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Design and Analysis of Multilayered Pressure Vessel

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A B S T R A C T

In thermal and nuclear power plants, the chemical and process industries, house and ocean depths, and fluid supply techniques in industries, pressure vessel cylinders find extensive applications. The permissible pressure for the weld force, represented as weld efficiency, is just right design follow. The ratio of the longitudinal (axial) force of a welded joint to the longitudinal force of the pipe or tank shell is known as efficiency. This thesis uses the ANSYS finite element analysis programme to analyse the pressure vessel's strength and design it based on the weld efficiency. When designing a pressure vessel, mathematical correlations will likely be taken into consideration. The organisation will target the design parameters based on the desired weld efficiency. CATIA will be used to complete the modelling. An ANSYS analysis of the pressure vessel with various composite materials will be conducted. Static analysis will be used in this project to find the strain, stress, and deformation. Using EN 32 Steel, Carbon fibre, and E-glass fibre materials, fatigue analysis is used to calculate the pressure vessel's life, damage, and safety factor. Using EN 32 Steel, Carbon fibre, and E-glass fibre materials, thermal analysis is used to calculate the temperature distribution and heat transfer rate per unit area of the pressure vessel. Finding the stress, deformation, and strain at various layer stackings, such as layers 3, 6, 9, and 12, is the purpose of linear layer analysis.

Keywords: CATIA, ANSYS, EN 32 Steel, Carbon fiber and E-glass fiber materials

INTRODUCTION

A container intended to hold gases or liquids at a pressure significantly different from the surrounding air is called a pressure vessel. Because of their potential for danger, pressure vessels have been involved in several tragic incidents during the course of their invention and use. As a result, laws support engineering authorities in their regulation of pressure vessel design, manufacture, and operation. Because of these factors, the definition of a pressure vessel differs between nations. Principal Components of a Pressure VesselPressure Vessel Shape Although practically any shape can be used for pressure vessels, sections of spheres, cylinders, and cones are the most common shapes. A typical design is a cylinder with heads on the ends. Head shapes are typically hemispherical or dished; more complex shapes are typically far more challenging to construct and have historically been much harder to analyse for safe operation. In theory, a spherical pressure vessel with the same wall thickness and optimal shape for holding internal pressure is roughly twice as strong as a cylindrical pressure vessel. But because spherical shapes are more expensive to produce and more difficult to make, most pressure vessels are cylindrical with 2:1 semi-elliptical heads or end caps on both ends.Introduce the paper here, and if needed, include a nomenclature in a box using the same font size as the body of the document. From this point on, the paragraphs are only broken up by headings, subheadings, formulas, and images. The section headings are bold, 9.5 point, and numbered in order. Here are some additional guidelines for writers.

CATIA is a powerful modelling tool that integrates 2D tools with 3D parametric features and covers all design-to-manufacturing processes. CATIA can be used to generate orthographic, section, auxiliary, isometric, or detailed 2D drawing views in addition to solid model sand assemblies. In the drawing views, model and creature reference dimensions can also be generated. The property of bi-directional associativeness in CATIA guarantees that deifications of themes made in the model are mirrored in the drawing view and vice versa.

Structural analysis

ANSYS is computer simulation tool for simulating the response of materials to short duration severe loadings from impact, high pressure or explosions.

Ansys mechanical

A finite element analysis tool for structural analysis, including dynamic, nonlinear, and linear studies, is Ansys Mechanical. This computer simulation programme supports material models and equation solvers for a variety of mechanical design problems, and it offers finite elements to simulate behaviour. Thermal analysis and coupled-physics capabilities encompassing acoustics, piezoelectric, thermal-structural, and thermo-electric analysis are also included in Ansys Mechanical. Components of the Pressure: Ship Steel is a common material for pressure vessels. It would be necessary to weld rolled and possibly forged parts together to create a cylindrical or spherical pressure vessel. If extra care isn't taken, welding may negatively impact some of the mechanical properties of steel that were obtained through rolling or forging. Modern standards require the use of steel with a high impact resistance in addition to sufficient mechanical strength, particularly for vessels used in cold temperatures. Special corrosion-resistant materials should also be used in applications where carbon steel would corrode. Certain composite materials, like filament wound composite made of carbon fibre bound together by a polymer, are used to make pressure vessels. These vessels can be extremely light due to the high tensile strength of carbon fibre, but their manufacturing is far more challenging. A composite overwrapped pressure vessel can be created by winding the composite material around a metal liner. Copper in plumbing and polymers like pet in carbonated beverage containers are two other extremely common materials.

LITERATURE REVIEW

P. Xu et al. [2009] Finite element analysis of burst pressure of composite hydrogen storage vessels. In this research ,a3 parametric finite element model is proposed to predict tthe damage evolution and failure strength of the composite hydrogen storage vessels, in which a solution algorithm is proposed to investigate the progressive damage and failure properties of composite structures with increasing internal pressure. The maximum stress, offman,tsai–hill and tsaiwu failure criteria which are employed respectively to determine the failure properties of composite vessels are incorporated into the numerical method as individual subroutines. Parametric studies in terms of the effects of different failure criteria are performed and the calculated failure strengths of composite vessels are also compared with the experimental results.

T.Aseerbrabinetal.[2011]Examined different existing predictive equation swhich are used to predict burst pressure by utilizing test data on different steelvessels. They found that faupel's bursting pressure formula is simple and reliable in predicting the burst pressure of thin and thick-walled steel cylindrical vessels. They suggested that variation in burst pressure values may be attributed to variation in strength properties of vessel material.

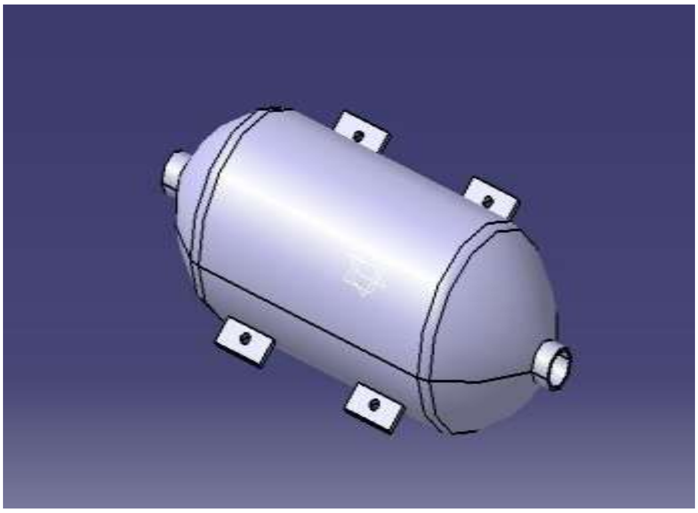
E.s. barbozaneto et al.[2011] Investigated the behaviour of pressure vessel liner under burst pressure testing. They used liner with polymer blend of 95% ldpe and 5% hdpe which is to be used in all composite carbon/epoxy compressed natural gas shell manufactured by filament winding process. Designing and failure prediction of composite laminate shell and liner were basedontsai-wu and vonmissescriteriar espectively. Liner so fdifferent thickness were tested in hydrostatic burst pressure testing machine. FEA simulations were conducted using abacus/cae6.8 in which model was meshed by using cax4r elemen ttype.

MATERIAL AND METHODS

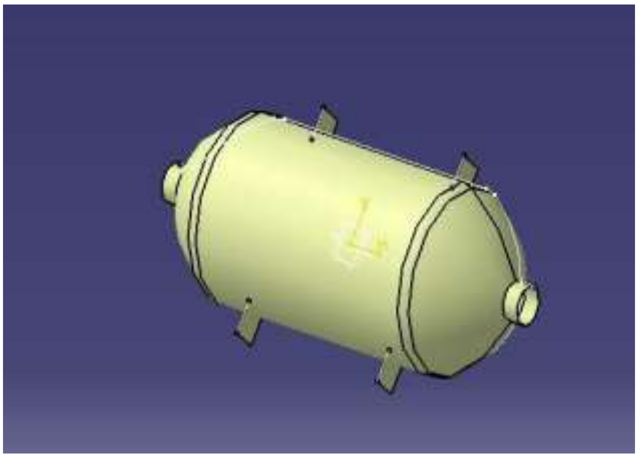
EN 32STEEL : EN32 (080M15) is a bright drawn engineering steel with low tensile strength and is intended foruseingeneral engineering applications, particularly for low stressed components. It is classed as an unalloyed low carbon engineering steel grade, when case hardened the material offers a hard, outer surface with tough internal core. Tempering of EN32 is recommended to offer maximum case toughness and stress relief with a tempering range from 150 – 200°C. A core strength of up to 490 N/mm² can be achieved for components when carburised. EN32 should be considered for any lightly stressed applications where good wear resistance is a consideration. Other engineering steels should be considered where extra strength is required Material properties of EN 32 steeYoung's modulus = 206000mpa Poisson's ratio = 0.29Density = 0.000007kg/mm3

Carbon Fiber

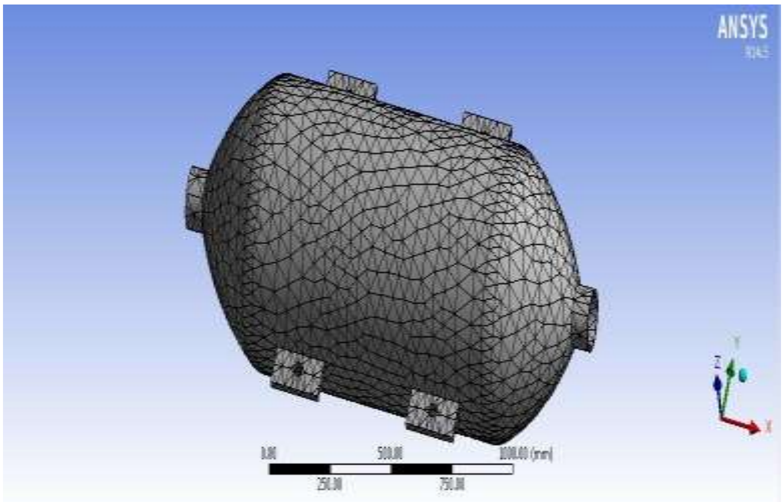
In fiber reinforced composites, fiber glass is the "workhorse" of the industry. It is used in many applications and is very competitive with traditional materials such as wood, metal, and concrete. Fiber glass products are strong, lightweight, non-conductive, and the raw material costs of fiber glass are very lowor for cosmetics, then other more expensive reinforcing fibers are used in the frp composite



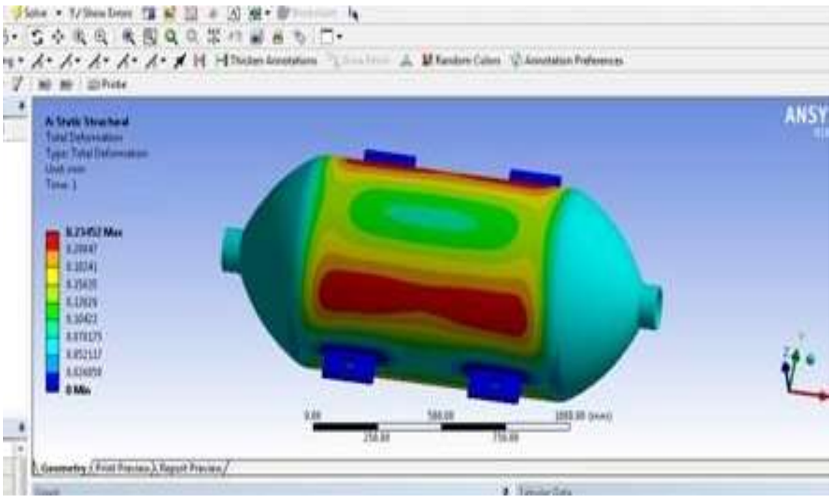
Solid model of cylindrical pressure vessel -I



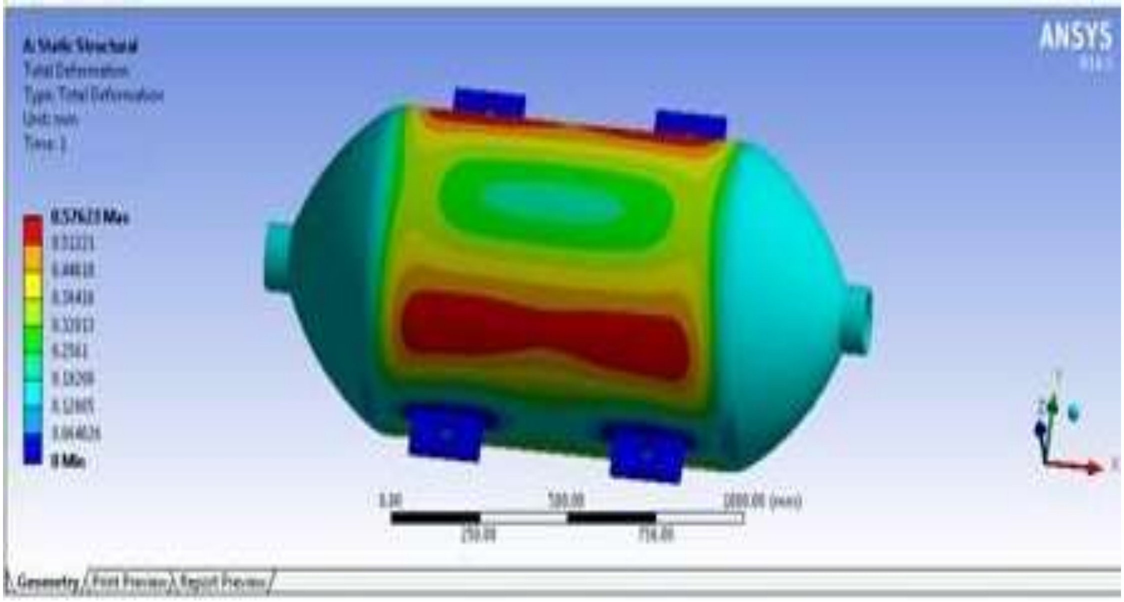
Solid model of cylindrical pressure vessel -II



Meshing of pressure vessel



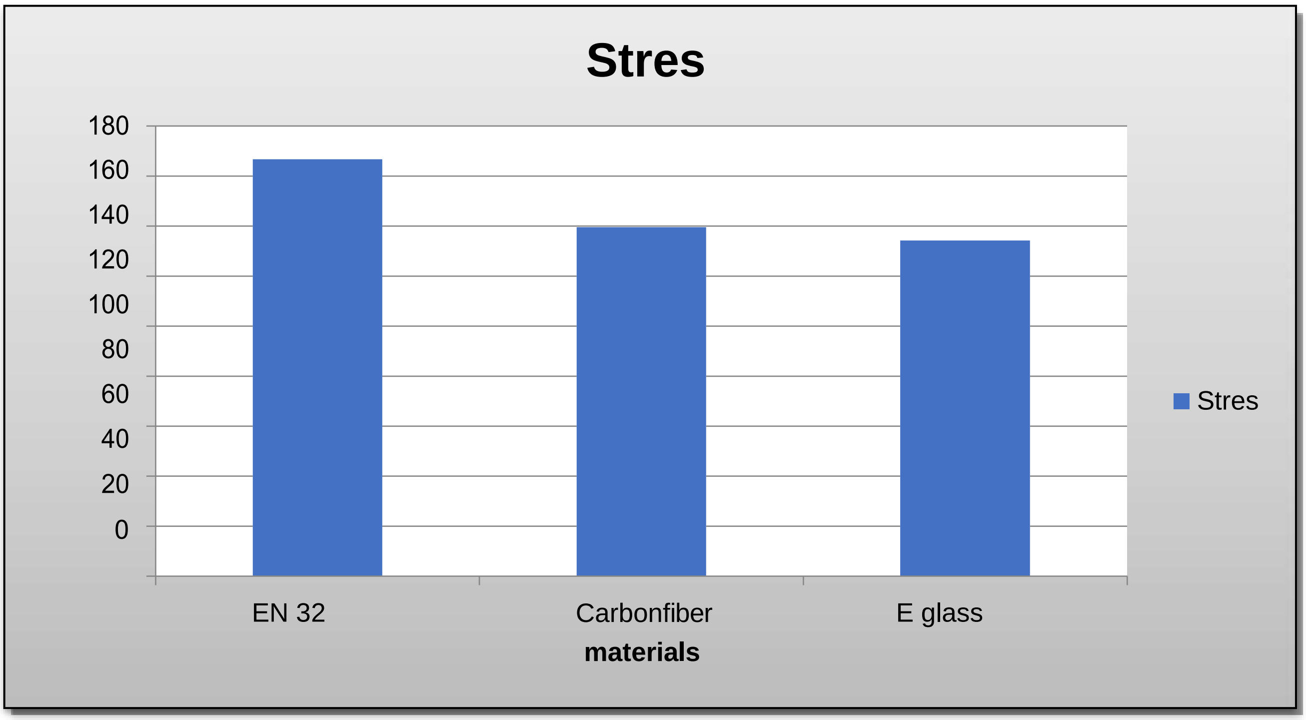
Total deformation for EN32 steel



Total deformation for Carbon fiber

RESULTS

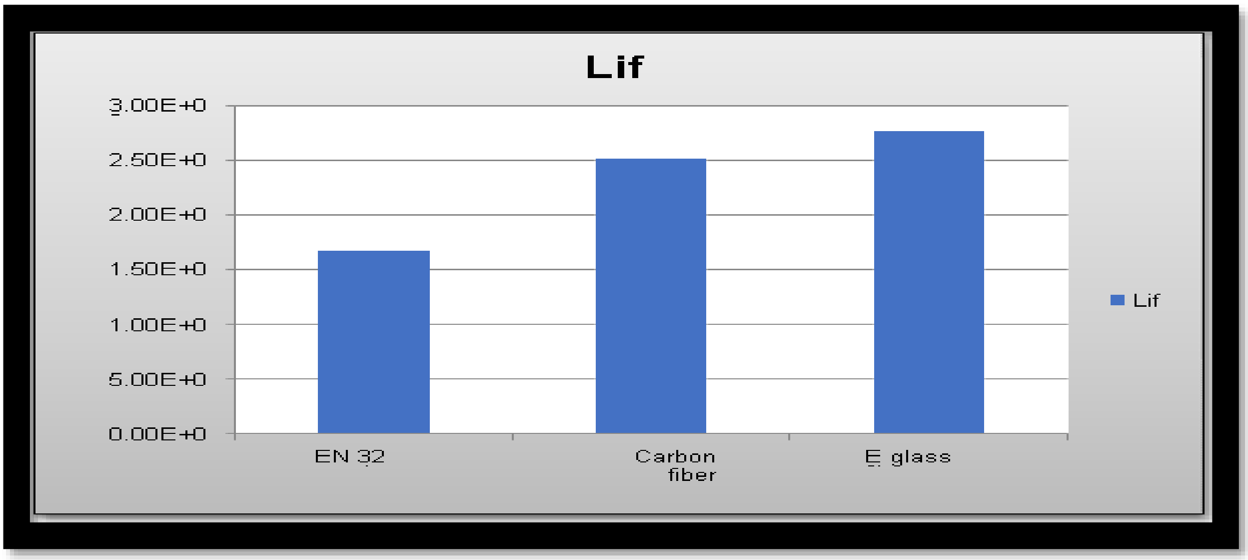
Material	Deformation (mm)	Stress (n/mm^2)	Strain
En 32 steel	0.23452	166.73	0.00083952
Carbon fiber	0.57623	139.64	0.0020695
E glass fiber	0.49539	134.21	0.0017375



Graph between Static analysis Stress andMaterials

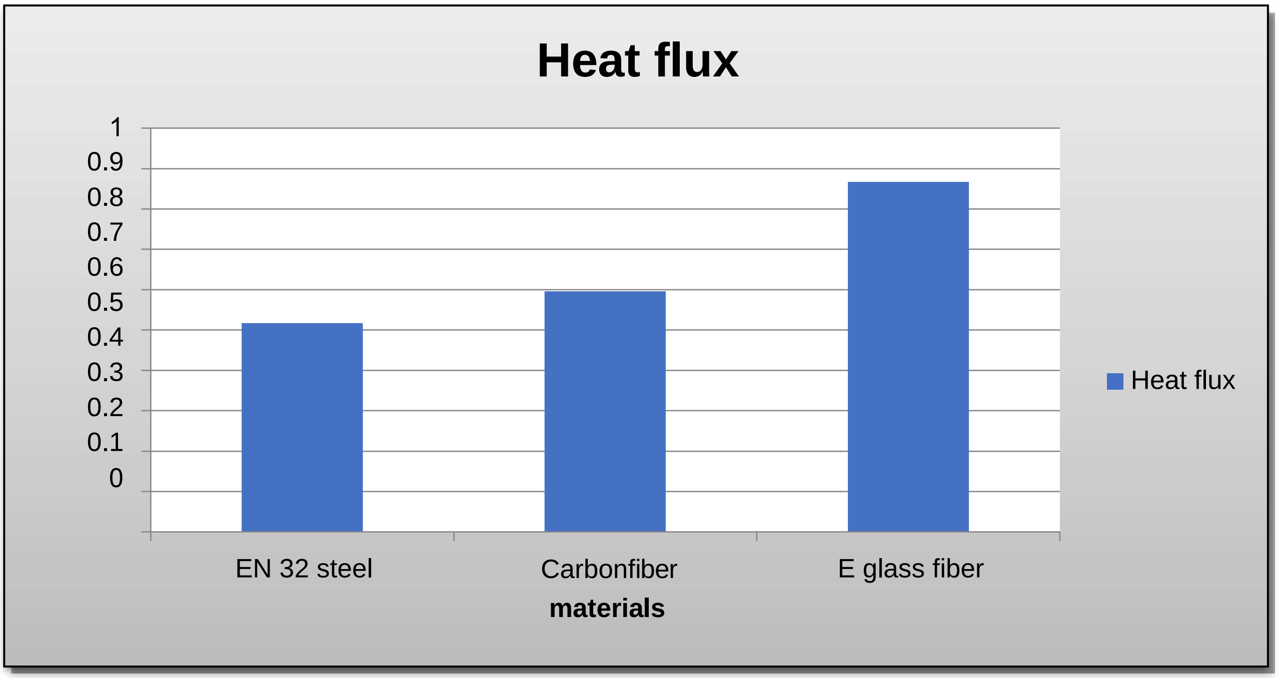
Material	**Life**	**Damage**	**Safety factor**
En 32 steel	$1.67e^{6}$	1323.9	0.13442
Carbon fiber	$2.52e^{6}$	834.72	0.16051
E glass fiber	$2.77e^{6}$	752.99	0.16699

Graph between Fatigue analysis Life and Materials



Graph between Fatigue analysis Safety factor and Materials

Material	**Temperature distribution(°c)**		**Heat flux(w/m²)**
	Min	**Max**	
En 32 steel	29.886	300	0.51658
Carbon fiber	30.00	300	0.5958
E glass fiber	30.002	300	0.86702



Graph between Thermal analysis Heat flux and Materials

CONCLUSION

In this thesis, the pressure vessel is designed according to the standards and analyzed for its strength using finite element analysis software ansys. Modeling will be done in CATIA parametric software.

1) Structural, linear layer, thermal, fatigue and linear buckling analysis is done in ANSYS on the pressure vessel with different materials and layers tacking.

2) By observing the static analysis, the stress values are decreased at E-glass fiber when compared other two materials (en 32 steel and carbon fiber).

3) In fatigue analysis, life of the pressure vessel is good at E-glass fiber comparing EN32 Steel and Carbon fiber.

4) By observing the thermal analysis results the heat dissipation is more for E-glass material compare with EN32 Steel and Carbon fiber materials.

5) In the linear layer analysis results, the stress values are less at 12 layers stacking pressure vessel model when compared to conventional model.

So it can be concluded that the E-Glass fiber material is better material and 12 layers stacking is more efficient for pressure vessel.

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