Structural analysis of cylindrical shaped component using aluminium-fiber reinforced epoxy resin laminated composite

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***Abstract* - Composite materials have interesting properties such as high strength to weight ratio, ability to bring tailor made properties, good electrical and thermal properties compared to metals. Composites are one of the most advanced and adaptable engineering materials known to men. Structural analysis of non-circular shaped had already done. So there was necessity of work on cylindrical shaped composite materials. This report will give an idea about why composite materials are preferable over non composite materials. Also, the failure of cylindrical shaped composite material under compressive loading condition is calculated.**

INTRODUCTION

Further research and advances in building materials, modern production has shifted from the use of traditional materials such as metals and pottery to composites. Comites are synthetic materials made from two or more substances that exhibit better physical and chemical properties than available compounds. Compact materials have interesting properties, for example, high power in the weight ratio, the ability to deliver custom structures, large electrical and thermal properties compared to metals. Composition is one of the most advanced and flexible building materials known to men. Advances in the field of building materials science and innovation have revealed these fascinating and fascinating features. Blends are made of a combination of at least two parts with fillers or reinforcing fibers and a composite matrix. The matrix may be metal, ceramic or polymeric at first. It gives the layers its shape, earthy appearance, natural durability and great durability while the tightening of the fibers retains many structural loads. Combined property can provide outstanding and new mechanical and physical properties as it joins the most outstanding properties of its components while blocking their attractive properties. Currently, composite materials play an important role in the aviation industry, the automotive industry and other design applications as they show remarkable strength in weight ratio and modulus in weight ratio. Elite compounds manufactured using glass, graphite, kevlar, boron or silicon carbide filaments on polymeric grids are heavily focused due to their system in the use of aircraft and space vehicles. Compounds are fully ordered in metal matrix (MMC), ceramic matrix (CMC) and polymer matrix (PMC) compounds. Polymer matrix compounds are much easier to produce than MMC and CMC. This is due to the moderately lower temperatures required to form the composite of the polymer matrix. A large part of the PMC consists of engineering fibers such as carbon, nylon, rayon or glass embedded in a polymer matrix, which binds and tightly binds to the fibers.

LITERATURE REVIEW

Quanjin et al. [1] explained the design and expansion of a 3-axis rowing machine and determined the various rope bending techniques and methods. This paper provides an overview of the wet method of injury. Wetting involves the insertion of a fiber into the resin, in the resin tub before damaging the surface of the mandrel. Part of the wound is treated to get the finished part. Hocine et al. [2] showed the experimental and analytical research of the circular part of a steel vessel reinforced with a rope while undergoing internal pressure. An elasto-plastic composite-reinforced concrete component is loaded with internal pressure is proposed and the analysis provides a direct solution to the line problem and is compared to the test value in the analysis value. Wanhill et al. [3] studied the flexible concept of fiber metal laminates. Fiber metal laminate (FMLs) is a composite layer that combines the alternating layers of thin sheets of metal sheets with composite composites. The interface between the metal and the polymer layer takes on an important function. FMLs have low relative strength and high relative strength, and other positive properties such as greater damage intensity: fatigue and symptoms of exposure, use, and fire prevention. In the present work, a small composition of aluminum-epoxy/glass and aluminum-epoxy / carbon composites is described. The interface between steel and polymer compounds with local treatment and without surface adjustment at various weights has been tested. Xing et al. [4] determined damage and failures of carbon fiber strengthen epoxy filament wound composite tubes, which helps to identify the various mechanisms of failure and easily accessible composite components. Alderliesten et al. [5] studied the cycle of making aluminum alloy-the main shaft. Their experiments showed that the type of component is carefully associated with thermal pressure due to the large difference in the equilibrium development of the two elements. Yang Jinhua et al. [6] various investigation the development of delamination made of shell made of drum under round loads. The formation of delamination in round and empty shells under external contours can cause fundamental disappointment. Depending on the degree of variability of the flow limit and looking at the contact interactions between delamination sites, in this paper, non-linear conditions for handling tube-shaped shells are determined, and a comparative limit is given for comparisons with connectivity conditions. Also, according to Griffith, recipes for pre-delamination energy sources are available. As a mathematical model, the delamination structure of axisymmetrical shell-covered shells, and the effects of delamination and size, mathematical parameters, material structures and stone-laying arrangements in delamination development are discussed. Kabir et al. [7] studied the analysis of Finite element composite pressure vessels with metallic liner Composite Structures. In this paper, the determination of the filament wound structures of stretch marks plays a very important role in the analysis of the structure since it involves a lot of flexibility and thinking. This work takes the form of a study that may investigate the operation and height of the end-to-end conditions in high-pressure steel vessels. Depending on the stress conditions, the shape of the metal mandrel is assessed in this work. To establish a large line of thread, the structure of the written analysis led to an elliptic integration solution that produced links to the closed head. Sinmazcelik et al. [8] studied fiber metal laminates, backgrounds, types used and testing methods. In this paper he studied the historical development, benefits and use of FMLs. Fiber metal laminates such as ARALL, GLARE, CARALL Production include five major functions: (1) ground metal treatment. (2) Placement of goods (3) preparation for treatment (4) treatment process (5) extension of the post-residual retention of FML residues resulting from the treatment process. Since the cohesion between laminate and steel alloys is an important problem for the complete operation of the metal-fiber laminate, so there is a need for adequate treatment of the steel surface. This paper has investigated the effects of advanced therapies that improved metallic surface morphology for better adhesion to composite laminates. Additional treatment methods such as mechanical, chemical, electrochemical, coupling agents and dry-spot treatments are introduced and should be comparatively effective to improve fiber metal laminates. To determine the properties of FML equipment the author has also reviewed the test methods for bending, fatigue, stiffness, low speed and the impact of high velocity and explosion loading tests. Rajkumar et al. [9] investigated the stiffness and bending behavior of aluminum hybrid fiber laminates in different order. A sheet of al 6061 alloy, bidirectional glass fiber, 600 gsm carbon fiber, epoxy resin and hardener was used to design FMLs with various staking sequences. FMLs are produced by the process of fungal cooling after proper treatment of the metal. Strength and flexibility tests are performed with different pressure levels (1 mm/min, 2 mm/min, 3 mm/min). The results should be that strong strength increases with increasing pressure but flexural strength decreases with increasing strength values. The sequence of both strength and flexural strength is summarized A3C6> A3C4G2> A3C2G4> A3G6. Inter-laminar shear strength was also determined by three point bending test which concludes that this value is higher for A3C6. Thus there is good bonding strength between Al and CFRP leads to crack arresting in flexural test while Al and GFRP bond have greater tendency for deboning between fibre and resin matrix. Stringer et al. [10] studied Optimization of the wet lay-up/vacuum bag process for the fabrication of carbon fiber epoxy composites with high fiber fraction and low void content. In this paper the resin viscosity rises to a certain level by incorporating the duration of the treatment cycle before applying the compound pressure and there is a time window between the same viscosity limits regardless of how the resin system simply creates viscosity / temperature / time features that allow optimal duration that we are predicted.

PROBLEM STATEMENT

Modern era we always look to modify and upgrade technology as change with time. Composite material is light in weight to most metals. Their lightweight property is important in most of applications. On the other hand, composite material can be designed to strong as well as light. This property can be used where we need high strength material at the lowest possible weight. Before substituting composite material to strengthen the component it is essential to analyze it for different test to avoid failure. Problem statement can be defined as "Structural analysis of cylindrical shaped component using aluminium-fiber reinforced epoxy resin laminated composite".

OBJECTIVES

a. To study various parameters of hand lay-up method.
b. To prove why composite materials are advantageous over traditional
c. Material by using finite element analysis to design cylindrical shaped aluminium fiber reinforced laminated composite material.
d. To manufacture aluminium-fiber reinforced epoxy resin laminate composite by hand lay method
e. To examine respected composite material under compression test.
f. To validate experimental results

METHODOLOGY

a. Phase 1: Design and optimization of laminated composite with finite element analysis After the intense study of literature I had got overall scenario of past and present work on composite material which is selected in proposed work.
b. Phase 2: Fabrication of component and experimental testing This phase includes fabrication of proposed component. For fabrication we have used hand lay-up method. After fabrication experimental testing for different loading condition had carried out.
c. Phase 3: Validation of results

MANUFACTURING TECHNOLOGY

Hand lay-up method:
Hand lay-up is an embellishment method appropriate for making broadly assortment of composite items from little to enormous. Hand lay-up is the least difficult composite embellishment strategy offering ease tooling, straight forward preparing and wide scope of parts size. There is least interest in hardware. With talented administrator great creation rates and steady quality are reachable. They incorporate autoclave shaping, hand lay-up, fiber winding, pultrusion, fiber arrangement, and Resin transfer moulding.

DESIGN

After intense study of literature, we made design for proposed work. Then we optimize the design for limiting condition. At the end I have selected following design to fulfill our second objective which is stated as– To prove why composite materials are beneficial over traditional material by using finite element analysis.

INITIAL MODEL

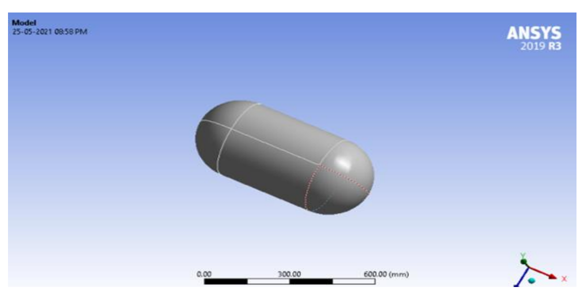

Fig No. 1: Initial model of cylindrical shaped component

GEOMETRIC MODEL

The geometry of cylindrical shaped component of GFRP material has been approximated by hemispherical ends of 150 mm radius. Length of the cylindrical portion is taken as 360 mm. The total length of the cylinder is taken as 660 mm. The thickness is 2.5 mm. It is assumed that internal pressure load of 1.3 MPa has been applied.

Analytical Calculation:

We have,

P = 1.3 MPa, D = 300 mm, t = 2.5mm

1) Longitudinal Stress (l)

l = PD/4t

= (1.3×300)/(4×2.5)

= 39 Mpa

2) Cylindrical portion hoop stress (h)

h = PD/2t

= (1.3×300)/(2×2.5)

=78 Mpa

3) Von mises stress (v)

v = √[(h×h)+(l×l)-(h×l)]

= √[(78×78)+(39×39)-(78×39)]

= 67.54 Mpa

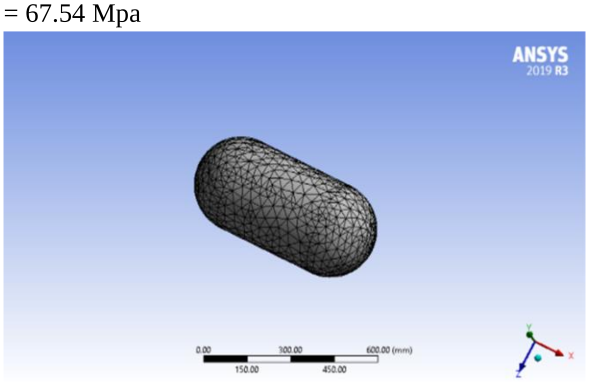

Fig No. 2: Geometric model of composite material

Case 1: Cylindrical component made up of GFRP

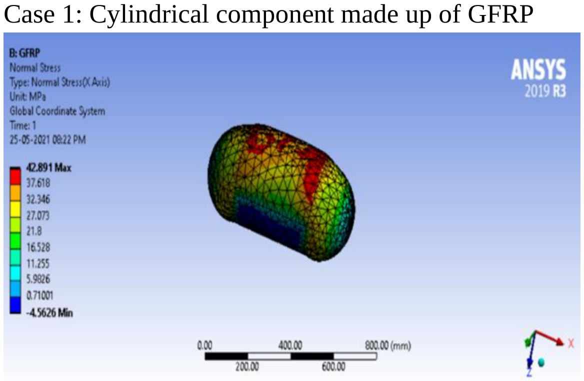

Fig No. 3: Longitudinal stress of composite material

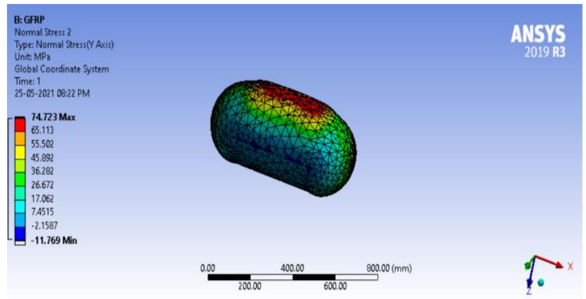

Fig No. 4: Hoop stress of composite material

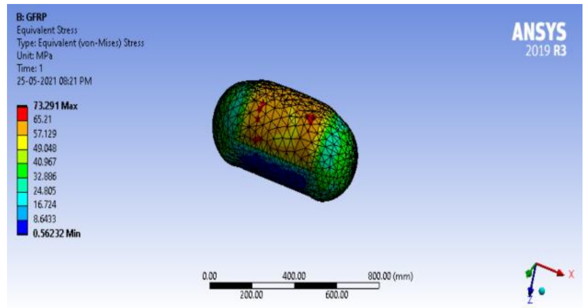

Fig No. 5: Von-mises stress of composite material

RESULT TABLE

Stress Result (MPa)	FE method	Analytical method
longitudinal stress	42.981	39
hoop stress	74.723	78
Von-mises stress	73.291	67.54

Table No. 1: Stress comparison results for GFRP material

CONCLUSION

There was an untouched area of work in cylindrical shaped composite material. Modern era we always look to modify and upgrade technology as change with time. Composite material is light in weight to most metals. Their lightweight property is important in most of applications. On the other hand, composite material can be designed to be both strong and light. This property can be used where we need high strength material at the lowest possible weight. Before substituting composite material to strengthen the component it is essential to analyze it for different test to avoid failure. Before going to test it was necessary to prove why composite materials can be used as substitute to non-composite materials. For that I had carried out comparison between composite and non-composite component of same dimension via finite element analysis. From FEA analysis we can conclude that composite materials are superior to non-composite materials. Also, weight of material can be reduced without affecting performance. Because of reduction in weight cost of material can be reduced.

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