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Finite Element Modelling and Analysis of Pressure Vessel

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Abstract: In recent years, most of the sectors replace conventional materials with aluminium matrix materials. Various mechanical studies have been done, such as tensile, impact, flexural, and hardness. For the same geometrical parameters of the steel pressure vessel, FE Analysis of Structural Steel pressure vessel is carried out, and stresses for internal pressures are determined. And the Geometric Modelling is carried out in design software solid works and analyse in ANSYS workbench. The Structural analysis of pressure vessel was carried out. The validation for Hoop stress, Longitudinal stress& Maximum shear stress was done. Cylindrical pressure vessels are widely used for commercial, under water vehicles and in aerospace applications. And the Geometric Modelling is carried out in solid works. And analysed in ANSYS Workbench. The Comparison has done between FEM results and Theoretical results for Validation purposes. The Calculations for Hoop Stress, Longitudinal Stress & Maximum Shear Stress was Calculated for theoretical. The boundary conditions and dimensions for Modelling of a Pressure vessel was taken from the paper and same Boundary conditions was applied for analysis purposes. For Structural steel the design is safe because the stress value is within range of yield strength. The Material properties used are structural properties of steel for the analysis Purposes.

Keywords: FEM, Pressure vessels, Mechanical Properties, ANSYS, Structural analysis, Hoop Stress, Longitudinal Stress.

I. INTRODUCTION

Because many liquids and gases must be held under high pressure, pressure containers are crucial. To avoid explosions due to rupture, the vessel's strength is given special consideration. The design of the container for a given set of parameters is regulated in codes for the safety of such vessels. The majority of pressure vessels are made of tubes and sheets that have been rolled into cylinders because they are only needed to carry low pressures. Those storage spaces or compartments with a weight difference between the interior and the exterior were given the name pressure vessel. Pressure vessels are containers made for industrial use that are intended to hold liquids and gases. The design, production, and use of pressure vessels are governed by national and international codes. A cylinder with head-style end caps is a typical design for a pressure vessel. Domed heads and conical heads are the two different forms of heads for pressure vessels. To guarantee that the desired pressure is not exceeded during this procedure, safety valves and relief valves are included in pressure vessels.

II. METHOD AND METHODOLOGY

A numerical method for analysing structures and continua is the finite element method. Numerous simultaneous algebraic equations are developed via the finite element method. which are produced and resolved by a computer. The analysis of a pressure vessel is carried out using ANSYS workstation and ANSYS 14.5 software. and modelled utilising the software Solid Works. The entire development process of mechatronic systems takes place in Solid Works. The software is initially used for project management, planning, visual ideation, modelling, feasibility analysis, and prototyping. The design and construction of mechanical, electrical, and software components are then done using the software. Using the dimensions from the journal article, a pressure vessel was modelled using Solid Works software. In Solid Works, a pressure vessel is modelled with dimensions of 670 mm for the cylinder diameter, 1030 mm for the cylinder height, and 10 mm for the shell thickness. The analysis software ANSYS workbench used for analysing the pressure vessel using the boundary conditions and pressure is applied inside the pressure vessel of 3MPa and fixed support is given to the bottom of the cylinder. Importance of the work in this project is carried out using pressure vessel. Where pressure vessel is Modelled in a solid works software and then imported in the ansys workbench for the analysis of a pressure vessel. The calculations were carried for the thin cylinder and Hoop stress, Longitudinal Stress, Maximum shear stress calculated theoretically. For all these stresses analysis was carried out in ansys 14.5 software and obtained the values for maximum stress developed in the region of the cylinder. From the results obtained in ANSYS Software red colour indicates the maximum region & blue colour indicates the minimum region. For hoop stress the direction of stress is uniformly distributed over the wall thickness. For Longitudinal stress the direction of the longitudinal stress in a pipe is parallel to the longitudinal axis of its centreline axis, which means that the stress acts in the direction of the pipe's length.

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Table 1: Properties of Structural Steel

Sl. No	Parameter	Value
1	Density	7850 kg/m^3
2	Poissons Ratio	0.3
3	Shear Modulus	7.9615 E+10
4	Tensile Strength	360 MPa
5	Yield Stress	240 MPa
6	Young's Modulus	200 GPa

III. LITERATURE REVIEW

The Journal paper which was referred for this project work was the comparison of von Misses stress and deformation of composite materials at optimal angles and optimal layers. In order to forecast critical pressures with and without stiffeners, analytical data are compared. The two methods used to determine the minimal buckling load are compared. The comparison is based on analysis done with ANSYS 12.0, and the outcomes of finite element analysis and theoretical conclusions are compared.

The work carried out is different from the above reference paper. Where pressure vessel is modelled in a solid works software and analysed in ANSYS workbench using the boundary conditions as per the paper of 3MPa and given fixed support to the bottom of the cylinder. Equivalent Von misses stress, Deformation, Hoop Stress, Longitudinal Stress, Maximum shear stress has been calculated. Finally Validation has been done for FEM and Theoretical result.

A. Analysis

The pre-processed dataset serves as the finite element code's input. In the finite element approach, a collection of sub-divisions known as finite elements is used to represent the actual continuum or body of matter, such as a solid, liquid, or gas. In the finite element approach, a collection of sub-divisions known as finite elements is used to represent the actual continuum or body of matter, such as a solid, liquid, or gas. At particular junctions, referred to as nodes or nodal points, these elements are thought to be connected. One of the most enticing aspects of FEA is its ability to solve a variety of issues with the same code by just choosing the appropriate element types from a library. The nodes typically sit on the edges of elements where it is thought that they are connected.

B. Meshed Model

For the meshed model. The components are utilised to characterise the area that will be modelled. Nodes are joined to make elements. The quadrilateral element is used to mesh the cylinder. Additionally, 34251 nodes and 17008 components are discovered.

C. Boundary Conditions

The pressure of 3 MPa is applied inside the pressure vessel using the global coordinate system, which is defined for cylinders. And the bottom surface of the cylinder is given the fixed support.

IV. OVERVIEW

Comparing the results in terms of Equivalent von Misses Stress, Deformation, Hoop Stress, Longitudinal Stress, and Maximum Shear Stress serves as evidence for the created modelling and analysis. The cylinder's size is determined by the profile that may be found in the literature [2]. The cylinder is constructed using calculations based on a thin cylinder.

A. Validation Study

The current formulation of pressure vessel is investigated for validation and results are compared with FEM and Theoretical values. The analysis carried out by using the boundary conditions of the pressure vessel and support is applied to the bottom of the cylinder. Comparison of FEM & Theoretical results for Hoop stress, longitudinal stress Maximum shear stress has been done. For Hoop & Maximum shear values obtained is minimum percentage or difference error.

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B. Structural Analysis

The objective of a structural analysis is to determine how changes to the structure as a whole or in part will affect the ultimate limit states and serviceability limit states. Establishing a sensible distribution of internal forces, moments, stresses, strains, and displacements over the entire or a portion of a structure is the goal of a structural study. The Static Structural Analysis calculates the displacements, stresses, strains, and forces in structures or components brought on by loads with minimal inertia and damping effects. In Structural analysis is used for the analysis for the Stress, strain & deformation values. The analysis carried out is pressure vessel and calculated the Equivalent von misses stress and deformation, Hoop stress, Longitudinal stress, Maximum shear stress. In pressure vessel, the pressure will be present inside the vessel for the applied pressure of 3MPa. The Cylinder is meshed using Quadrilateral element.

V. RESULTS AND DISCUSSIONS

A. Equivalent Von misses Stress

The Von Mises criteria is a formula for integrating the three main stresses into an equivalent stress, which is then compared to the material's yield stress to determine the situation under which the material will fail.

Both the major stress and the individual stress components can be used to determine Von Mises stress. Since main stress makes Von Mises stress easier to visualise, it is more frequently utilised in stress calculations. For the given dimension, Design is safe because the stress value is within range of yield strength.

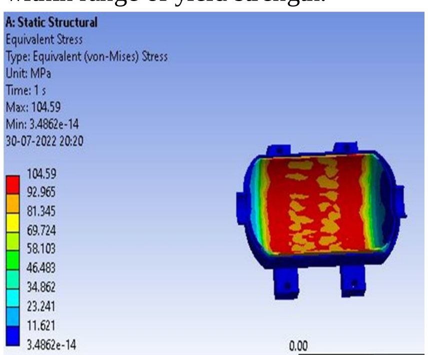

Figure 1. Equivalent von misses Stress

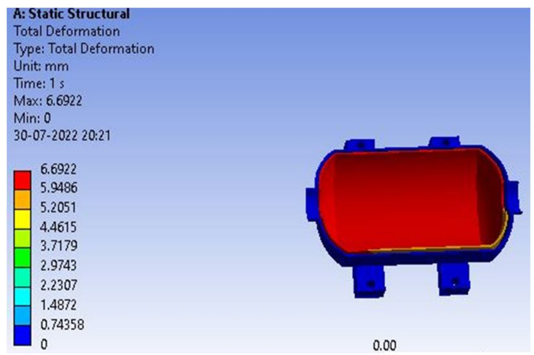

Figure 2. Deformation

B. Deformation

The term "deformation" describes how an object changes in size or shape. Displacements are the total shift in an object's location at a certain point. The relative alteration of an object's exterior displacements is known as deflection. The deformation option known as total deformation allows you to view all deformation results pertaining to the model in three coordinates (X, Y, and Z).

C. Hoop Stress

While the longitudinal stress increases with pipe length, the hoop stress causes the pipe's diameter to increase. When a cylinder is under internal pressure, the hoop stress created is twice as great as the longitudinal stress. The relationship between hoop stress and the pipe's diameter and wall thickness is that its amplitude changes as these parameters change. Hoop or circumferential stress is the term for the tensile stress that is created in the cylinder's wall along its circumference.

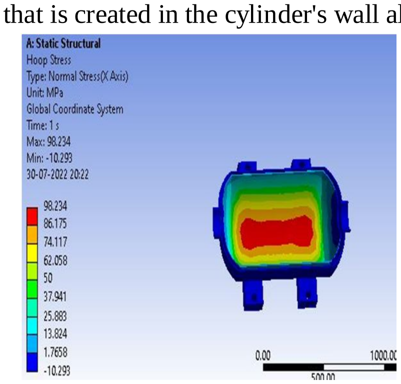

Figure 3. Hoop Stress

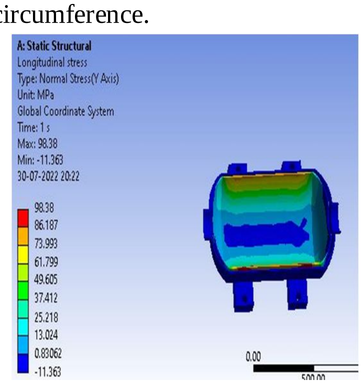

Figure 4. Longitudinal Stress

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D. Longitudinal Stress

The tension that results from subjecting a pipe to internal pressure is known as longitudinal stress. A pipe's longitudinal stress acts in the direction of the pipe's length because it runs parallel to the longitudinal axis of the pipe's centreline axis. Tensile longitudinal tensions are categorised as normal stresses. Longitudinal stress is the tensile stress that is applied to the wall along its longitudinal path.

E. Maximum Shear Stress

The terms "maximum stress" and "minimum stress" both refer to the maximum tensile stress and the minimum compressive stress, respectively. The absolute difference between the maximum and least stress was used to define the stress range. The neutral axis is where there is the most shear stress. The shear stress value decreases until it reaches zero at both extremes as the point is displaced from the neutral axis.

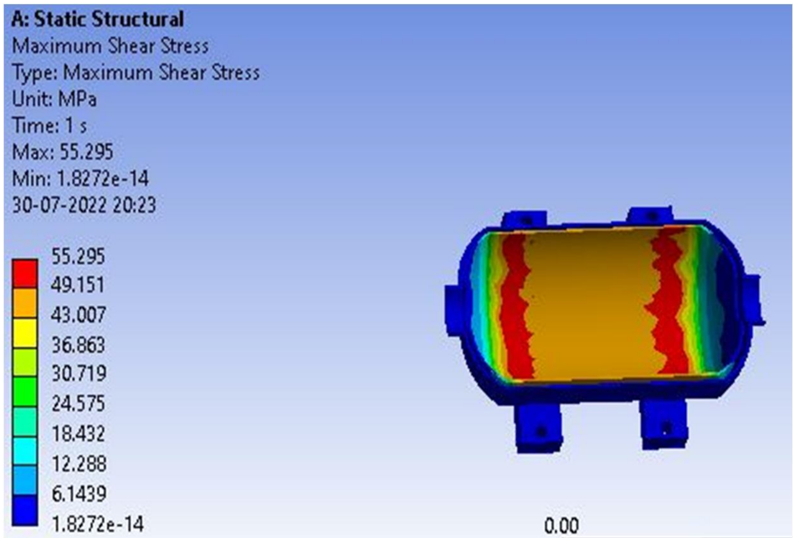

Figure 5. Maximum Shear Stress

Table 2. Results

	Equivalent von misses Stress(MPa)	Deformation (mm)	Hoop Stress (N/mm^2)	Longitudinal Stress (N/mm^2)	Maximum Shear Stress(MPa)
Theoretical	-	-	100.5	50.25	50.25
FEM Results	104.59	6.6922	98.234	98.38	50.295

Table 3. Difference between theoretical and FEM

Variables	Difference
Hoop Stress	2.266 N/mm^2
Longitudinal Stress	48.13 N/mm^2
Maximum Shear Stress	0.045 N/mm^2

VI. CONCLUSION

Finite element analysis was carried out for the pressure vessel and the values for Equivalent von misses stress in ANSYS workbench and obtained the value as 104.59 MPa. For Structural steel the design is safe because the stress value is within range of yield strength. Validation has been done by comparing with FEM results &Theoretical results. For Hoop Stress and maximum shear stress obtained the minimum error percentage values or the difference such as 2.266 N/mm^2 and 0.045 MPa. For Longitudinal stress obtained more error percentage value compared to Hoop and maximum shear stress such as difference value of 48.13 N/mm^2.

REFERENCES

[1] S.A. Sajjadi, H.R. Ezatpour, M. Torabi Parizi, Mater. Des. 34 (2012) 106–111 and "Modelling and stress analysis of aluminium alloy based composite pressure vessel through ANSYS software.'' International Journal on Emerging Technologies 11(3): 278-280(2020)

[2] Alexis A. Krikanov., "Composite pressure vessels with higher stiffness," 1999 Elsevier science Ltd. Composite structures, vol-48, pp 119-127 (2000).

[3] McLaughlin P Forth S., and Grimes L. Report "composite overwrapped pressure vessels," a primer. NASA/SP-2011-573 (2011).

[4] McLaughlin p. Forth S, "A study of residual burst strength of composite over wrapped pressure vessel due to low velocity impact," International Journal of Pressure Vessels and Piping 194 (2021) 104511

[5] Rao Yarrapragada K.S. S, Krishna Mohan, B. Vijay Kiran, "Design Optimisation of a Composite Cylindrical Pressure Vessel Using FEA," International Journal of Scientific and Research Publications, Volume 5, Issue 12, December 2015 522 ISSN 2250-3153.

[6] M. Jadav Hyder, M Asif, "A Review Paper on Pressure Vessel Design and Analysis," International Journal of Engineering Research & Technology (IJERT) IJERT ISSN: 2278-0181 Vol. 3 Issue 3, March – 2014.

[7] Shah Alama, Gregory R. Yandek, Richard, Lee, Joseph Mabry, "Design and development of a filament wound composite overwrapped pressure vessel," Composites Part C: Open Access 2 (2020) 100045.

[8] Deva Raju, A., and Pazhanivel, K., (2015), "A study on stress analysis for design of pressure vessel," International journal of mechanical and production engineering, 3(11), pp. 98-101.

[9] Nitin Chandra, R, Patel., Avinash, vasava., Jalesh, vasava., alpesh, kunapura., and savan, patel., (2013), "Design and analysis of pressure vessel amalgamating with selection of material used in marine applications," International Journal of Innovative Research in Science, Engineering and Technology, 6 (2), pp. 2035 – 2042 3.

[10] Sadanandam., Ramesh., and Samuel Tamerat., (2017), "Design and Analysis of pressure vessel using finite element method," International journal of latest technology in engineering, management and applied science (IJLTEMAS), 5(6), pp. 1-3.

[11] Sandeep gond., Akhilesh., Anoop, singh., vinod, Sharma., and shyaam, Bihari, lal., (2004), "Design and analysis of the pressure vessel," International Journal of scientific and engineering Research, 4(5), pp. 939-942.

[12] Sheik, Abdul, Lathuef., and K Chandra, Sekhar, K., (2012), "Design and structural analysis of pressure vessel due to change of nozzle location and shell thickness," International journal of advanced engineering research and studies., 2(1), pp. 1-4.

[13] Goran Vukelica, Goran Vizentina, Zeljko Bozicb, Luka Rukavina. "Failure analysis of a ruptured compressor pressure vessel." International Journal of Fatigue 112, 301-307.

[14] Sugaring Kushwah, Shreyashkumar Parekh, Harsh Mistry, Jainil Daria, Rutvik Gandhi. "Analysis of cylindrical pressure vessels with dissimilar ends and material comparison." Materials Today Proceedings xxx (xxxx) xxx.

[15] Ali Mehmanparast Kamran Nikbin. "Local creep damage effects on subsequent low temperature fatigue crack growth behaviour of thick-walled pressure vessels." Engineering Fracture Mechanics 272 (2022) 108720.