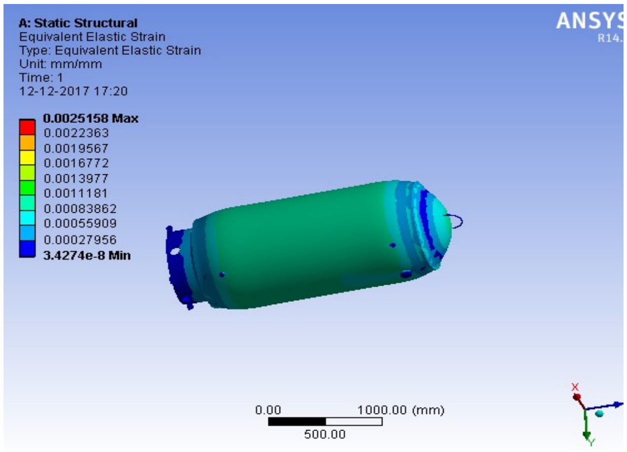


Fig: Strain of Vertical Pressure Vessels using High Carbon Steel by applying internal pressure

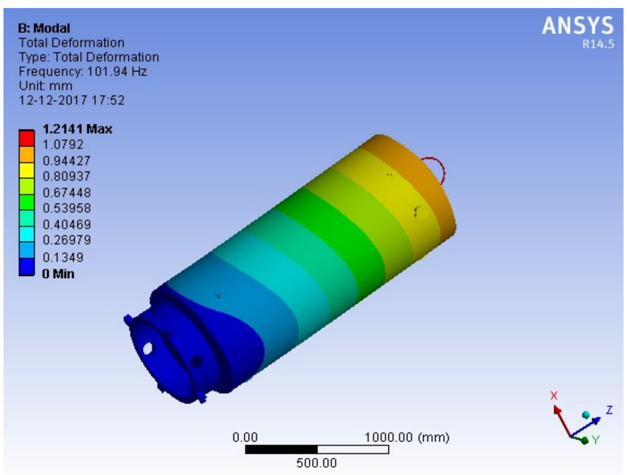


Fig: Mode-1 of Vertical Pressure Vessels using High Carbon Steel by applying internal pressure

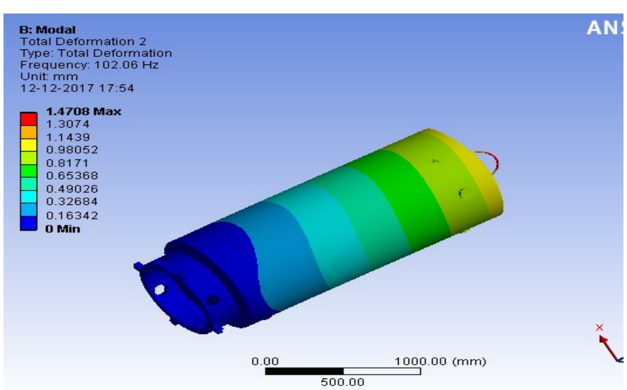


Fig: Mode-2 of Vertical Pressure Vessels using High Carbon Steel by applying internal pressure

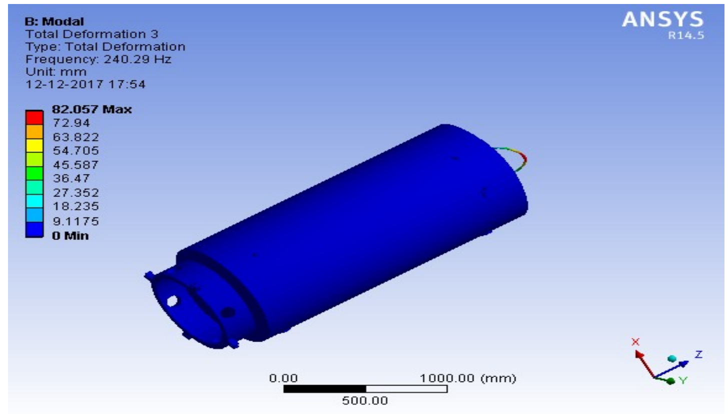


Fig: Mode-3 of Vertical Pressure Vessels using High Carbon Steel by applying internal pressure

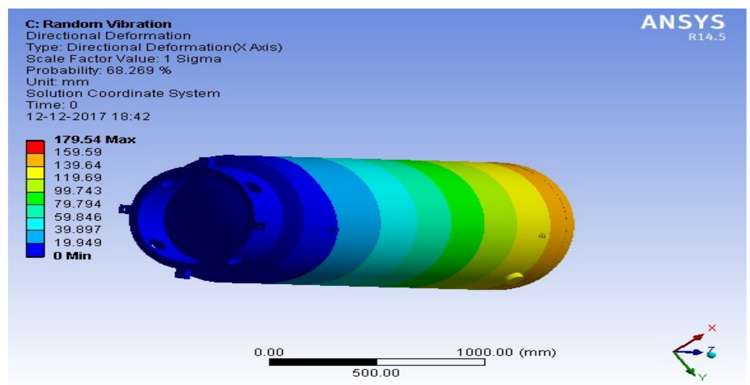


Fig: Directional Deformation of Vertical Pressure Vessels using High Carbon Steel by applying internal pressure

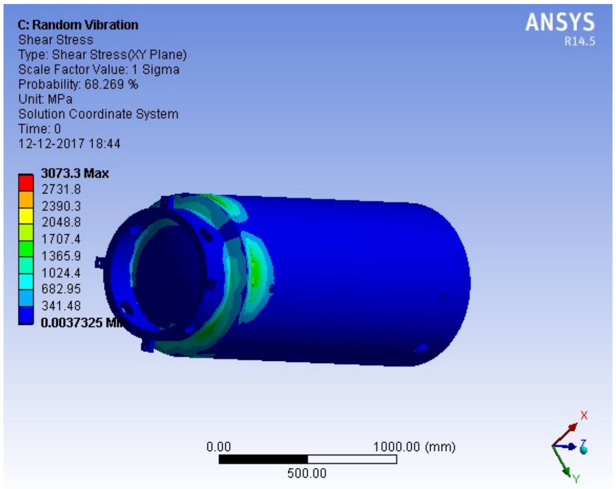


Fig: Shear Stress of Vertical Pressure Vessels using High Carbon Steel by applying internal pressure

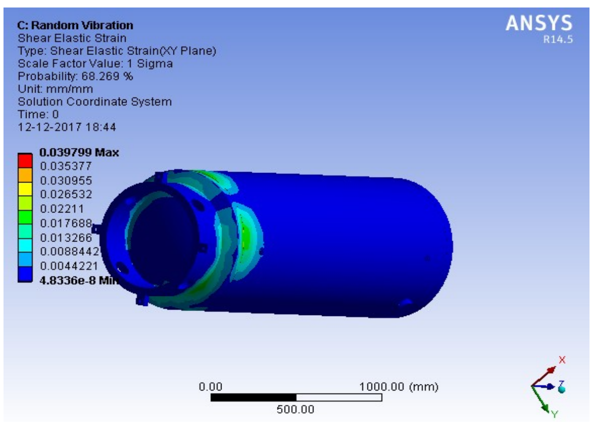


Fig: Shear Elastic Strain of Vertical Pressure Vessels using High Carbon Steel by applying internal pressure

BY APPLYING INTERNAL & EXTERNAL PRESSURES

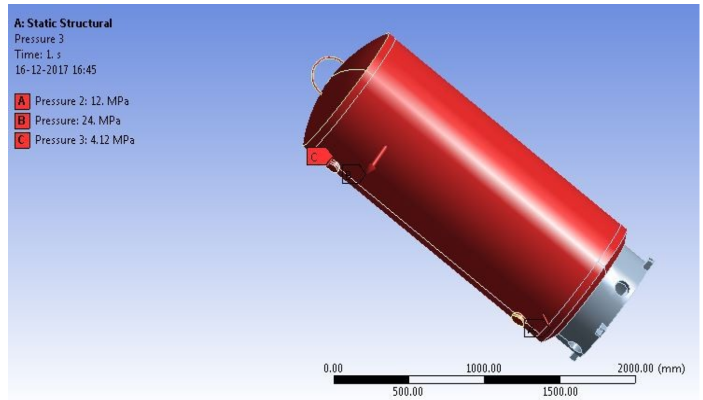


Fig: Pressure is applied internally and externally on the Pressure Vessel

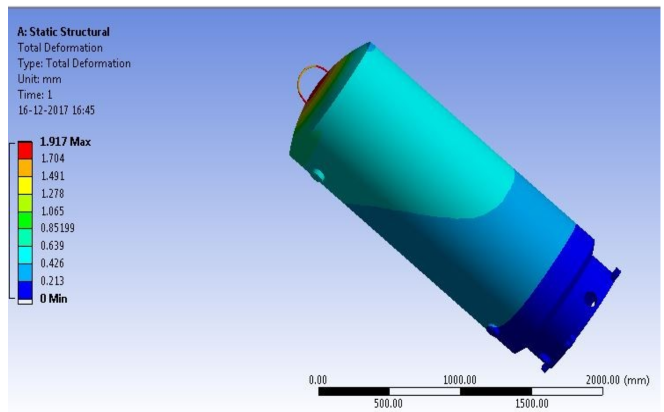
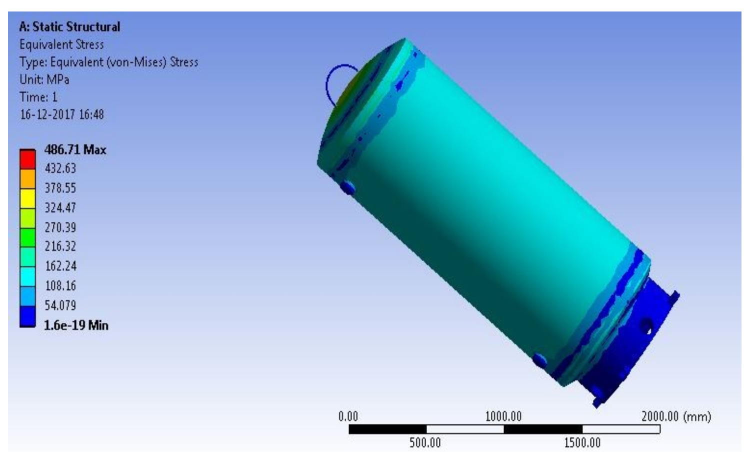


Fig: Total deformation of Vertical Pressure Vessel using High Carbon Steel by applying internal & external pressure



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p-ISSN: 2348-795X
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Fig: Stress of Vertical Pressure Vessels using High Carbon Steel by applying internal & external pressure

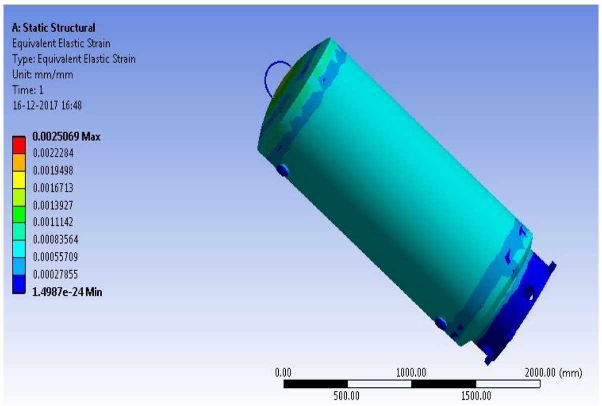


Fig: Strain of Vertical Pressure Vessels using High Carbon Steel by applying internal & external pressure

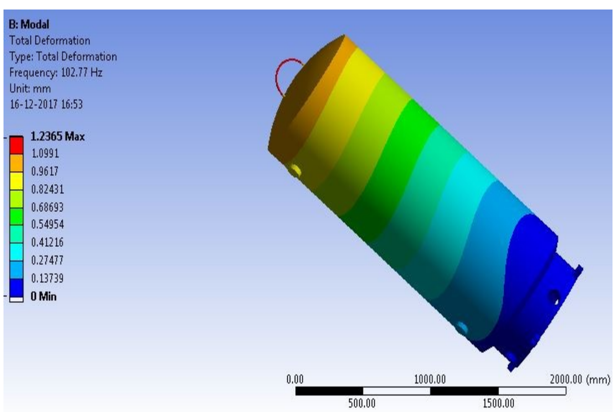


Fig: Mode-1 of Vertical Pressure Vessels using High Carbon Steelby applying internal & external pressure

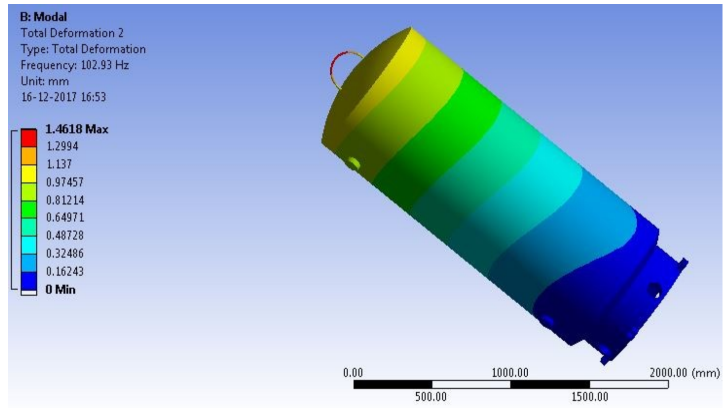


Fig: Mode-2 of Vertical Pressure Vessels using High Carbon Steelby applying internal & external pressure

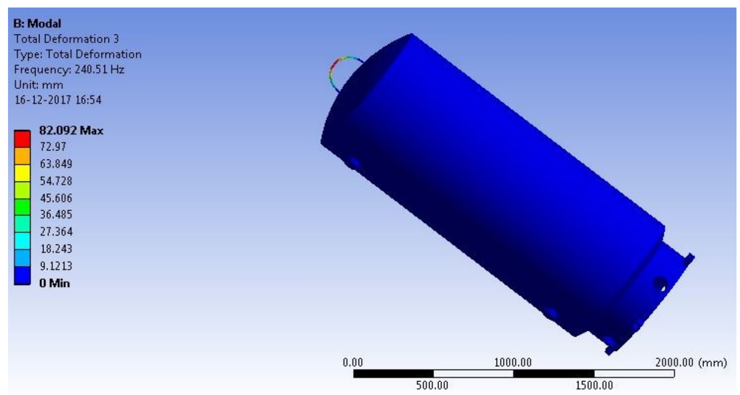


Fig: Mode-3 of Vertical Pressure Vessels using High Carbon Steelby applying internal & external pressure

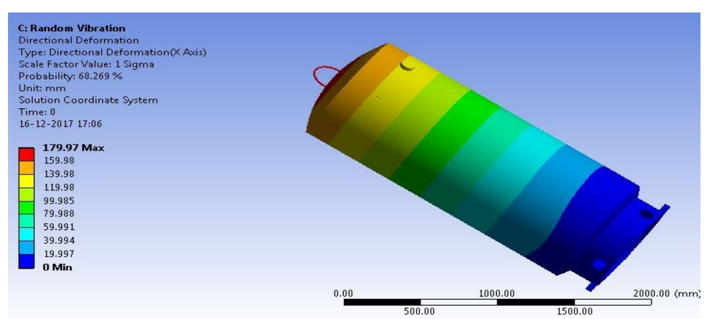


Fig: Directional Deformation Vertical Pressure Vessels using High Carbon Steelby applying internal & external pressure

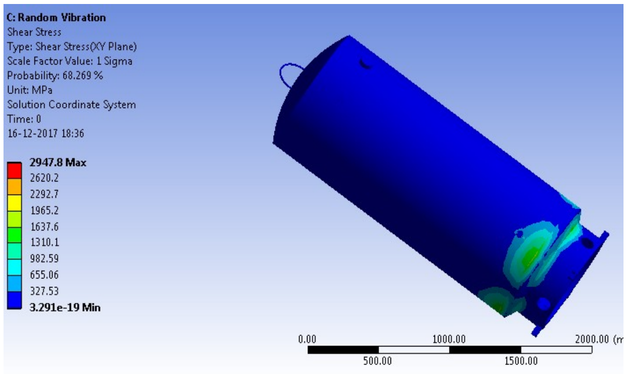


Fig: Shear Stress of Vertical Pressure Vessels using High Carbon Steelby applying internal & external pressure

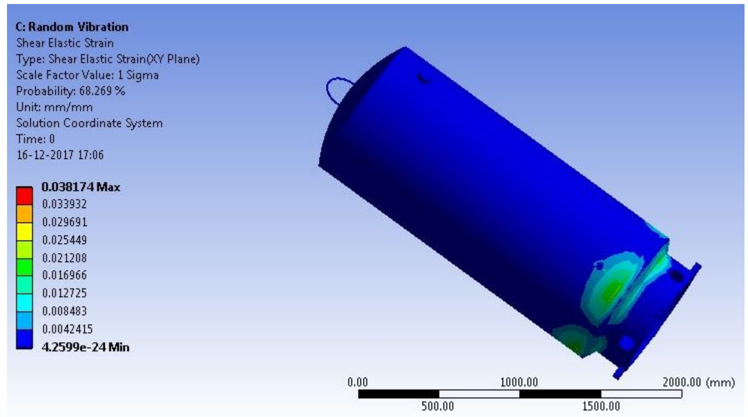
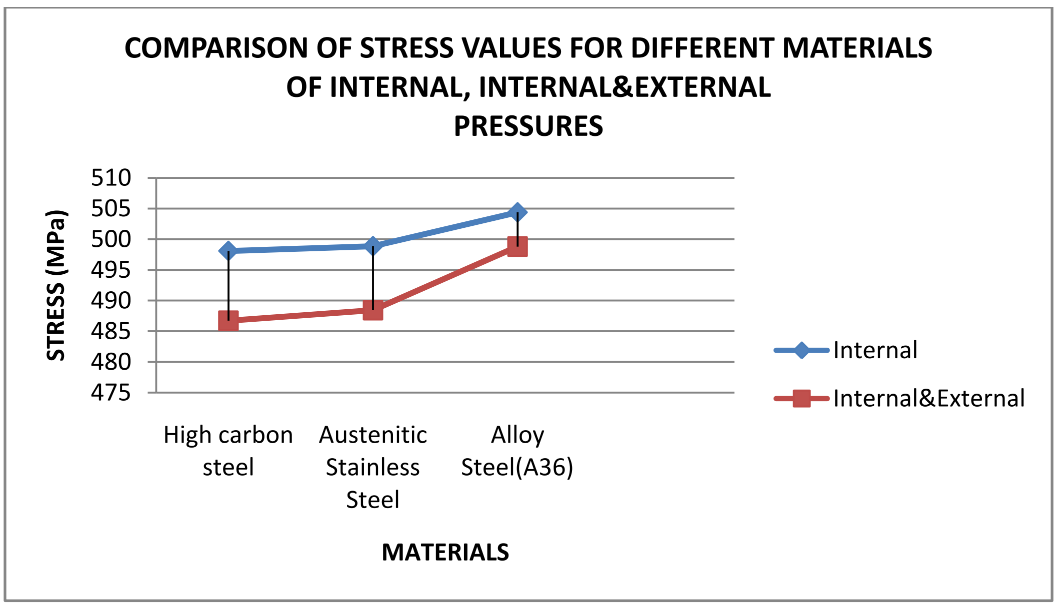
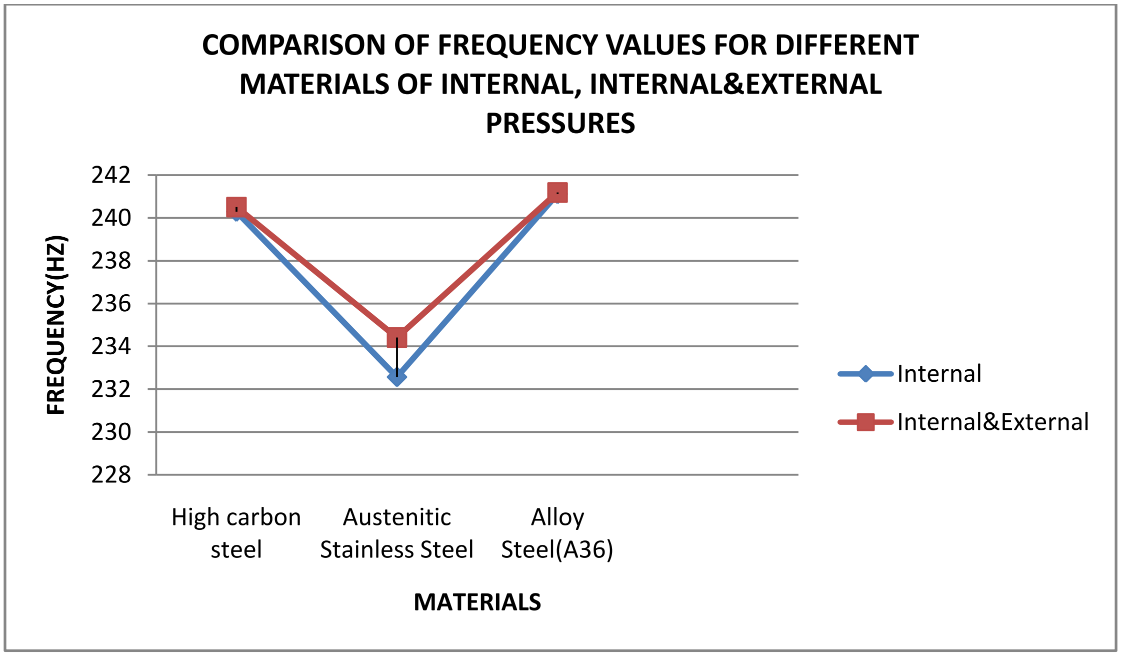
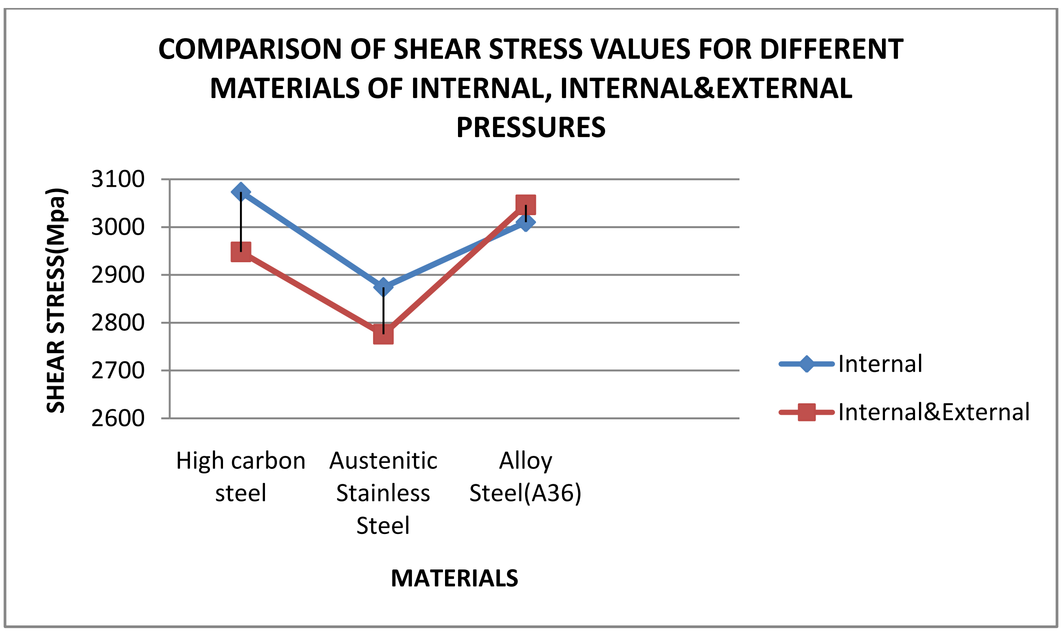


Fig: Shear Elastic Strain of Vertical Pressure Vessels using High Carbon Steelby applying internal & external pressure

GRAPHS FOR COMPARISION OF RESULTS OF INTERNAL, INTERNAL&EXTERNAL PRESSURES







CONCLUSION

By observing static structural analysis results, the stresses are reducing for internal + external pressures. The stresses are decreasing by applying internal + external pressures by about 2.282% for High Carbon Steel, by about 2.08% for Austenitic Stainless Steel and by about 1.1% for Alloy Steel when compared with by applying internal pressures.By observing modal analysis results, the frequencies are slightly increasing when internal + external pressures are applied than applying internal

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue-17
December 2017

pressures.By observing Random Vibration analysis results, the shear stresses are reducing for internal + external pressures. The stresses are decreasing by applying internal + external pressures by about 4.08% for High Carbon Steel, by about 3.41% for Austenitic Stainless Steel and by about 1.19% for Alloy Steel when compared with by applying internal pressures.

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