Design And Manufacture Of Composite Bicycle Frame And Evaluation Of Compressive Properties Of ±45^0 E-Glass/Epoxy Composite With Different Introduced Defects

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Abstract— **A Bicycle frame is prominent part in whole racing cycle system which is subjected to static and dynamic loads. The dependency of the performance is directly proportionate to weight of the bicycle and frame structural design, Optimization of weight and structure of the frame is the best scope of optimizing the overall performance of the racing cycle, A monocoque design is advisable in racing utility hence we are targeting towards composite design and how its frame can be optimized by using static and Dynamic analysis, Thus a composite frame which is three times stronger and four times lighter than Steel will have a higher efficiency. Such bicycles can be categorized as Advanced Bicycles. However, some of the composites have low compressive strength and this fact limits the full potential application of these composites. The compression testing of the composites is very challenging due to various reasons. The object of this research paper is to design a composite structural frame, which should take on the role of a frame in a normal bicycle and compression test on the frame specimen under different conditions**.

Keywords—Epoxy; Diamond Frame; E-Glass Fiber; Creel Stand; Resin Bath.

I INTRODUCTION

Composites are combination of two or more materials (reinforcing elements, fillers, and composite matrix binder), differing in form or composition on a macro scale. Rather, they are a judicious mixture of the reinforcements and the matrix. The constituents retain their identities, that is, they do not dissolve or merge completely in to one another although they act in concert. The properties of a composite will differ from the constituents in isolation and set of performance characteristics is greater than that of the components taken separately [1-3]. Composite materials are becoming more important in the construction of aerospace structures. Aircraft parts made from composite materials, such as fairings, spoilers, and flight controls, were developed during the 1960s for their weight savings over aluminum parts. The primary advantages of composite materials are their high strength, relatively low weight, and corrosion resistance. Structural properties, such as stiffness, dimensional stability, and strength of a composite laminate, depend on

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the stacking sequence of the plies [4]. The stacking sequence describes the distribution of ply orientations through the laminate thickness. Proper selection of ply orientation in advanced composite materials is necessary to provide a structurally efficient design. The part might require 0° plies to react to axial loads, ±45° plies to react to shear loads, and 90° plies to react to side loads, because the strength design requirements are a function of the applied load direction, ply orientation and ply sequence have to be correct. It is critical during a repair to replace each damaged ply with a ply of the same material and ply orientation [5].

II THEORITICAL BACKGROUND

- *BICYCLE FRAME:* The frame of the bicycle is the main structure to support the external loads. Traditional materials of the bicycle frame are the steel or aluminum alloy. For the purpose of reducing weight, the carbon/epoxy composite materials are now widely used to make the bicycle frames. An example of the carbon/epoxy bicycle frame only weighs 2 kg, which is much less than the 7 kg weight of the corresponding steel frame. In the design process of the bicycle, the structural analysis of the frame or other parts is a very important stage. With the aid of theoretical or numerical calculations, the strength and stiffness of the bicycle structures can be predicted and modified to the optimal design before the manufacture of the prototype and commercial products. The finite element method is one of the numerical calculations applied in various physical problems. It usually plays a major role to calculate the stress and deformation of the structures.

- *MATERIALS FOR BICYCLE FRAME:* Fiberglass is a material consisting of numerous extremely fine fibers of glass. Glass fiber is formed when thin strands of silica-based or other formulation glass is extruded into many fibers with small diameters suitable for textile processing. These are useful because of their high ratio of surface area to weight. However, the increased surface area makes them much more susceptible to chemical attack. Woven from glass fiber texturized yarn upon shuttle looms to produce required size. Fiberglass cloth is used as heat insulating material and an excellent substitute for asbestos cloth. It is widely applied as insulation of soft or hard tubes, heat insulation covering of heater and cooler, fire resistant shell, other insulation protecting covering and insulation of watercraft equipment because of its brilliant characteristics of high intensity, low density and good insulation.

Fiberglass cloth manufactured by us offers the best control over thickness, weight and strength of all forms of fiberglass textiles. This cloth include properties like high tensile strength, dimensional stability, high heat resistance, fire resistance, good thermal conductivity, durability, etc.

III DESIGNING AND ANALYSIS OF 3-D MODEL OF BICYCLE FRAME

Required CAD was developed using 3-D modeling software. The cad geometry has basic requirement for Head tube, top tube, bottom tube, chain stays, seat stays, bottom bracket shell and the two triangles commonly says diamond frame. This is the model of the bicycle frame. A bicycle frame is the main component of a bicycle, onto

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which wheels and other components are fitted. The modern and most common frame design for an upright bicycle is based on the safety bicycle, and consists of two triangles, a main triangle and a paired rear triangle. This is known as the diamond frame. Frames are required to be strong, stiff and light, which they do by combining different materials and shapes. Fig.1. shows the cad model of bicycle frame.

Fig.1. CAD Model

IV ANALYSIS OF BICYCLE FRAME

If analysis is done in solid works then it is called as "simulation". Simulation is the imitation of the operation of a real-world process or system over time the act of simulating something first requires that a model be developed; this model represents the key characteristics or behaviors/functions of the selected physical or abstract system or process. The model represents the system itself, whereas the simulation represents the operation of the system over time.

For the dimensions analysis of S-glass frame gives us the thickness of the bicycle is safe for the applied load hence the thickness can be reduced from 5mm to 3mm which is also safe thickness and bicycle can work properly without any failure. With the properties of S-glass fiber which is a high strength glass fiber. The concept derived from the considerations was simulated using the solid works simulation software by applying the loads at the points where it generally occurs.

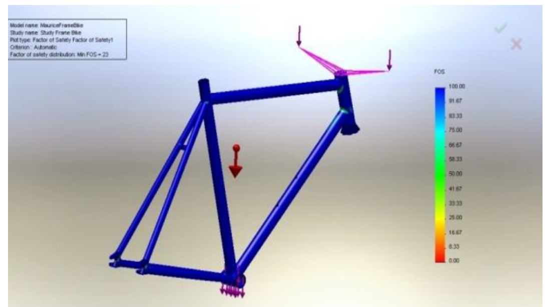

Fig.2. Analysis of Bicycle frame

To manufacture the bicycle frame using Composite fibers, a Specimen of the Composite Fiber used for Manufacturing is first tested against Compressive Stresses in a Universal Testing Machine (UTM) and the following results were observed. Fig.2. shows the analysis of bicycle frame.

V COMPRESSIVE PROPERTIES OF STANDARD SPECIMEN

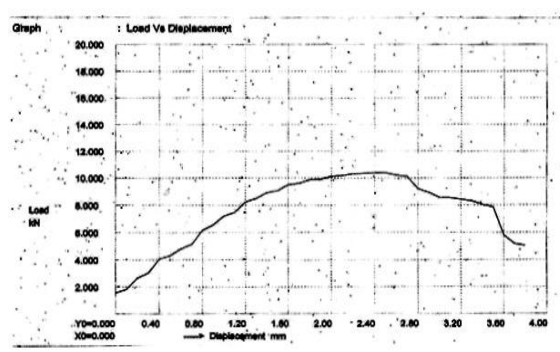

Fig.3. Graph Load vs. Displacement graph for standard specimen

TABLE-I COMPRESSIVE STRESS IN STANDARD SPECIMEN

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S. No	Dimensions (mm)	Area (mm2)	Load (KN)	Compressive Stress(N/mm2)
1	140 x 23.6 x 5.03	119.16	10.38	87.10

VI MANUFACTURE OF A BICYCLE FRAME

The manufacture we made to attain the tubes of diamond frame which are further joined into required shape. The tube wrapping follows cleaning the surface of tube. After the cleaning is done, Wax pool is applied on the surface of tube and after that PVA is also applied. Applying fibers and pouring resin on Wax pool is to cast the mould of the Bicycle Frame. This is then allowed to cure and then ejected from the mould.

Fig.4. Tube wrapping process

VII ASSEMBLY OF JOINTS

Assembly of joints is been a major drawback in the composite materials. This process is done in a step by step manner. Initially the steel member is cleaned with acetone liquid. And is made rough by using the sanding paper, then a thin layer of the resin mixture is applied over it and Impregnating a steel member at the joints is the only possible solution that can be done. Selecting a steel member which can be easily go through the manufactured composite member and thus cutting it and joined and another problem which we has undergone is the modulus mismatch between the composite and the steel member. In this case, the composite material has a young's modulus of 35-40 G pa. And the steel has enormous young's modulus of 220Gpa. There is a huge amount of difference; to overcome this we wrapped a carbon fiber cloth around the steel member and applying the resin mixture over it and joining them completely. Now if we compare the modulus of the joined material, it is almost stable, the carbon which has a young's modulus of 70-80 G pa.

After all the operations performed such as making of rods, steel members inserting joining laying on top of the joints the final frame is obtained and then fitted with the available parts in the market and cycle is ready to test and use. The final product bicycle manual powered vehicle is obtained.

Fig.5. Bicycle

VIII RESULTS AND DISCUSSIONS

The Structural analysis of Bicycle frame by specifying the material as a Composite S-Glass Fiber. The compressive test fixture is

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designed and manufactured. The average value of compressive stress for standard specimen is 85.76 N/mm^2. The average value of compressive stress for damaged specimen is 48.32 N/mm^2. The average value of compressive stress for specimen with 6mm diameter circular hole is 76.02 N/mm^2. The average value of compressive stress for specimen with square hole of side 6mm is 73.26 N/mm^2. The average value of compressive stress for with 8mm diameter circular hole specimen is 71.45 N/mm^2. The average value of compressive stress for specimen with square hole of side 8mm is 69.47 N/mm^2. It has be concluded from the above result that the compressive strength is reduced with damage in the laminate.

IX CONCLUSION

This research paper is aimed to Design and manufacture of Composite frame bicycle and compressive test fixture for the evaluation on compressive properties of ± 45 E-glass Epoxy composite with different introduces defects. The following conclusions are made with this project work

- By using S-glass fibre as reinforcement and EPOXY 556/FINEHARD 951 as matrix material, the bicycle frame produced is of 2.5kgs which is very less when compared to normal bicycle frame of 7 kg.
- The cost of the bicycle frame made is around 3500 to 4000 rupees which is economical when compared to the aluminium bicycle it is around 15000 rupees. This is high when compared to normal bicycle frame but when compared to Carbon frame it is very low.
- Due to similar applications and properties to that of a carbon fiber with low cost glass fiber bicycle frames comes as future source of bicycles.

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