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Optimization Of Pressure Vessel Using A Composite Material

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ABSTRACT

The project is proposed to analyse and design a cylindrical pressure vessel made up of composite material. The new composite material considered is waspaloy. In today's aviation brass is the major element used for construction of pressure vessels .It has high mingling properties which provide various properties. ButBrass has many disadvantages like getting deformed, bursting, hydraulic failure and pneumatic failure. The design features focus on providing high fuel efficiency, reduction of bursting of pressure vessels in aircrafts. Pressure vessels have been manufactured by filament winding for a long time. Although they appear to be simple structures, pressure vessels are difficult to design. The advantages are superior specific strength and stiffness, resulting in a lighter design. This makes the use of fiber reinforced composites ideally suited for applications where a pressure vessel must withstand high internal pressure along with axial, bending, and shear loads. In certain applications, significant loads are imparted to composite pressure vessels due to accelerations caused by transportation and handling operations. This project will present the development, application and results of this new composite material which shows better performance results. We are going to design and analyse the pressure vessel to enhance the performance characteristics of the pressure vessel using composite material.

Keywords— Waspaloy-hydraulic failure-filament winding-lighter design-advantages of composite wrapped pressure vessels-better performance results.

I. INTRODUCTION

Pressure vessels are being widely used in commercial and aerospace industries, for example in rocket motor cases, fuel tanks, portable oxygen storage bottles, and so on. They offer a high stiffness and strength combined with a low weight and an excellent corrosion resistance. Pressure vessels are commonly constructed with a filament overwrap of fiberglass, carbon fiber, or Kevlar in customized resin systems. Various properties can be achieved through an appropriate selection of fiber type, fiber orientation, and resin matrix of the composite structure required for the applications in question. The strong and stiff fibers carry the load imposed on the composite, while the resin matrix distributes the load across the fibers. The process for producing a composite pressure vessel is termed filament winding. The techniques for filament-wound composite pressure vessel can be classified into two main types: geodesic winding and in-plane winding, which consist of three basic steps. First, the fibers are impregnated with a resin. To obtain good results, the impregnation must be done in a carefully controlled manner, by pulling the fibers through a basin filled with the resin. Then, by the use of a winding machine, the fibers are positioned onto a mandrel, which has the shape of the pressure vessel required. Finally, the wet fibers are removed from the winding machine and placed in an oven, where the resin is cured under well-defined conditions of temperature and time. Typicalpressure vessels are generally designed with a central cylindrical section and two spherical end caps with optional polar openings. The relative dimensions of different sections of the vessel are designed according to the corresponding space and weight requirements and the pressure levels that the vessel is expected to withstand. Along with thickness and length dimensions, the shape of the end caps also plays a vital role in the design. This is due to the fact that the dome regions undergo the highest stress levels and are the most critical locations from the viewpoint of structure failure. The design concept requires that the pressure vessels provide extremely high efficiencies in meeting the overall yielding and buckling failure criteria. Moreover, the slippage tendency of the band at its edges must be taken into account, especially when utilizing the in-plane winding technique.

1.2 PRESENT PROBLEMS IN PRESSURE VESSEL

1) **Burst from Over-pressurization**. The unexpected burst of a PV from over pressurization is mitigated by material certification, designing to conservative material allowable and proof-pressurization of the vessel during acceptance testing. The external pressurization source must also be controlled to prevent accidental excessive pressurization.

2) **Fatigue Failure of the Metallic Liner**. Fatigue failure of the metallic liner is mitigated by inspection and testing. Nondestructive inspection of the liner at manufacture ensures that critical flaw sizes are adequately screened. The PV design may then be pressurization cycle-tested during qualification to a factor significantly greater than the design life to ensure an adequate margin on design cycle life.

3) **Burst Resulting from Metallic Liner.** Failure of the is mitigated by appropriate protection from damage and damage-tolerance testing. Visual inspection may be valuable in identifying surface damage, although subsurface damage to the composite or liner may not be easily identifiable.

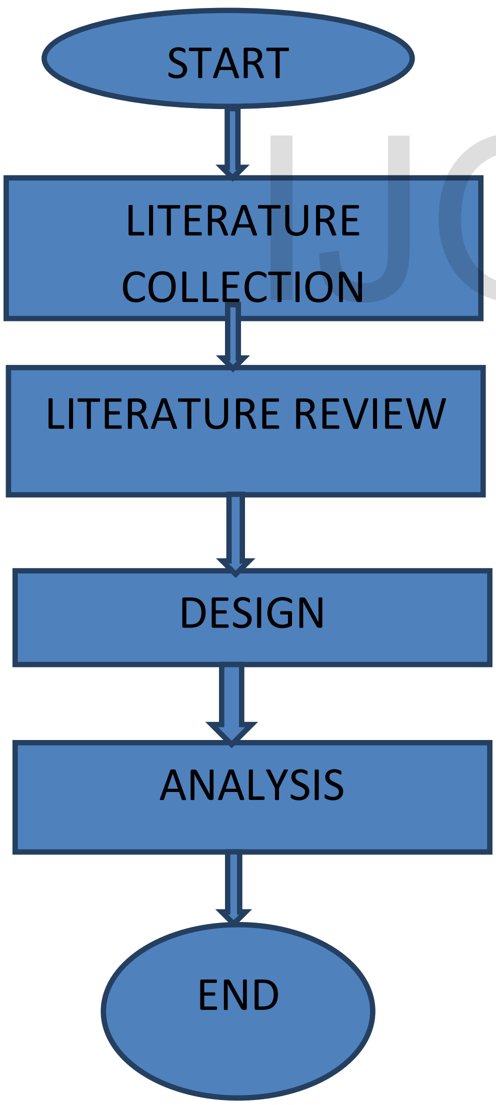
4) **Stress Rupture.** Fiber-wrapped vessels differ from metal vessels in that they experience an effect known as stress rupture, or static fatigue. Stress rupture is a situation in which the composite experiences degradation, as a function of time. This degradation results in a sudden structural failure of the pressurized vessel's composite overwrap, resulting in the rapid release of the vessel's contents and the stored energy of the pressurized gas – possibly causing serious injury and damage to the surroundings.

1.3 PROJECT CONCEPT

This project is proposed to analyse and design a cylindrical pressure vessel made up of composite material. The new composite material considered is waspaloy. In today's aviation brass is the major element used for construction of pressure vessels .It has high mingling properties which provide various properties. But Brass has many disadvantages like getting deformed, bursting, hydraulic failure and pneumatic failure. The design features focus on providing high fuel efficiency, reduction of bursting of pressure vessels in aircrafts. Pressure vessels have been manufactured by filament winding for a long time. Although they appear to be simple structures, pressure vessels are difficult to design. The advantages are superior specific strength and stiffness, resulting in a lighter design. This makes the use of fiber reinforced composites ideally suited for applications where a pressure vessel must withstand high internal pressure along with axial, bending, and shear loads. In certain applications, significant loads are imparted to composite pressure vessels due to accelerations caused by transportation and handling operations. This roject will present the development, application and results of this new composite material which shows better performance results.

II PROJECT METHODOLOGY

Project methodology is defined as the steps taken by the team for successful completion of the project. The project methodology involves theinitiative step to the final step till the completion of the project.



III CALCULATIONS

3.1 METHOD FOR DETERMINING STRAIN IN AXIAL DIRECTION

STRAIN : It is defined as the ratio of change in dimension by original dimension.

For theoretical calculation strain is

$£_x = 1/E(\alpha_x - ¥\alpha_y)$

Where

$£_x$=strain acting

E=young's modulus

$\alpha_{x=}$stress in axial direction

α_y=stress in circumferential direction

¥=poisons ratio

3.2 METHOD FOR DETERMINING STRAIN IN CIRCUMFRENTIAL DIRECTION

$£_y = 1/E(\alpha_y - ¥\alpha_x)$

where

$£_x$=strain acting

E=young's modulus

α_x=stress in axial direction

α_y=stress in circumferential direction

¥=poisons ratio

IV DESIGNS

4.1 DESIGN SPECIFICATION

MATERIAL 1-PRESSURE VESSEL MADE OF BRASS

Diameter of the pressure vessel =0.075m

Thickness of the vessel =0.001m

Length of the vessel =0.1m

Pressure applied in the vessel=0.2 to 1 kg/cm^2

MATERIAL 2-PRESSURE VESSEL MADE OF COMPOSITE MATERIAL (WASPALOY)

Diameter of the pressure vessel =0.075m

Thickness of the vessel =0.001m

Length of the vessel =0.1m

Pressure applied in the vessel=0.2 to 1 kg/cm^2

FIG 1 PROPOSED DESIGN OF THE PRESSURE VESSEL

V DESIGN RESULTS

5.1 ANALYSIS OF PRESSURE VESSEL MADE UP OF BRASS

DISPLACEMENT NODAL DIAGRAM

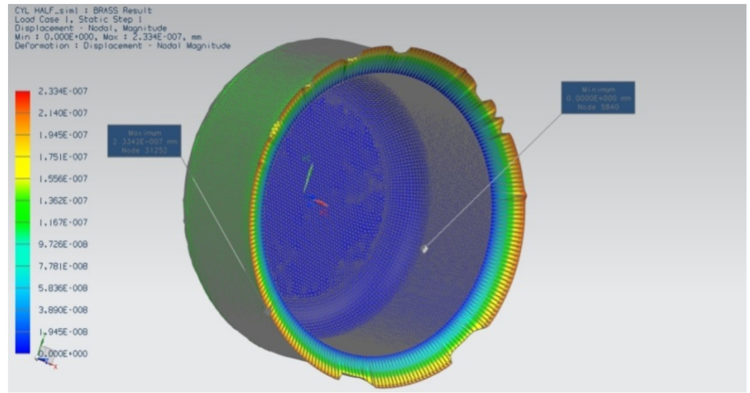


FIG 1

REACTION FORCE NODAL DIAGRAM

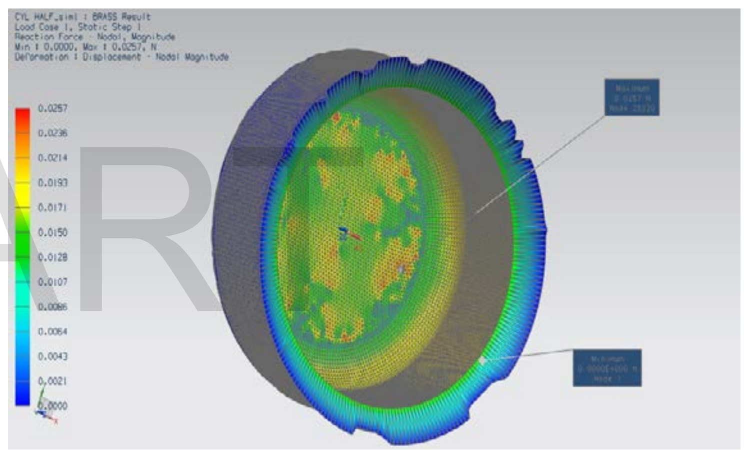
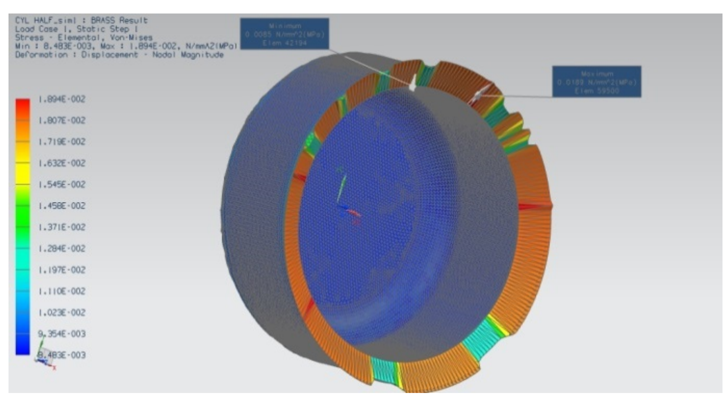


FIG 2

VONMISES CHANGE DIAGRAM



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5.2 ANALYSIS OF PRESSURE VESSEL MADE UP OF COMPOSITE MATERIAL (WASPALOY)

DISPLACEMENT NODAL DIAGRAM

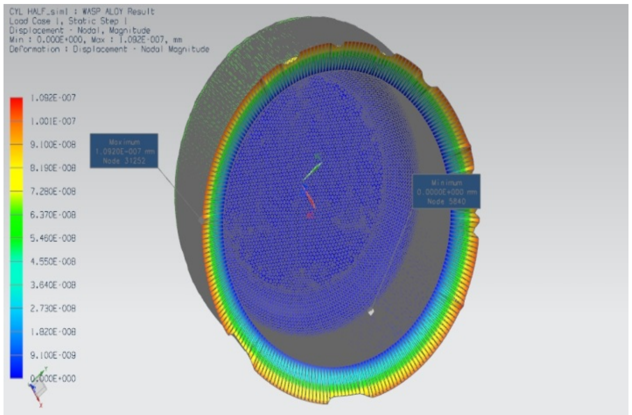


FIG 4

REACTION FORCE NODAL DIAGRAM

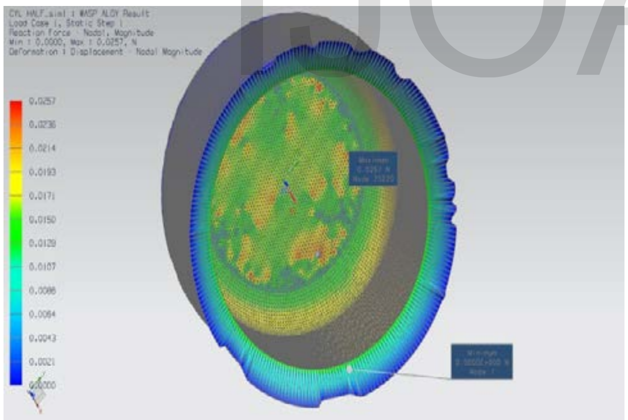
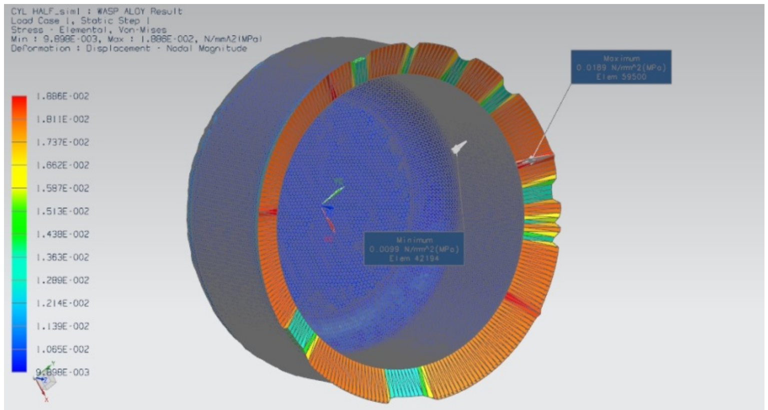


FIG 5

VONMISES CHANGE DIAGRAM



VI RESULTS AND DISCUSSIONS

From the analysed results it is evident that waspaloy has greater performance parameters than brass.

6.1COMPARISON OF THE ANALYSED DATA

PARAMETERS	BRASS	WASPALOY
DISPLACEMENT NODAL	2.3334E+.007	1.092E+.007
REACTION NODAL	0.0257	0.0257
VONMISES STRESS	1.894E+0.02	1.874E+0.02

TABLE 2

6.2 DISCUSSIONS FROM THE ANALYSED RESULTS

- ✓ From the analyzed results it is clear that the new composite material has better performance results than brass.
- ✓ The displacement variation is much less in waspaloy than brass.
- ✓ Reaction force of brass and waspaloy is almost equal.
- ✓ Vonmises stress variation is lesser for waspaloy.

VII CONCLUSIONS

Structural Composites Industries has developed, qualified, and delivered a number of high performance composite wrapped pressure vessels for use in military aircraft where low weight, low cost, high operating pressure and short lead time are the primary considerations. This paper describes product design, development, and qualification for a typical program. The vessel requirements included a munitions insensitivity criterion as evidenced by no fragmentation following impact by a .50 cal tumbling bullet. This was met by the development of a carbon-Spectra hybrid composite overwrap on a thin-walled seamless nickel liner. The same manufacturing, inspection, and test processes that are used to produce lightweight, thin walled seamless aluminum lined carbon/epoxy overwrapped pressure vessels for satellite and other space applications were used to fabricate this vessel. This report focuses on the results of performance in the qualification testing. Thus the assumed results are got. When comparing waspaloy and brass; waspaloy shows better performance results.

In future we have to study about analysis of the axial displacement of the pressure vessel, material collection with less cost and a real time model with the assumed dimensions and testing of the model.

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