Use of Composite Material for Replacement to Steel in Conventional Two Wheeler Axle

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Abstract - **The importance of materials in modern world can be realized from the fact that much of the research is being done to apply new materials to different components.Increasing competition and innovation in automobile sector tends to modify the existing products by new and advanced material products.This paper presents development and manufacturing of two wheeler axle by using epoxy resin and glass fiber composite material.In this paper, the aim is to manufacture the composite wheel axle and compare the results with conventional steel axle under different mechanical testing with evaluating of different mechanical properties such as tensile strength,bending strength,impact strength,fatigue strength by using appropriate experimental technique.**

Keywords: ***Axle, Composite, Glass Fiber Reinforced plastic (GFRP),Tensile test, Bending test, Impact test, Fatigue test,Pultrusion.***

1. INTRODUCTION

Composite materials are commonly used in structures that demand a high level of mechanical performance. Their high strength to weight and stiffness to weight ratios has facilitated the development of lighter structures[1]which often replace conventional metal structures.Glass fibers are used to increase the mechanical and physical pro perties of the material.Particulate glass fiber tend to be much weaker and less stiff than continuous glass fibers,so pultrusion process is used to manufacture the component which creates continuous composite profile. In glass fiber material damage can easily detect which is important to identify the factor that contributes to permanent deformation,it would be very dangerous in some application such as automobiles.Because of all these factors,comparative test has to be carried out.

2 .MATERIALS AND PROCESSING METHODS

2.1 Selection of Matrix Material

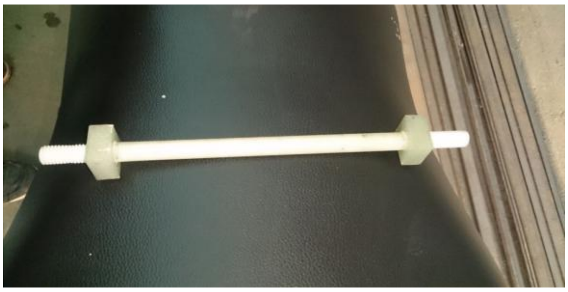
Epoxy resin is one of the excellent thermosetting polymer resins. The cost-to-performance ratio of epoxy resin is outstanding. Epoxy resins possess characteristics such as high strength, low creep, good adhesion to most of the substrate materials, low shrinkage during curing and low viscosity[2].
Bisphenol A, more commonly known as BPA ,is a chemical widely used to make epoxy resin[3] .This resin uses a 2:1 hardener. Mixing 2 parts epoxy to 1 part hardener will give you the appropriate final mixture. The 2:1 hardener has a pot life of 35-40 minutes at 80 ^{0} F, set time of 5-6 hours and a drying time of 24-48 hours.

2.2 Selection of Reinforcement Material

Because of high youngs modulus ,High strength and stiffness with low density S-glass fibers are used for reinforcement material[4]

2.3 Processing Method

Pultrusion process is used to manufacturing the composite wheel axle This process creates continuous composite profile by pulling raw composite through heated die.The die is heated to a constant temperature and may have several zones of temperature throughout its length which will cure the thermosetting resin.Specimens of suitable dimensions are cut using an electrically operated cutter for mechanical testing.For this,70 to 75 % S-glass fiber and 25 to 30 % epoxy resin is used to manufacture the specimens.



Photograph 1- Composite axle made by pultrusion process

3. Experimental setup and conducting the test

3.1 Tensile test

In this test,the tensile behavior of glass fiber reinforced composites in different weight percentages of glass (70% and 75%) is presented.The tensile test was carried out on universal testing machine. The commonly used specimen for tensile test is prepared as per ASTM D-638standards[5]

Photograph 2- Composite specimen for Tensile test

3.1.1 Tensile test results

S-GFRP		Mild steel (Grade300)	
Yield stress	Tensile strength	Yield stress	Tensile strength
362.385 N/mm^2	699.441 N/mm^2	835.507 N/mm^2	938.471 N/mm^2

Table 1-Tensile test results

3.2 Bending test

In this test, the bend behavior of glass fiber reinforced composites in different weight percentages of glass (70% and 75%) is presented. The bending test was carried out on computerized universal testing machine. The flexural specimens are prepared as per the ASTM D790 .The two specimens were subjected to flexural test and their values were reported.

Photograph 3- Three point bending test set up

Photograph 4- Composite specimen after flexural load

The 3-point flexure test is the most common flexural test for composite materials. Specimen deflection is measured by the crosshead position[5]. The testing process involves placing the test specimen in the universal testing machine and applying force to it until it fractures and breaks.

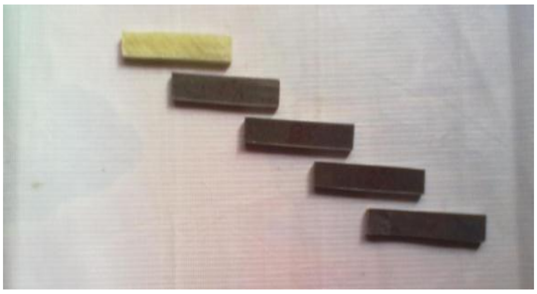
3.2.1 Bending test results

S-GFRP		Mild steeel(Grade300)	
Load (KN)	Deflection (mm)	Load (KN)	Deflection (mm)
100	2	100	2
200	4	200	2.5
300	5	300	3
400	6	400	4
500	7	500	5
600	9	600	6

Table 2-Bending test results

3.3 Impact test

In this test, the impact behavior of different glass fiber reinforced composites is presented. The Impact test was carried out on Impact testing machine. The impact test specimens are prepared according to the required dimension as per ASTM-A370 standard.



Photograph5- Impact test specimen

3.3.1 Impact test set up

During the testing process, the specimen must be loaded in the testing machine and allows the pendulum until it fractures or breaks. Using the impact test, the energy needed to break the material can be measured easily and can be used to measure the toughness of the material and the yield strength.

Photograph 6 - Impact test set up

Photograph 7- Composite specimen after test

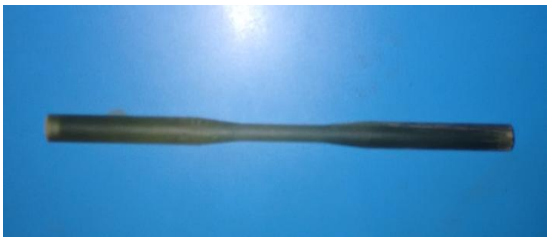
3.3.2 Impact test result

Energy absorbed by materials(Joule)	
S-GFRP	108
Mild steel	56

Table3- Energy absorbed by different materials

3.4 Fatigue test

The Fatigue test was carried out on Fatigue testing machine. The test specimens are prepared as per ASTM D3479M-96 standards. In this test fatigue life of glass fiber reinforced composites is presented.



Photograph 8-Fatigue test specimen

3.4.1 Fatigue test set up

In fatigue testing, first Measure the dimension of the specimen then mount the specimen in the rotating bending machine after that apply the load and record the bending moment from scale applied on specimen. Reset the counter to zero Start the machine and wait until the specimen is broken.

Photograph 9- Fatigue test set up

3.4.2 Fatigue test result

For Mild steel(Grade 300) specimen

Sr no	Bending moment	Revolution	Time
1	150 kg-cm	8500rpm	1.91min

Table 4 Fatigue test result for MS specimen

For S GFRP Specimen

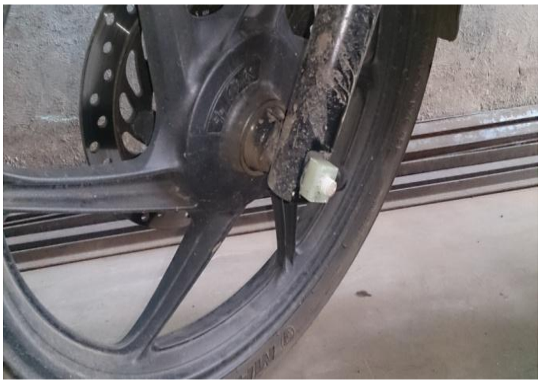
Sr no	Bending moment	Revolution	Time
1	75 kg-cm	26000rpm	4.05 min

Table 5 Fatigue test result for composite specimen

3.5 Actual Component Test

In component test,first composite axle is made by pultrusion process then replace the Honda trigger front axle by composite axle after that check the performance of bike by actual riding along with dynamic and static testing on front axle and compare it with actual steel component.

Photograph 10-Front Axle on Honda trigger (MS)



Photograph 11- Front Axle on Honda trigger (GFRP)

4. RESULTS AND DISCUSSIONS

4.1 Tensile test analysis

Fig 1 shows stress-strain behavior composite specimen and fig 2 shows stress-strain behavior of mild steel specimen.

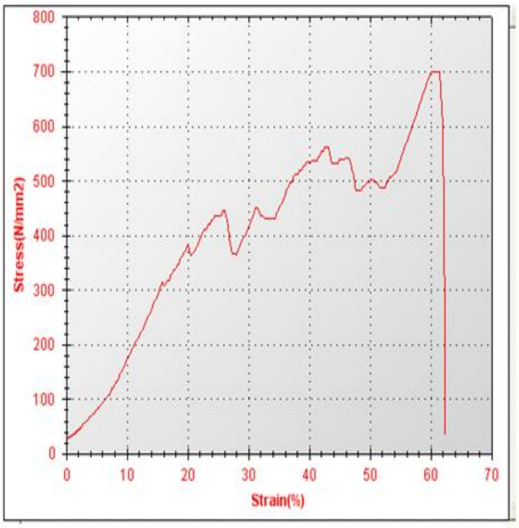


Fig 1 Stress-strain behavior of composite specimen in tensile test

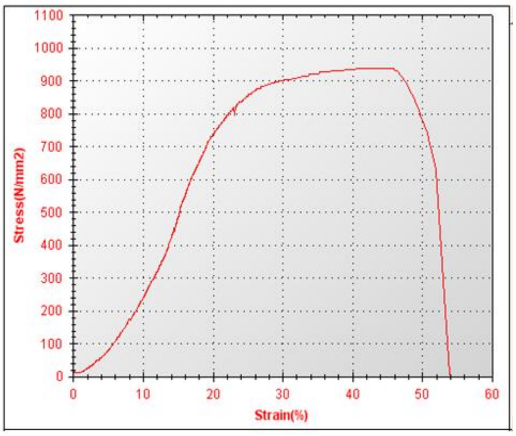


Fig 2 Stress-strain behavior of mild steel specimen in tensile test

In case of composite, load at yield point is 39.63KN whereas 91.37 KN for mild steel specimen.

4.2 Bending test analysis

Fig3 shows comparision of bending behavior between mild steel and composite specimen at different load conditions.

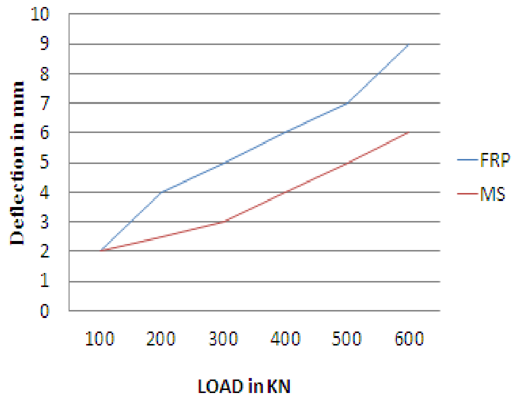


Fig 3 Comparision of bending behavior between mild steel and composite specimen at different load conditions

In bending test composite specimen is deflected by 9mm at 600KN load whereas 6mm for mild steel specimen at same load.

4.3 Impact test analysis

Fig 4 shows energy absorbed by GFRP material is 108 joule and mild steel is 56 joule.

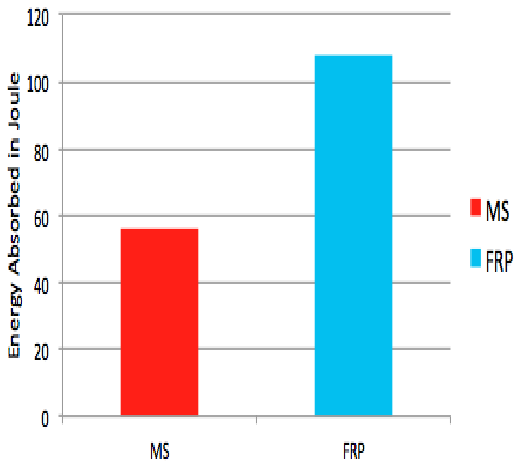


Fig 4 Energy absorbed by different materials

4.4 Fatigue test analysis

In fatigue analysis the composite specimen break at 26000 RPM when bending moment is 75 Kg-cm and Mild steel specimen fails at 8500RPM when bending moment is 150 Kg-cm.

CONCLUSIONS

The replacement of composite materials has resulted in considerable amount of weight reduction about 64% when compared to conventional mild steel shaft. Also, the results reveal that the orientation of fibers has great influence on the dynamic characteristics of the composite shaft.

Weight reduction

The weight of composite specimen is 78gms whereas the weight of MS specimen is 217 gm so there is 64% weight reduction because of less density of glass fiber. the density of glass fiber is 2500 kg/m^3 and MS density is 7500kg/m^3.

Impact strength increased

The energy absorbed by composite specimen is 108 Joules and energy absorbed by MS specimen is 56 Joules, the energy absorbed by composite is twice than the MS because of FRP has more absorption properties than MS.

High Bending strength

In bending test there is permanent deformation of MS specimen at 550KN and at same load composite specimen gets back to original shape because composite material are more flexible than MS material.

Tensile strength reduced

Tensile strength of composite is less than MS, due to crushing at clamping.

Good fatigue strength

Fatigue strength of composite is better than mild steel.

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