A REVIEW PAPER ON FRP COMPOSITE OPEN CYLINDER

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ABSTRACT:-Cylindrical structures are being used in various fields as pressure vessels, engine cylinders, pipes for transport of gas or fuel, storage tanks, and in vehicles for carriage of fuel water etc. Here a review has been done on the work of previous researchers on the analysis of pressure vessel made up of fiber reinforced composite. As pressure vessels made up of composites provides high strength to weight ratio within economic cost and better life and also focus will be on the work of the researchers who has used ANSYS or any other software that works on finite element method.

Keyword: **-ANSYS workbench, Rule of mixture.**

I. INTRODUCTION.

Nowadays cylindrical structures are being used in various fields as pressure vessels, engine cylinders, pipes for transport of gas or fuel, storage tanks, and in vehicles for carriage of fuel water etc. For weight saving and strength purpose composite has taken the place of conventional materials that are being used for making of cylinders. Not only strength but also composite provides design of cylinder handy because of conventional and consist of various desired properties such as resistance to corrosion and resistance to chemical reaction. In case of pressure vessels use of composites has increased alarm before failure in various terms. Here if due to deformation fiber breakage takes place then the fraction of the single fiber acts as two different fibers and per takes the load due to presence of matrix. About composite cylinder one disadvantage is that Cylinders reinforced or built-up with a fibre material usually must be inspected more frequently than metal cylinders. Mainly in practice all the pressure vessels can be divided into two categories thick cylinder and thin cylinders. Thick cylinder [22, 23] is a cylinder whose wall thickness is greater than 1/20 times of its internal diameter. Here circumferential stress varies along thickness of shell. And radial stress is not negligible because a thick cylinder is required to have a heavy internal pressure. It is also termed as mono block pressure vessel here extrusion is mainly the production process of this type of cylinders. Thin cylinder [22, 23] is a cylinder whose thickness is less than 1/20 times of its internal diameter as here the internal stress is not so high so radial stress is negligible. Through thickness stress varies but as thickness is very less there is no such effect as thick cylinder. Now-a-days these thick or thin cylinders are made up of composites called FRP composite cylinder [22, 23] for better weight savings and for better strength in composites the main role is played by either matrix or fibers matrix binds the fibers in place and fiber contributes to strength. As fiber diameter is nearly equal to its crystal diameter so very less flaws will be their then bulk materials and hence more strength can be gained. Rule of mixture [24]. Rule of mixture is the simple relation between the properties of a composite and those of its constituents it is otherwise known as law of mixture. Here we have used rule of mixture for the calculation of composite properties from fiber and matrix. Volume fraction and weight fraction and density are the key in the relation.

The relationship of this below form is known as rule of mixture.

$E_c = E_f V_f + E_m(1 - V_f)$(1.0)

using the below formulas the properties of composites can be calculated.

$\rho_c V_c = \rho_f V_f + \rho_m V_m$(For the calculation of density)(1.1)

$\sigma_c A_c = \sigma_m A_m + \sigma_c A_c$(For the calculation of tensile yield strength.)(1.2)

$E_c = E_f V_f + E_m(1 - V_f)$(For the calculation of young's modulus.) (1.3)

II. Literature survey

Tomonori Kaneko et al.[18] have conducted impact analysis of pressurized cylinder and studied the influence of inner pressure on failure modes and the impulse, load at penetration. They have noticed that, when there is too much inner pressure, the failure mode changes and there is a possibility of burst failure. Velosa et al.[9] studied a new generation of composite pressure vessels for large scale market applications. The vessels consist on a thermoplastic liner wrapped with a filament winding glass fiber reinforced polymer matrix structure. Prototype pressure vessels were produced in the defined conditions to be submitted to pressure tests. They were compared between the FEM simulations and experimental results. Bonakdar et al.[12] used a static and modal analysis of laminated hollow cylinders subjected to various kinds of loadings and boundary conditions are performed using 16-node cylindrical super element. The accuracy of the result is evident from comparison of the results with exact solution method and conventional finite element. The element can predict the structural behaviour of laminated cylinders in complex loading and boundary conditions in an efficient manner. Madhavi et al.[13] Material characterization of FRP of carbon T300/Epoxy for various configurations as per ASTM standards is experimentally determined using filament winding and matched die mould technique. The mechanical and physical properties thus obtained are used in the design of the composite shell. The results can be utilized to understand structural characteristics of filament wound pressure vessels with integrated end domes. Doh and Hong et al. [20] has studied the burst failure of a filament wound pressure vessel composed of T-800 graphite epoxy. A degenerated finite shell element was implemented for analysis. A progressive failure analysis was performed by using failure criteria with a property degradation model. Christoset al.[6] has simulated a fiber reinforced composite pressure vessel for three different ply layers in order to find out the damage growth due to internal pressure .Indhrani et al.[7]developed fiber reinforced polymer (FRP) confined concrete columns for new construction and rebuilding of concrete piers/piles in engineering structures. A 3-D finite element model of FRP confined concrete column was developed by them using ANSYS. Based on the FEA results, a test data base was developed taking into account all the possible ranges of the design parameters which affect the confined concrete strength. Kranti et al.[19] proved that a minimum of 100mm length is required to study the behaviour of infinitely long FRP composite cylinder. S. Bhavya et al.[15]has observed that load bearing capacity of an FRP composite open cylinder decreases with increase of D/T ratio. J. C. Velosa et al.[9] has studied composite pressure vessels for large scale market applications which consist of thermoplastic liner wrapped with a filament winding glass fiber reinforced polymer matrix structure. Lakshmi nair et al.[11] did material characterization of FRP of carbon T300/Epoxy for various configurations as per ASTM standards. The design of laminated pressure vessel is described in detail. Netting analysis is used for the calculation of hoop and helical thickness of the pressure vessel. A balanced symmetric ply sequence for carbon T300/epoxy is considered for entire pressure vessel. Progressive failure analysis of composite pressure vessel with geodesic end dome is carried out. The results can be utilized to understand structural characteristics of filament wound Pressure vessels. Sayman et al.[16] develops an explicit analytical formulation anisotropic elasticity theory that determines the behaviour of fibre reinforced composite pressure vessel under hydrothermal loading. The loading is studied for three cases separately which are plain strain case, free ends and pressure vessel cases. He observed that for free ends and pressure vessel cases the vessel is free to expand on the other hand for plain strain case the vessel is prevented to expand. Shaikh and Mistry et al.[1] has designed glass fiber reinforced plastic pressure vessel, subjected to internal design pressure of 1.089 kg/cm^2 in accordance with the procedure set out in ASME section A-Design rules. Destructive testing was done to find out the modulus of elasticity and flexural modulus. A Tripathi et al.[2] has found that the weight of LPG cylinder can be saved enormously by using composites and the stress values are also well within the limit of capability of materials. FRP composite LPG cylinders offer Leak before fail approach of design which may be a design advantage in terms of safety and reliability. Rao et al.[5]established superiority of fiber reinforced plastic over steel. They carried out finite element analysis of composite cylinder and steel cylinder subjected to internal pressure and concluded that the weight of LPG cylinder can be seven enormously by using FRP composites and the stress value are also well within the limit of capability of materials. This gives clear justification for its use in household applications. Rashmirekha et al.[14] in their article introduces the concept of lighter and transparent fiber glass to be used in domestic cooking gas cylinder. They mentioned that a see through, light weight, safe, eye-catching, environmental friendly cooking gas cylinder made of fiber glass will be an asset for the kitchen of the future. Composite gas cylinder apart from imparting maximized strength and optimized safety, also offer additional advantages like non-corrosive construction, high strength weight ratio, light weight and explosion proof fabrication making this an obvious alternate cooking gas cylinder. Ramkrishna et al.[3] described about the manufacturing of liquefied petroleum gas cylinders their testing under stringent norms before they get certified by Bureau of Indian Standards (BIS) for market use. They mentioned that cylinders produced on batch from row material specified in Indian Standard and tested before dispatching to market. Raju and Rao et al.[10] they did design analysis of fiber reinforced multi-layered composite shell with optimum fiber orientations; minimum mass under strength constraints for a cylinder under axial loading for static and buckling analysis of pressure vessel has been studied. Ashok and Harikrishna et al.[17]stressed in the innovation of alternative materials of liquid petroleum gas (LPG) they carried out elemental analysis of liquid petroleum gas(LPG) made of steel and fiber reinforced plastics (FRP) composite. They used FE analysis package ANSYS to model the shell with FRP composites. They compared weight and variations of stress and deformation for steel, glass fiber reinforced plastics composites LPG cylinders. Alok et al.[4] has created the LPG model in CATIA VRR20 software and performed a finite element analysis of LPG cylinder which is subjected to an internal pressure, by taking three different materials from ANSYS software. The values estimated by ANSYS are compared with the classical mathematical formulations. The LPG cylinder calculations are performed to determine the cylinder weight and the material with the least weight is selected for new LPG cylinder.

III. PROBLEM STATEMENT

From the above literature survey it is concluded that Boron, and Armide like famous fiber has not been used as fibers for making composite cylinder also natural fiber has not given importance for analysis purpose and for making of composite cylinder. Effect of change of diameter and effect of symmetry on burst pressure has not been analysed constraining the motion along the z axis. And also in case of 4 layer cylinder analysis has not been done using one matrix and two different fibres i.e. using two composites.

IV. Works that can be done based upon the problem statement.

A. Effect of change of thickness on deformation at maximum working pressure will be observed.
B. Effect of symmetry using maximum stress and T Sai Wu failure criteria will be observed.
C. Deformation along x and y axes will be observed.
D. Analysis will be done to calculate the weight savings.
E. Stress intensity on cylinder surface will be computed.

F. Analysis of factor of safety using Von-mises stress criteria.

G. Effect of D/T ratio on strength.

H. Impact load test can be done to find hardness experimentally and using software.

I. Cost analysis can be done for the use of various pressure ranges so that the volume fraction can be adjusted for each layer with thickness in order to make the product economical without hampering the required strength.

V. CONCLUSION.

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VI. REFERENCE.

1.A. Shaikh, Rajiv A. Mistry, “Design of Fiber Reinforced Plastic Pressure Vessel by ASME Section X”, International Journal of Emerging Technology and Advanced Engineering Journal, Volume 4/11, pp. 523-528, 2014.

2. A Tripathi Anil Kumar M.K. Chandrakar Department of Mechanical Engineering Govt. Engineering College Raipur (C.G.), India “Design and Analysis of a Composite Cylinder for the Storage of Liquefied Gases”IJSRD - International Journal for Scientific Research & Development| Vol. 5, Issue 03, 2017 | ISSN (online) pp: 2321-0613.

3.Akula Ramakrishna, Nihal A. Siddiqui and P. ojanLal, 2014 “Development of empirical formulas for LPG cylinder”, International Journal of Applied Engineering and Technology, Vol. 4/1 pp. 54-61, 2014.

4.Alok Tom, Geo Mathew Pius, George Joseph, Jacob Jose and Mathew J Joseph, “Design and analysis of LPG cylinder,”*International Journal of Engineering and Applied Sciences*,vol. 6, pp. 17–31, 2014.

5.Ch.Bandhavi and N.AmarNageswara Rao, “Design and Analysis of LPG Cylinder using ANSYS Software,” International Journal of Mathematical Sciences Technologies and Humanaties 58, pp 635 – 646, 2012.

6.Christos C. Chamis, pascal k. Gotsis and LevonMinnetyan, “Progressive Fracture and Damage Tolerance of Composite Pressure Vessels”.

7.IndraniVenkataVolety “ModelingofFiber Reinforced Polymer Confined Concrete Cylinders” Louisiana State University, May, 2006.

8.J. C. Velosa, J. P. Nunes, P. J. Antunes, J. F. Silva and A. T. Marques, “Development of a new generation of filament wound composite pressure cylinders”, Ciencia e Tecnologia dos Materiais, Vol.19, 2007.

9.J.C. Velosa, J. P. Nunes, P.J. Antunes, J. F. Silva “Development of a new generation of filament wound composite pressure cylinders”, Ciencia e Tecnologia dos Materials, Vol. 19, 2007.

10.KSahityaRaju, Dr. S. Srinivas Rao, “Design optimization of a composite cylindrical pressure vessel using FEA”, International Journal of Scientific and Research Publications, Volume 5/12, pp. 2250-3153, 2015.

11.Lakshmi Nair, YezhilArasu, Indu V S, “Design of Laminated Pressure Vessel”, International Journal of Science and Research, Volume 4/8, pp. 2319-7064, 2015.

12.M. T. Ahmadian and M. Bonakdar, “A new cylindrical element formulation and its application to structural analysis of laminated hollow cylinders”, Finite Elements in Analysis and Design 44, 2008, pp.617 – 630.

13.M. Madhavi, K. V. J. Rao and K. Narayana Rao, “Design and Analysis of Filament Wound Composite Pressure Vessel with Integrated-end Domes”, Defence Science Journal, Vol. 59, No. 1, 2009, pp. 73-81.

14.RashmiRekha and HimanshuShekahar “Composite gas cylinders” Science Reporter, pp 14-15, 2012.

15.S. Bhavya, P. Ravi Kumar, Sd. Abdul Kalam, “Failure Analysis of a Composite Cylinder”, IOSR Journal of Mechanical and Civil Engineering, Volume Number 3, pp. 01-07.

16.Sumeyrasayman, “Analysis of fiber reinforced composite vessel under hygro thermal loading” MS thesis The middle east technical university, 2003.

17.T.Ashok and A.Harikrishna, “Analysis of LPG Cylinder Using Composite Materials”, International Journal of Mechanical and Civil Engineering, Vol.9, pp. 33-42, 2013.

18.Tomonori Kaneko, Sadayuki Ujihashi, Hidetoshi Yomoda and ShusukeInagi, “Finite element method failure analysis of a pressurized FRP cylinder under transverse impact loading”, Thin-Walled Structures 46, 2008, pp. 898–904.

19.V. Kranthi Kumar, K. Ravi Kumar, V. Bala Krishna Murthy, “Stress analysis of six layered FRP composite cylinder”, International Journal of Applied Engineering Research, Volume 6, Number 19, 2011, pp. 2243-2250.

20. Y.D Doh and C.S.Hong “Progressive Failure Analysis for filament wound pressure vessel”, Department of Aerospace Engineering, Korea Advanced institute of Science and Technology. 373-1 Kusong-dong, yusung-gu, Taejon, 305-701, Korea.

22. Mechanics of Composite Materials, Jones, R. M., Mc-Graw Hill.

23. Engineering Mechanics of Composite Materials, Daniel, I.M. and Ishai, O., Oxford University Press.

24 PROF. R. VELMURUGAN composite material Module iii micro mechanics of lamina Lecture 19.