Modeling And Analysis Of Multila- Yer Pressure Vessel

Johny Shaida shak[1, a *], L Ramesh[2, b], B Ramesh Nayak[3, c]

Assistant Professor[1], Department of Mechanical Engineering, Gudlavalleru Engineering College, Seshadri Rao Knowledge Village, Gudlavalleru, PIN-521 356, Krishna Dist., Andhra Pradesh, India

Assistant Professor[2], Department of Mechanical Engineering, Gudlavalleru Engineering College, Seshadri Rao Knowledge Village, Gudlavalleru, PIN-521 356, Krishna Dist., Andhra Pradesh, India

Assistant Professor[3], Department of Mechanical Engineering, Gudlavalleru Engineering College, Seshadri Rao Knowledge Village, Gudlavalleru, PIN-521 356, Krishna Dist., Andhra Pradesh, India

Abstract

The main objective of this paper is to modeling and analysis of multilayer pressure vessel, features of multilayered pressure vessel and their advantages over the single layer pressure vessels. As the multi layered pressure vessels are superior to the single layered pressure vessels to withstand high pressures and to increase the durability. Internal pressure analysis has done on single and multi layer pressure vessels with different materials (steel and composite materials (HM /epoxy)) to find out the Von misses stress and deflections and the stresses developed in Multilayer pressure vessel are analyzed by using commercial available software ANSYS and compared the results between single and Multi layer Pressure vessels. It has been absorbed from the result the composite materials are best suitable material for multi layer pressure vessel.

Keywords: *Modeling, Multilayer pressure vessel, Single layer pressure vessel, FEA, ANSYS*

Introduction

Pressure vessels have been manufactured by filament winding for a long time. Although they appear to be simple structures, pressure vessels are among the most difficult to design. Filament-wound composite pressure vessels have found widespread use not only for military use but also for civilian applications. Applications include breathing device, such as self-contained breathing apparatus used by fire-fighters and other emergency personnel, scuba tanks for divers, oxygen cylinders for medical and aviation cylinders for emergency slide inflation, opening doors or lowering of landing gear, mountaineering expedition equipment, paintball gas cylinders, etc. Composite vessels with very high burst pressures (70-100 Mpa) are in service today in the aerospace industry. Vessels with burst pressure between 200 – 400 Mpa have been under investigation and such containment levels were achieved in the late 1970's through mid 1980's. Advanced ultra-high pressure composite vessels design techniques must be employed to achieve such operation. A maximum pressure of 35 Mpa is permitted under current regulations, 21 Mpa is a standard vehicle refueling system's nominal output pressure for civilian applications. Higher pressures are not yet approved for use on public roads or commercial aircraft. This implies a need for advancement in composite pressure vessel technology.

Finite element analysis of composite high-pressure hydrogen storage vessels by Javad Marzbanrad, Amin Paykani had a study on hydrogen pressure vessel based on unit load method ,along with complete stud analysis and evaluations of fatigue life time using FEA commercial code ABAQUS.This unit load method covers many of the weakness of traditional method and carries out node detailed design using many factors that composite material provide for design using many factors that composite material provide for designer. Thus the obtained FEM results are comparing with experimental one and had a great result [1]. Finite element analysis of burst pressure of composite storage vessels by Shanmugavel.M, Velmurugan.T had a analysis on composite pressure vessel made of glass fiber reinforced polymer (GFRP) using ANSYS software .A FEA model of GFRP is proposed to predict the damage evolutions and fatigue strength using Hoff-man, Tsai-Hill, Tsai-Wu criteria the failure properties of composite vessel is determined and also to investigate the progressive damage and failure properties of composite structures with increasing internal pressure a solution algorithm is proposed [2].Pavo et.al. Have chosen a pressure vessel of elliptical head to analyze its strength and they described a method for calculating strength, and also described the distribution of total circumferential forces and radial forces of the cylindrical vessel with ellipsoidal heads [3]. . S Suleiman, S Borazjani and S H Tang says in this paper the aluminum pressure vessel is overwrapped by Carbon /epoxy fiber (CRPF) using commercial available software ABAQUS 6.12 and also FEM was utilized to investigate the effects the winding angle on pressure vessel. For this the lamina is oriented in different and results was noted by using criteria like Tsai-wu,Tsai-Hill and maximum stress failure were employed and finally the result investigated is the wind angle fails only at 55degrees angle [4]. Min-Gu Han,Seung –Hwan Chang says in this the paper says Type III hydrogen pressure vessel composed was aluminum liner and thick composite layer was analyzed under an impact load to determine material failures .for this the thick composite laminated pressure vessel was modeled using ply modeling behavior for better results impact load ,autofretage pressure ,service pressure ,imposed on FEM and material failure was predicted Hasin criteria and finally concluded that some layers may fail in the transverse direction through proper delamination .Apart from that the structure is safe [5].Ramazan karaku and Burant Muraticten says that in this paper says that in order to determine the energy absorbing capability of plates and impact behavior of a laminated Glass/epoxy composite plate .It is heated to a high temperature and concluded that the perforated threshold increase with increasing temperature . [6]

Materials and Method

In order to investigate the maximum stress and maximum deflection of the multilayer pressure vessel for the static loading conditions the material which is used is HM/Carbon epoxy and explained in detail below the following steps

First

The model is drawn in the 2Ddiagram manually by using geometrical instruments according to required dimensions for both the solid layer and multi layer pressure vessel.

Second

The model is converted into 3D model by using software package lime Unigraphics.

Third and final

In this stage the ANSYS software is used to determine the maximum stress and maximum deflection separately for solid layer and multilayer pressure vessel considering the element type such as shell 99,4 nodes ,dof as 6 and finally the resultant values were drawn in the below giving the conclusions.

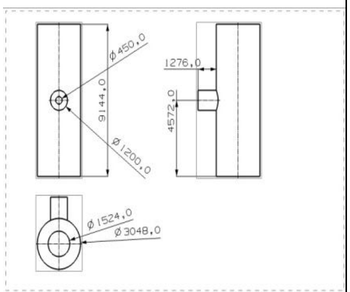
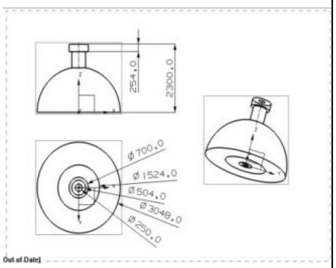
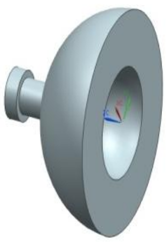
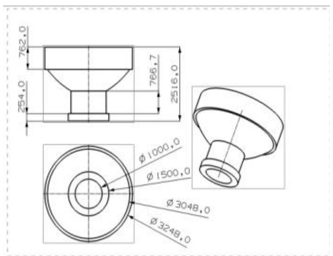
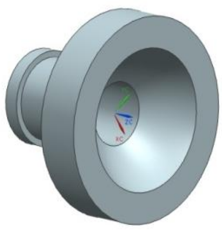
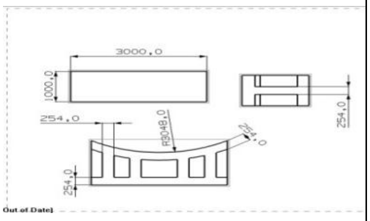
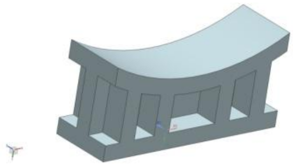
2 D MODEL	3D MODEL
Shell body design 	
Right side head design 	
Left side head design 	
Support design 	

Table.1 Properties of HM Carbon/Epoxy

S. No	Property	Units	HM Carbon/Epoxy
1.	E_{11}	GPa	190.0
2.	E_{22}	GPa	7.7
3.	G_{12}	GPa	4.2
4.	ν_{12}	-	0.3
5.	$S^t_1 = S^c_1$	MPa	870.0
6.	$S^t_2 = S^C_2$	MPa	154.0
7.	S_{12}	MPa	30.0
8.	ρ	Kg/m^3	1600.0

RESULT AND DISCUSSION.

RESULTS

Single layer pressure vessel

Deflection

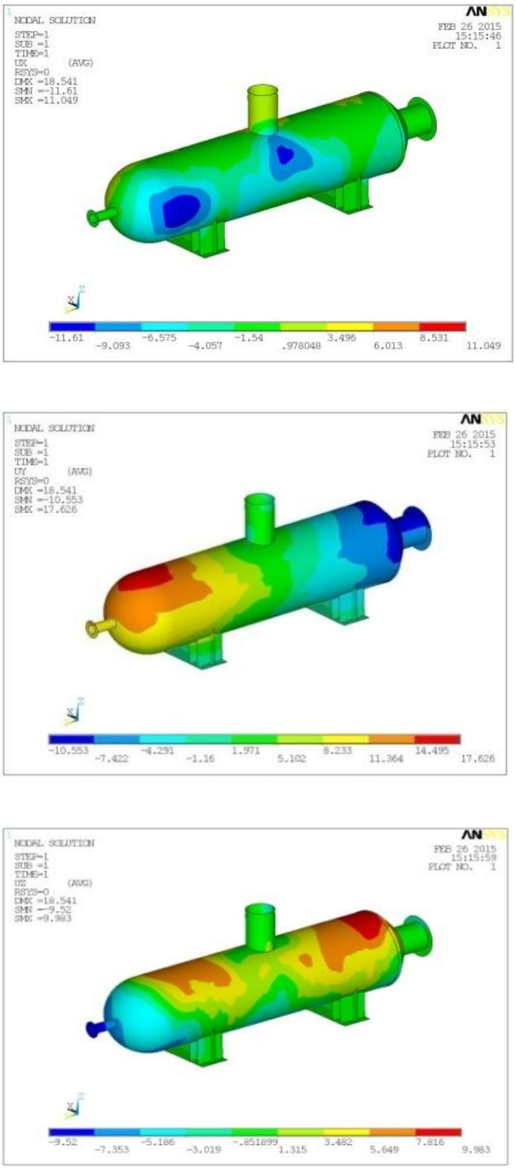


Fig.13.Shows the max. Displacement of pressure vessel assembly in X, Y and Z direction

STRESS

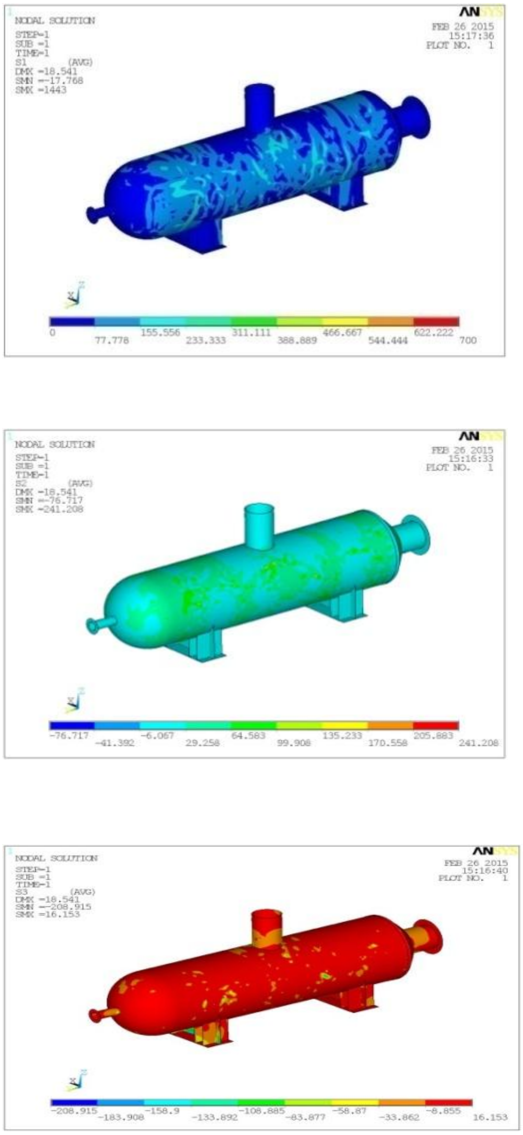


Fig.16. Stress in X, Y and Z direction

Max. VonMises stress:

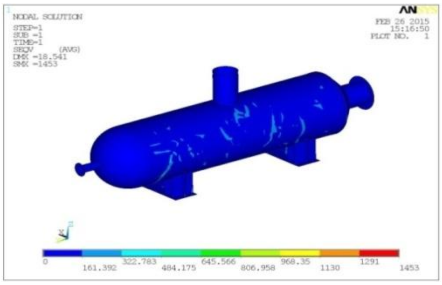


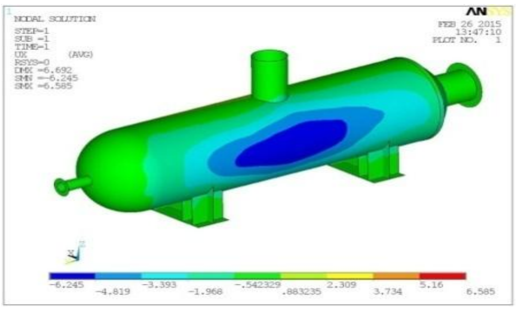
Fig.18 shows the max. VonMises stress of pressure vessel assembly

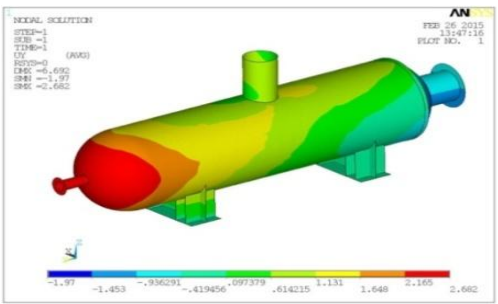
Table.3 shows the max. Deflection and Max. Stress

S.NO.	DEFLECTION (mm)				STRESS			
	UX	UY	UZ	USUM	S_1	S_2	S_3	VON MISES
1	11	17	9	19	1455	241	16	1453

Multi layer pressure vessel

Deflection





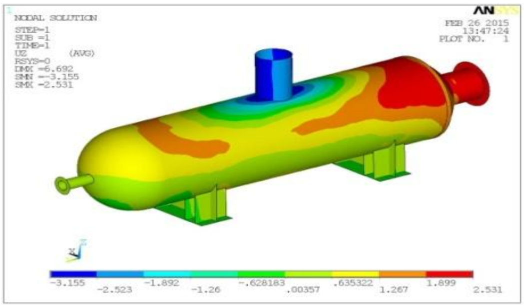
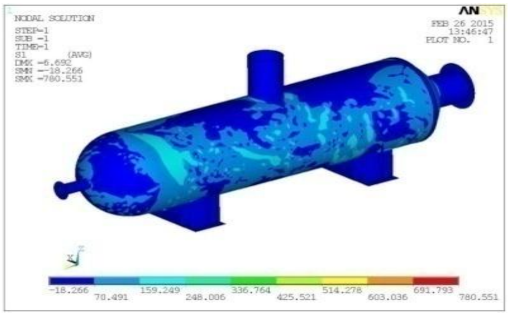
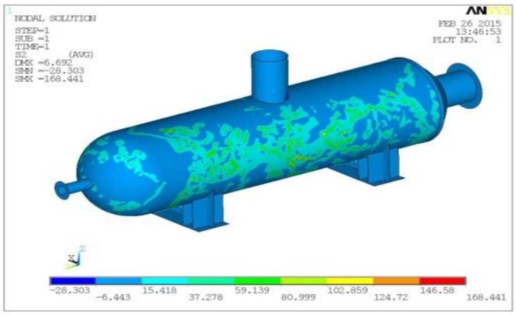


Fig.18 shows the max. Displacement of pressure vessel assembly in X, Y and Z direction

STRESS





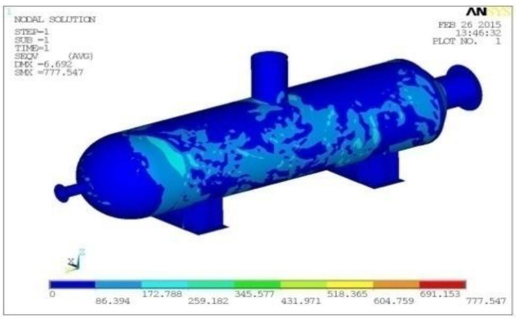


Fig.21 stress in X, Y and Z direction

***Max. Von Misses stress*:**

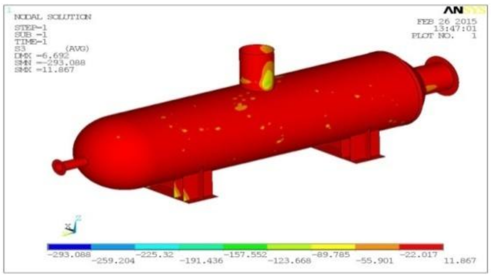


Fig.23 shows the max. VonMises stress of pressure vessel assembly

Table.4 shows the max. Deflection and Max. Stress

S.NO.	DEFLECTION (mm)				STRESS			
	UX	UY	UZ	USUM	S_1	S_2	S_3	VON MISES
1	6.5	2.7	2.5	6.6	778	168	11	777

DISCUSSION.

FEA Analysis on single and multi layer pressure vessels

The finite element analysis is brought out to compare maximum stress, deflection and von Misses stress for both solid layer and multi layer pressure vessel using composite material like HM/carbon epoxy material for this the FEM software package and ANSYS has been used to analyze the pressure vessel at steady state analysis.

Thus the internal pressure analysis is done using ANSYS software for structural analy-sis and the maximum deflection and maximum stress values are listed in below table in comparison

CONCLUSIONS

In the present paper a pressure vessel assembly is designed and optimized for static loading conditions. From the above analysis it is concluded that the pressure vessel assembly has stresses and deflections within the design limits of the composite materials (HM/epoxy).

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