

Experimental evaluation and analysis of Glass Fiber Reinforced Composite under mechanical loading by using FEA software

Author 1

Mr.P.A.Pandav

*Assistant Professor, Mechanical Department,
D.Y.Patil college of Engineering and Technology, Kolhapur, Maharashtra, India*

Author 2

Mr.D.A.Sawant

*Assistant Professor, Mechanical Department,
D.Y.Patil college of Engineering and Technology, Kolhapur, Maharashtra, India*

Abstract

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 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. Also the experimental results are compared with the FEA results by using ANSYS R15.

Keywords: Matrix, Reinforcement, Axle, Composite, Glass fiber Reinforced plastic (GFRP), Tensile test, Bending test, Impact test, Fatigue test, Pultrusion, ANSYSR15

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 properties of the material. Pultrusion is a continuous, automated process that is cost effective for high volume production of parts with uniform cross section so this process is used to manufacture the component which creates continuous composite profile. Two wheeler axle is made by GFRP material and compare the performance 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 along with the experimental results are compared with the FEA results by using ANSYS R15.

Material Selection

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, and 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 ° F, set time of 5-6 hours and a drying time of 24-48 hours.

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

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 has 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

Mechanical Testing

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-638 standards [5]



Photograph 2: Composite specimen for tensile test

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 are subjected to flexural test and their values are reported.



Photograph 3: Three point bending test set up

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.

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.



Photograph 4: Composite specimen after test

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 5: Fatigue test set up

FEA Analysis

FEA consists of a computer model of a material or design that is stressed and analyzed for specific results. The model which is exported in .stp format is imported in ANSYSR15 Design modeler then the model is meshed using Hexa elements using Mapped face meshing.

Tensile test analysis

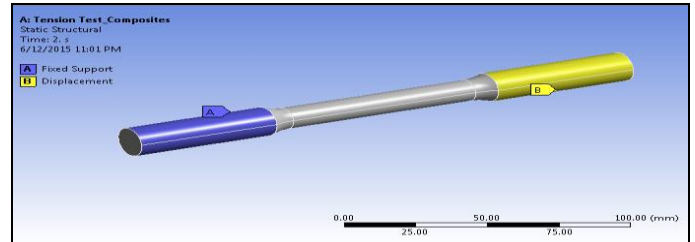


Fig 1: Load and Boundary condition

Various loading and boundary conditions like fixed support, tensile load are applied for appropriate parts. Here one end of specimen is fixed and for other end tensile load is applied. The Figure 1 shows loading and boundary conditions of composite specimen.

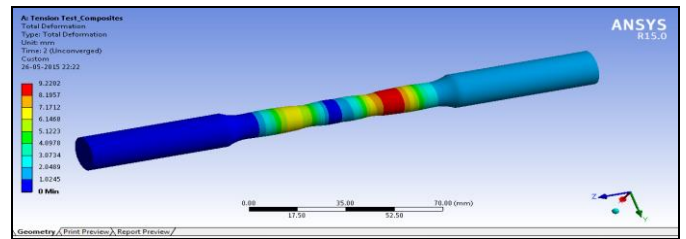


Fig.2: Total deformation-composite specimen

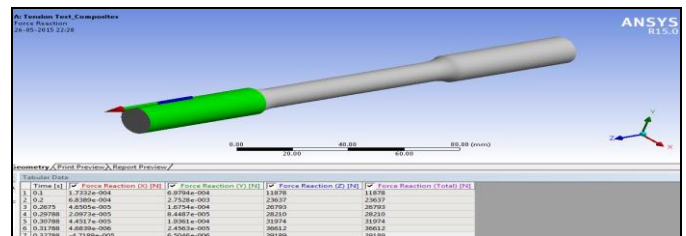


Fig 3: Reaction (Applied Load) at Yield

Bending test analysis

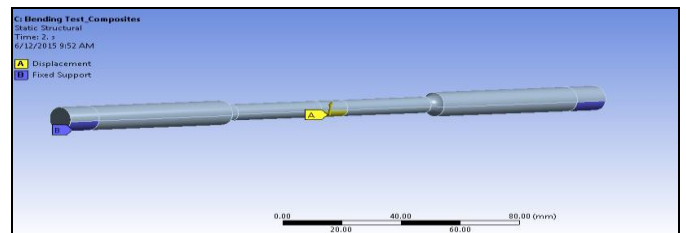


Fig 4: Loading and boundary condition

The analysis of composite specimen is carried out by applying above stated loading and boundary condition. Here both end of specimen are simply supported and bending load is applied

At the centre from 100KN to 600KN as shown in fig 4. The total deformation and equivalent stresses for flexural load shown in Figure 5 and Figure 6 respectively.

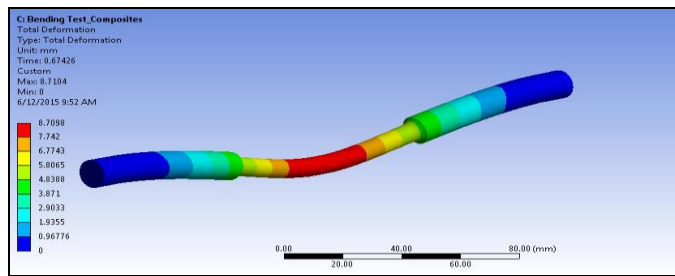


Fig.5: Total deformation-composite specimen

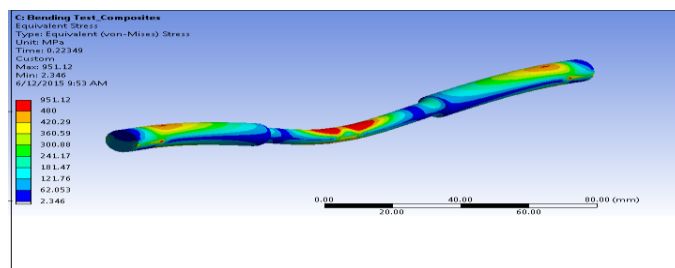
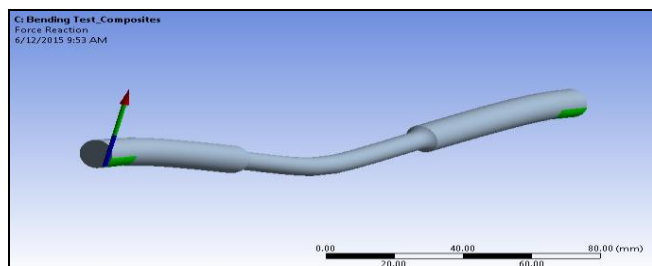


Fig 6: Equivalent stress-composite specimen



| Maximum Value Over Time | |
|---------------------------------|---------------|
| <input type="checkbox"/> X Axis | 0.26559 N |
| <input type="checkbox"/> Y Axis | 1.9023e-002 N |
| <input type="checkbox"/> Z Axis | 6.2704e+005 N |
| <input type="checkbox"/> Total | 7.1943e+005 N |

Fig 7: Results for the flexural analysis of composite axle

Results and Discussion

Tensile test results

Fig 8 shows stress-strain behavior composite specimen and fig 9 shows stress-strain behavior of mild steel specimen. In case of composite, load at yield point is 39.63KN whereas 91.37 KN for mild steel specimen.



Fig 8: Stress-strain behavior of composite specimen

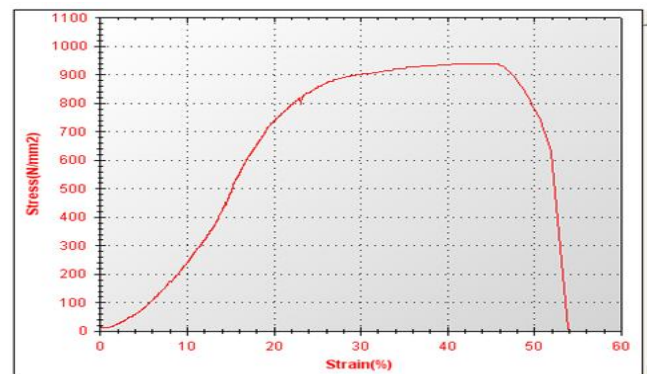


Fig 9: Stress-strain behavior of mild steel

Bending test results

Fig 10 shows comparison of bending behavior between mild steel and composite specimen at different load conditions.

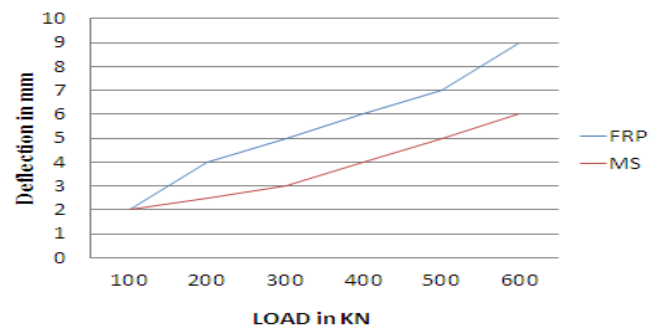


Fig 10: Comparison of bending behavior between mild steel and composite specimen at different load conditions

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

Impact test results

Fig 11 shows energy absorbed by GFRP material is 108 joule and mild steel is 56 joule.

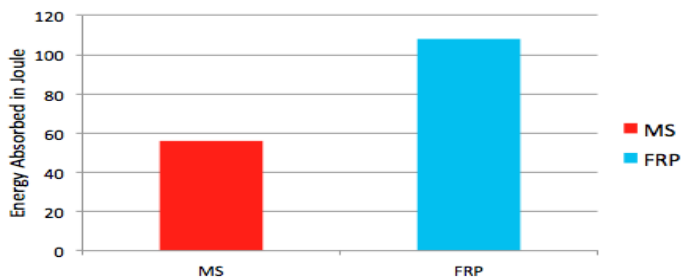


Fig 11: Energy absorbed by different materials

Fatigue test results

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 fibres 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 7500 kg/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.

References

[1] G.Rathnakar, H Shivanan (2013), "Experimental Evaluation of Strength and Stiffness of Fiber Reinforced Composites under Flexural Loading" International Journal of Engineering and Innovative Technology, 2, 7, 2277-3754.

[2] Sivasaravanan.S (2014), "Impact Characterization of Epoxy LY556/E-Glass Fiber/ Nano Clay Hybrid Nano Composite Materials" 12th global congress on Manufacturing and management.

[3] Mathpati S. S, Hawal T. T., Kakamari P. P., Nikhil R.(2014), "Analysis and characterization of tensile and compressive, properties of chopped stand mat- E Glass fiber reinforced epoxy composites, "An international journal of advanced engineering and applied science ,2320-3927.

[4] Mhajan G.V, Aher V.S.(2012), "Composite material: a review over current development and automotive applications" International journal of scientific and research publication, 2, 11, 2250-3153.

[5] Sanjay M R., Arpitha G R, B Yogesha (2014), "Investigation on Mechanical Property Evaluation of Jute-Glass Fiber Reinforced Polyester" IOSR Journal of Mechanical and Civil Engineering, 4, 11, 2320-334X.

[6] Surywanshi B K Damle P.G(2013), "Review of design of hybrid aluminum composite drive shaft of automobile "International journal of technology and exploring engineering,2,4,2278-3075.

[7] Singh S P, Gubran H. B. H, Gupta K(1997), "Development in dynamic composite material shafts" international journal of rotating machinery,3,3,189-198.

[8] Kumar N. K., Kumar M. P. , Rao D. S. (2013), "Experimental investigation on mechanical properties of coal ash reinforced glass fiber polymer matrix composites" international journal of emerging technology & engineering ,3,8,2250-2459.

[9] Mhaske R.,Parkhe R., Nimbalkar S.(2014), "C-Glass/Epoxy composite material- A Replacement for steel in conventional leaf spring for weight reduction "International journal of engineering, 2,4,2319-6378.

[10] Pazilarasu V.,Perameshwaranpillai T.(2013), "Comparison of performance of glass fiber reinforced plastic leaf spring with steel leaf spring", International journal of chem. Tech research ,5,3,1339-1345.

[11] Hameed N, Sreekumar P.A, Francis B, Yang W, Thomas S, (2007), "Morphology, dynamic, Mechanical and thermal studies an poly (styrene-co-acrylonitrile) modified epoxy resin/glass fiber composite" Composites: part A, 38,2422-2432.

[12] Tosun N,Hasin P (2012), "Investigation of the wear behavior of Glass-fiber-reinforced Composite and plain polyester resin" Computer science and technology, 62,367-37.

[13] Ana Trombev (2011), "Influence of the Composite Components on the Tension Behavior of FRP Materials" 2011 International Conference on Physics Science and Technology,22,584-589.