IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

DESIGN AND STRUCTURAL ANALYSIS SUBMARINE AUV PRESSURE HULL WITH DIFFERENT MATERIALS

[1] Asso. Prof. Rahul D. Shelke, [2] Pathan Aawej Aaphajal
[1] HOD, Associate Professor, [2] ME Student
[1, 2] Department of Manufacturing Engineering,
[1, 2] EESGOI, Aurangabad, India

Abstract: An AUV is a robot designed specifically to operate in water without the need for human intervention. AUVs are a subset of the wider category of underwater devices known as UUVs. High hydrostatic pressures can cause the buckling collapse of an autonomous underwater vehicle's (AUV) typically cylindrical shell construction before yield stress failure. Welded stiffeners boost buckling resistance in larger submarines but lower internal volume and generate residual strains in smaller AUVs. By proposing the use of sliding stiffeners as part of the frame used to house the electronics inside the vessel, this study aims to offer a novel approach for the structural design of an AUV pressure vessel. The pressure vessel for an AUV was designed in catia and analyzed in Ansys; the material used was sand-which beams.Four total cases were used in this study. CASE 1: 2mm Steel + 2mm Rubber +2mm Steel. CASE 2: 2.5mm Steel + 1mm Rubber +2.5mm Steel.CASE 3 :2mm Ti64Al + 2mm Rubber +2mm Ti64Al.CASE 4 : 2.5mm Ti64Al + 1mm Rubber +2.5mm Ti64Al.The results of the static study of the stresses, strains, deformations, and shear stresses in a pressure vessel led to the following conclusion: Find the modes in modal analysis by looking at Deformation as a Function of Frequency.

***Index Terms* - ANSYS, Static Modal Analysis, Assembly Analysis AUV, Stress..**

Introduction

Autonomous underwater vehicles (AUVs) are robotic vehicles that can be programmed to navigate the ocean without human intervention in real time. Some AUVs allow for some human oversight by transmitting satellite signals or underwater acoustic beacons to human operators on a periodic or continuous basis.When scientists use AUVs, they may send the vehicle off to collect data from the ocean's surface or depths while they focus on other studies aboard the ship. Some autonomous underwater vehicles (AUVs) have the ability to reason about their surroundings and adjust their mission profile accordingly.

In 1957, Stan Murphy, Bob Francois, and subsequently Terry Ewart created the first autonomous underwater vehicle (AUV) at the University of Washington's Applied Physics Laboratory. The outer hull of a submarine, known as the light hull (casing), provides hydrodynamic efficiency through its design but does not hold pressure difference. The inner hull of a submarine is called the pressure hull because it stores the pressure differential between the ocean and the sub's interior. Submarines and AUVs rely on their pressure hulls as their primary load bearing structure. The compressive forces of hydrostatic pressure need a special kind of construction known as a "pressure hull." Pressure hulls are often made up of a mix of ring-stiffened cylinders and cones with spherical or torispherical domes at each end, as these geometries are the most effective at resisting these compressive stresses.

Due to the intense pressure conditions and extremely low tolerances required, the design and production process of a pressure hull is a challenging technical task. The pressure hull was developed using ASME guidelines and simulated using the Finite Element Method (FEM).

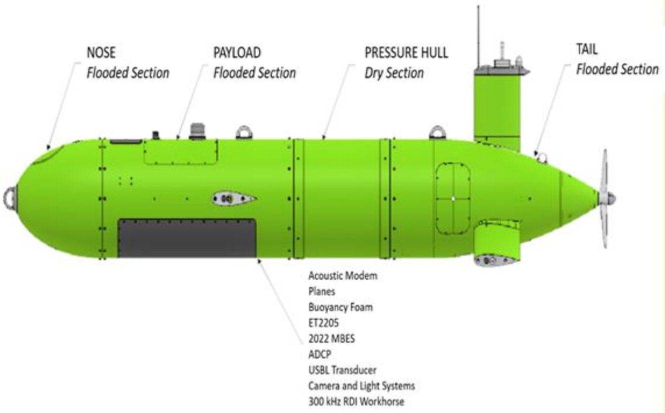


Figure No 1.1: Outer part of AUV

For the pressure hull, we chose stainless steel for its superior mechanical qualities and great corrosion resistance, and we paired it with two acrylic spheres. Even the earliest and smallest contemporary submarines and submersibles have a single hull. However, the methods have diverged for huge submarines. Each and every one of the Soviet Union's heavy submarines features a dual hull design. A robust hull, or pressure hull, with normal atmospheric pressure inside sits beneath the protective outer hull. Pressure hulls are often built out of thick, high-strength steel with a complicated structure and high strength reserve, and are divided up into multiple compartments by watertight bulkheads. Because the pressure and light hulls are joined, the resulting three-dimensional structure is far more robust. Some of the machinery that doesn't need a continual supply of pressure is housed in the inner hull. Submarines' lists vary widely, but usually consist of things like a variety of water and oxygen tanks. Light hull and pressure hull of a single-hull submarine look identical save from the front and back. The phrase "pressure hull" refers to the inner hull of a submarine that maintains a pressure that is roughly equivalent to atmospheric pressure when the submarine is submerged. Construction of a pressure hull is a challenging endeavor. The hull of a submarine, no matter how big, needs to be built with extreme accuracy. In spite of the stiffener rings' best efforts, even a one-inch (25 mm) out of roundness reduces the hydrostatic load by more than 30 percent.

LITERATURE SURVEY

Specifically, Arentzen and Mandel [1]. All current and historical tiny submarines and submersibles are monohull vessels. However, the methods have diverged for really large submarines. The hulls of all Soviet heavy submarines are designed to work together as a pair. A submarine's pressure hull is its interior, where atmospheric pressure is kept at around sea level when the sub is submerged. Submarines are built to function at extreme depths. Since the submarine's strength is the primary concern, the Hull structure has taken on more significance. Submarines experience a rise in external water pressure while submerged, but internal pressure remains constant at one atmosphere.

McDaniel, [2]. The paper "Structural Analysis and Design of Pressure Hulls: the State of the Art and Future Trends" [3] by John R. MacKay explains that pressure hulls are the primary load-bearing structures of submarines used for military, scientific, and commercial purposes. This document is occasionally concerned with the entire collection of thin-walled curved structures designed for unreliability, hereafter referred to as buckling-critical shells, because of the many similarities between pressure hulls, some civil engineering structures, offshore, and aerospace. This document accepts the modern methods of structural analysis and design for pressure hulls by doing the following: 1) reviewing novel design procedures for buckling critical shell structures; 2) elaborating on the nature of structural strength, and associated weaknesses, in pressure hulls; 3) providing a summary of both classical and modern structural analysis and design techniques for pressure hulls; and 4) identifying trends in numerical modeling of buckling-critical shell structures. It is stated that nonlinear numerical approaches for strength forecast might improve the present design approach's layered conservatism, and that this would pave the way for pressure hull design. A study by Liam Gannon [4] entitled "Prediction of the Effects of Cold Bending on Submarine Pressure Hull Collapse" provides an explanation of how cold bending may cause a submarine's pressure hull to collapse. Cold bending is used to form the frames and shell plating of submarines. Significant residual stress is introduced in these components during cold bending, which may compromise the integrity of the structure. Methods to consolidate cold bending residual stresses in the assessment of pressure hulls taking into account non-circular mode shapes are compared and contrasted in this work. Several techniques for analyzing the collapse of a pressure hull, taking into account both interframe and global collapse modes, are examined and contrasted. Empirical methods, finite difference methods, and finite element methods are among examples. When contrasted with results from finite element analysis, collapse pressures anticipated using the procedures stipulated in the UK MoD submarine structural design standard, SSP 74, are found to be conservative. Explicit modeling of the cold bending process yields collapse pressure predictions that are in good agreement with those obtained using effective stress-strain curves to account for the influence of cold bending residual stress and finite element models. This shows that the effects of cold bending residual stress on the collapse pressure of a submarine pressure hull may be adequately accounted for by employing effective stress, strain curves. To effectively and efficiently address structural issues, finite elements are needed. Linear, nonlinear, and structural stability issues are all amenable to FEM's analysis. UNIGRAPHICS uses the FEA program ANSYS to model the structure, analyze the hypermesh, and provide design documents. ANSYS is multifaceted structural analysis software that is commonly applied to maritime constructions.It's a powerful tool for pre- and post-processing hyper mesh synthesis from geometry alone to create virtually any element type. Beam elements are used to simulate stiffeners, whereas shell elements are used to model a cylinder's shell (Paleti Srinivas et al, [5]). ANSYS uses the Newton Raphson method to address nonlinear issues. [6] (Prabu) et al. The loads in this issue are presented as a series of load increases. The improvements to the load are spread out throughout a number of load stages. The procedure is repeated until there is no longer an issue.

A article by Liam Gannon [7] titled "Prediction of the Effects of Cold Bending on Submarine Pressure Hull Collapse" describes how cold bending is used to form the frames and shell plating of submarines. Residual stress introduced by cold bending is substantial and can compromise the structural integrity of these parts. In order to assess pressure hulls, this research compares many approaches for consolidating cold bending residual stresses while taking into account non-circular mode shapes. Several techniques for analyzing the collapse of a pressure hull, taking into account both interframe and global collapse modes, are examined and contrasted. Empirical methods, finite difference methods, and finite element methods are only a few examples.

T.P.Khatua [9], the bending stiffness of face layers have been taken into account in the analysis, and the idea of the common shear angle for all the cores has been excluded. Swathi [8] has performed a static and dynamic analysis of a sandwich structure in FRP beams and found the relation between the core thickness and damping coefficient. Recently, however, higher order shear deformation theories have been developed, which account for the layered character of the material and incorporate higher order factors into Taylor's expansions of the displacements in addition to thickness.

When dealing with sandwich beams, Frosting et al.[10] split the beam in half, with one half reflecting the core's shear absorption capacity and the other half being free of shear pressures. Assuming an incompressible core, Kant and Swaminathan[11] formulated the in-plane displacements as cubic functions of the thickness coordinate. The notion of minimal potential energy is used to derive the equilibrium equation, and closed-form solutions for specific circumstances have been derived by applying Navier's method to the boundary value issue.

I. EXPERIMENTAL INVESTIGATION

The skins on the outside: if the sandwich is held in place on both sides and then strained with a force in the centre of the beam, the shear forces introduced by the bending moment will deform the skins. The bottom skin is stretched by the shear pressures, while the top skin is compressed. These two layers are separated by the core substance. The composite's strength increases with increasing core thickness. This concept functions similarly to an I-beam.

Connecting the inside and outside: The adhesive layer experiences shear force because the shear stresses in the composite material vary rapidly between the core and the skin. Delamination is a likely outcome if the adhesive connection between the two layers is insufficient.

Sandwich beams are composite structures with advantageous weight, stiffness, and strength profiles. Common sandwich beams have two skin layers that are relatively thin and a thicker core that separates the two. Industry has been able to construct structures that are strong, stiff, light, and durable by adhering thin, strong skin sheets to heavier, lightweight core materials.

When the skins and core are fused together, they form a single structural element with the benefits of both. Sandwich beams are employed as lightweight load bearing components due to their excellent stiffness-to-weight and strength-to-weight ratios. The transverse shear stresses are mostly encountered by the core, whereas the tensile and compressive stresses are primarily handled by the skins. The skins are often made of metals like steel or aluminum sheets. The core's primary role is to boost the sandwich beam's flexural stiffness, hence reducing the amount of transverse deformation. The honeycombs, foams, and corrugated cores utilized are often constructed of polymers or metals.

Sandwich panels are a common use of sandwich structures; there are many variations on this theme, including FRP sandwich panels, aluminum composite panels, etc. Polyester reinforced plastic, multi-axial high-strength glass fiber, and PP honeycomb panel are solidified in a vacuum at a constant temperature to produce a FRP polyester reinforced composite honeycomb panel (sandwich panel).

The behavior of a beam, plate, or shell with three layers (two face sheets and one core) is described by the sandwich theory. Linear sandwich theory, an extension of first order beam theory, is the most popular form of this theory. Sandwich beams have many applications in construction, transportation, aviation, and refrigeration engineering, and linear sandwich theory is crucial to their design and analysis.

The term "sandwich" itself was originally used by Englishman Sir William Fairbairn in 1849. The concept of using a combination of materials to boost a structure's strength was first applied in the 1930s. In 1940, the English Mosquito bomber was built using sandwich construction extensively during World War II. The Mosquito was built with a plywood sandwich. The foundation was established in the USA. Hexcel Corporation was founded in the late 1940s, and it is mostly credited for pioneering sandwich architecture. Sandwich beams have several uses, including those in spacecraft, trains, and transportation vehicles (Vinson, 2005).Sandwich beams, which typically consist of polymer components, can display time-dependent behavior.

Problem Identification & Objective are as follows:

Failure is due to poor quality materials. The project's goal was to use finite element analysis to develop and optimize the use of diverse materials (sand which beam) to reinforce the cylindrical part of a submarine's pressure hull. Because of the pressure differential between the inside and outside of this pressure hull, the hydrostatic pressure exerted on it is 65 Bar. Therefore, a structural static analysis was performed at first to examine the loads and deflections. Given the significant dynamic stresses experienced by the pressure hull, we have performed a vibration and shock analysis. The frequency range of operation for the pressure hull is 0 to 300 Hz.For this reason, it can't resonate. The initial pressure hull model's natural frequencies have been determined by modal analysis. Two distinct natural frequencies, at 0 and 300 hertz, were measured.There have been attempts to raise these natural frequencies above the pressure hull's analytic functioning Window.

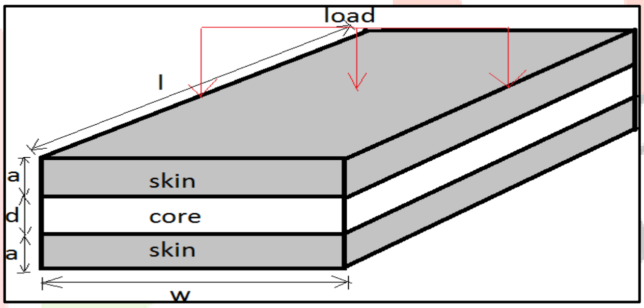
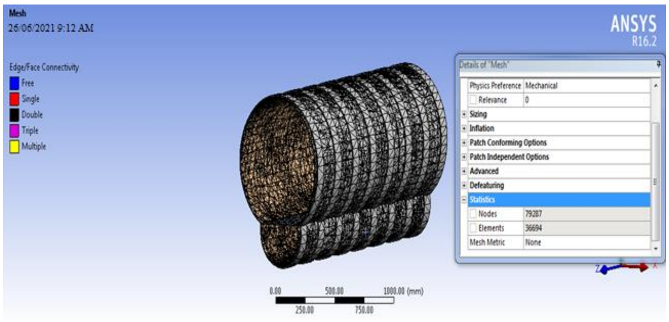


Figure 3.1: Sand which beam layers

IV. RESULTS AND DISCUSSION

The stresses and deflections of the pressure hull were calculated using a static analysis of the structure under an external pressure of 65 bars. The pressure hull's ends are clamped in place in all degrees of freedom, and an external pressure of 65bars @ 6.5Mpa is applied to the hull's shells. Pressure hull loading and boundary conditions are depicted in the illustration.



Physics Preference Mechanical
Relevance 0
Nodes 79287
Elements 36694
Mesh Metric None

Figure 4.1: Mesh in ansys workbench Nodes:79287, Elements:36694

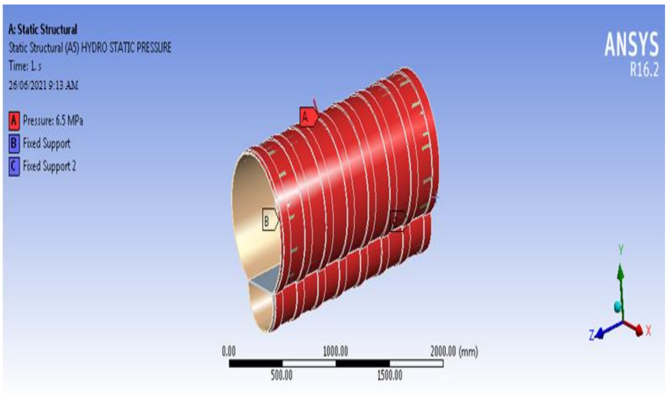


Figure 4.2: Boundary conditions in static analysis in ansys workbench

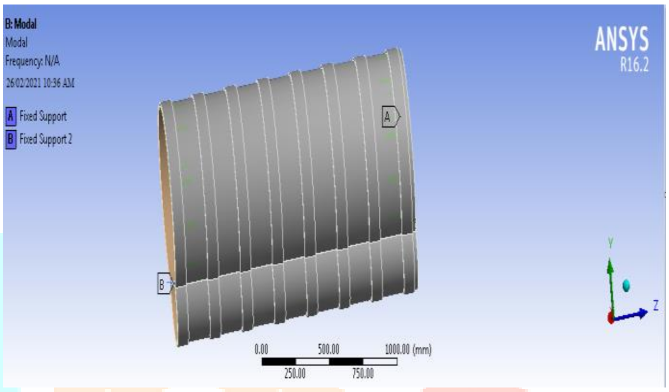


Figure 4.3: Boundary conditions in Modal analysis in ansys workbench

The stresses and deformations in the pressure hull were calculated using a static and modal analysis of the structure under an external pressure of 65 bars. The pressure hull's ends are rigidly fastened in all degrees of freedom, and an external pressure of 65 bars is exerted on the hull's shells. Pressure hull loading and boundary conditions are depicted in the illustration.

V. CONCLUSION

An AUV is a robot designed specifically to operate in water without the need for human intervention. AUVs are a subset of the wider category of underwater devices known as UUVs. Conduct static and modal analysis, as well as design an AUV pressure vessel. In this project, we used the catia and ansys programs to design and analyze a pressure vessel for an AUV made of sand-which-beam material. 2mm steel, 2mm rubber, 2mm steel (Case 1), 2.5mm steel, 1mm rubber, 2.5mm steel (Case 2). Ti64Al (in Case 3), Rubber (in Case 4), and Ti64Al (in Case 4) each measure 2 millimeters in thickness.

Static examination of the stresses, strains, deformations, and shear stresses in the Ti64Al + 2mm Rubber +2mm Ti64Al sand combination used to construct the pressure vessel led to the following conclusion: Find the modes in modal analysis by looking at Because it can withstand dynamic loads and strains better and can deform less over a range of frequencies, this material is ideal for the pressure hull.

REFERENCES

[1] Project thesis of Roberts Tompkins submitted to TAMU University- Visco elastic analysis of Sandwich beam having Aluminum and Fiber reinforced polymer skins with polystyrene foam core- December 2009 2. Y. Swathi and Sd Abdul Kalam, "Sandwich Treatment in FRP beams: Static and Dynamic Response". IJERT, vol1 9, 2012, pp 2-5.

[2] Noor AK and Burton WS, "Stress and free vibratuion analysis of multilayered composite panels" Compos Structures, vol11,1989,pp 183-204

[3] Frostig Y, Baruch M, Vinley O and Sheinman I, "High order theory for sandwich beam behaviour with transversely flexible core", J Eng Mech, vol 1 18, 1992, pp1026-1043.

[4] Kant T and Swaminathan K, "Analytical solutions for the static analysis of laminated composite and sandwich plates based on a higher order refined theory", Compos Structures, vol56, 2002, pp. 329-344. 6. Pandit MK, Sheikh AH and Singh BN, " Analysis of laminated sandwich plates based on improved higher order zig zag theory", J Sandwich Struct Mater, Vol 12 2010, pp.307- 326.

[5] K.Malekzadeh, M. R. Khalili and R.K. Mittal, "Local and Global Damped Vibrations of Plates with a viscoelastic soft flexible core: An improved high order approach" , Journal of sandwich structures and materials, vol7 2005,pp 431.

[6] Ju F, Lee HP, Lee KH, "Finite element analysis free vibration of delaminated composite plates". Compose Eng 1995,5(2), pp,195-209.

[7] Ahrari, E. (2010) 'Transformation of America's Military and Asymmetric War', Comparative Strategy, 29 (3), pp. 223 - 244.

[8] British Standards Institution. (2009) 'PD 5500'.[in Specification for unfired fusion welded pressure vessels. London: BSI.

[9] Geiger, V. (2009) 'The Submarine as a Potent Weapon For Littoral Water Operations'. www.sea-technology.com. [Online]. Available at:http://seatechnology.com/features/2009/1109/submarine_littoral.html. Last accessed 20 April 2011.

[10] Germanischer Lloyd. (2007). World's First Submarine in Class. Available: http://www.glgroup.com/pdf/bravo_zulu_2007-01_E.pdf. Last accessed 20 April 2011.

[11] Germanischer Lloyd. (2008) 'Rules for Classification and Construction - Naval Ship Technology'.[in Hamburg: Germanischer Lloyd.

[12]Graham, D. (2007) 'Predicting the collapse of externally pressurised ring-stiffened cylinders using finite element analysis', Marine Structures, 20 (4), pp. 202-217.

[13]Hoffman, F. G. (2006) 'Complex Irregular Warfare: The Next Revolution in Military Affairs', Orbis, 50 (3), pp. 395- 411.