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Study of Epoxy Based Hybrid Composite Leaf Spring with Aluminium Powder And E-Glass Fibres

Engineering

KEYWORDS : Epoxy resin, Aluminium powder and E-glass fibre

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ABSTRACT

Reducing weight while increasing or maintaining strength of products is getting to be highly important research issue in this modern world. Composite materials are one of the material families which are attracting researchers and being solutions of such issue. Automobile industry has great interest for replacement of steel leaf spring with that of composite leaf spring. Composite materials have high strength to weight ratio, good corrosion resistance. Epoxy based composites moulds are frequently used for wax and polymer materials injection. In the present paper, Tri Phase materials compose by an Epoxy resin, Aluminium powder and E-glass fibre, were fabricated with standard dimensions and various Mechanical tests are to be conducted as per ASTM.

In this paper composite leaf spring is fabricated using hand lay-up technique and to replace metallic leaf spring of light passenger vehicle. Different tests were performed to compared the load carrying capacity and stiffness of E-Glass/Epoxy composite.

INTRODUCTION

Composites materials are extending the horizons of designers in all branches of engineering, and yet the degree to which this is happening can easily pass unperceived. In composites, materials are combined in such a way as to enable us to make better use of their virtues while minimizing to some extent the effects of their deficiencies. Use of synthetic polymers in every segment of our life has increased the plastic waste in large quantities, which forms one of the major environmental problems the world is facing today. New environmental regulations and societal concern have triggered the search for new products and processes that are compatible to the environment.

Ever increasing demands of high performance together with long life and light weight necessitate consistent development of almost every part of automobile. Increasing competition and innovations in automobile sector tends to modify the existing products or replacing old products by new and advanced material products. A suspension system of vehicle is also an area where these innovations are carried out regularly. Leaf springs are mainly used in suspension systems to absorb shock loads in automobiles like light motor vehicles, heavy duty trucks and in rail systems. The suspension leaf spring is one of the potential items for weight reduction in automobiles un-sprung weight. This achieves the vehicle with more fuel efficiency and improved riding qualities. Weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing processes.

The study demonstrated that composites can be used for leaf springs for light weight vehicles and meet the requirements, together with substantial weight savings. The introduction of composite materials was made it possible to reduce the weight of leaf spring without any reduction on load carrying capacity and stiffness. Since, the composite materials have more elastic strain energy storage capacity and high strength-to-weight ratio as compared to those of steel. A composite material is the combination of two or more materials that produce a synergistic effect so that the combination produces aggregate properties that are different from any of those of its constituents attain independently. This is intentionally being done today to get different design, manufacturing as well as service advantages of products. Upon those products leaf spring is the focus of this paper for which researches are running to get the best composite material, which meets the current requirement of strength and weight reduction in one, to replace the existing steel leaf spring.

2. LITERATURE REVIEW

Investigation of composite leaf spring in the early 60's failed to yield the production facility because of inconsistent fatigue performance and absence of strong need for mass reduction. Researches in the area of automobile components have been receiving considerable attention now. Particularly the automobile manufacturers and parts makers have been attempting to reduce the weight of the vehicles in recent years. Emphasis of vehicles weight reduction in 1978 justified taking a new look at composite springs. Studies are made to demonstrate viability and potential of FRP in automotive structural application.

[1] P.V. Vasconcelos et al.,

Studied impact fracture of the epoxy –based composites with aluminium particles and milled fibres, in this paper the milled fibres and aluminium addition increases slightly the impact resistance of the aluminium filled composites.

[2] Gulur Siddaramanna Shiva Shankar et al.,

In this paper a single leaf with variable thickness and width for constant cross sectional area of unidirectional glass fiber reinforced plastic (GFRP) with similar mechanical and geometrical properties to the multi leaf spring, was designed, fabricated (hand-layup technique) and tested.

[3] Mouleeswaaran Senthil Kumar et al.,

In this paper composite leaf spring is design on basis of fatigue failure .Theoretical equation for prediction fatigue life is formulated using fatigue modulus and its degrading rate. The dimensions and number of leaves for both steel leaf spring and composite leaf spring are considered to be same. The stress analysis is performed using finite element method.

2.1 *Classification of composite materials*

Most composite materials developed so far have been fabricated to improve mechanical properties such as strength, stiffness, toughness, and high temperature performance. It is natural to study together the composites that have a common governing strengthening mechanism. The strengthening mechanism depends strongly on the geometry of the reinforcement. Therefore, it is quite convenient to classify composite materials on the basis of the geometry of the reinforcement. Figure 2.1represents a commonly accepted classification scheme for composite materials.

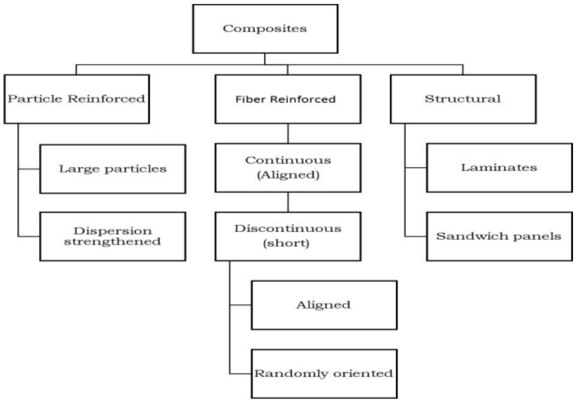

Figure2.1: : Classification of Composite Materials [9]

2.2Leaf springs:
Originally called laminated or carriage spring, a leaf spring is a simple form of spring, commonly used for the suspension in wheeled vehicles. It is also one of the oldest forms of springing, dating back to medieval times.

The advantages of leaf spring over helical spring are that the end of the springs may be guided along a definite path. Sometimes referred to as a semi-elliptical spring or cart spring, it takes the form of a slender arc-shaped length of spring steel of rectangular cross-section. The center of the arc provides location for the axle, while tie holes are provided at either end for attaching to the vehicle body.

A leaf spring can either be attached directly to the frame at both ends or attached directly at one end, usually the front, with the other end attached through a shackle, a short swinging arm. The shackle takes up the tendency of the leaf spring to elongate when compressed and thus makes for softer springiness. Some springs terminated in a concave end, called a spoon end (seldom used now), to carry a swiveling member. There were a variety of leaf springs, usually employing the word "elliptical". "Elliptical" or "full elliptical" leaf springs referred to two circular arcs linked at their tips. This was joined to the frame at the top center of the upper arc; the bottom center was joined to the "live" suspension components, such as a solid front axle.

2.3 Material for conventional steel leaf springs:
Conventional steel leaf springs are manufactured by EN45, EN45A, 60Si7, EN47, 50Cr4V2, 55SiCr7 and 50CrMoCV4 etc. These materials are widely used for production of the parabolic leaf springs and conventional multi leaf springs. In general terms higher alloy content is mandatory to ensure adequate harden ability when the thick leaf sections are used. Plain carbon steel, Chromium vanadium steel, Chromium- Nickel- Molybdenum steel, Silicon-manganese steel, are the typical materials that are used in the design of leaf springs. The material used for this work is 65Si7.

2.4 *Theoretical calculations:*
Here Weight and initial measurements of four wheeler Light commercial vehicle is taken. Mass of vehicle= 1550 kg Taking factor of safety (FS) = 2 Acceleration due to gravity (g) = 9.81 m/ s^2

Therefore; Total Weight = 1550*9.81 = 15205.5N
Since the vehicle is 4-wheeler, a single leaf spring corresponding to one of the wheels takes up one 4th of the total weight.

15205.5/4 = 3801.375 N,

But 2F = 3801.375 N.

F = 1900.6875N.

Span length, 2L = 850 mm,

L= 425mm.

Now the Maximum Bending stress of a leaf spring is given by the formula Bending Stress, $\sigma b = \frac{6FL}{nbt^2}$

= (6*1900.6875*425) / (3*60*82) = 420.725 MPa

The Total Deflection of the leaf spring is given by

$\delta max = \frac{6FL^3}{Enbt^3}$

= (6*1900.6875*4303) / (2.1*105*3*60*83) = 45.234 mm.

3. FABRICATION PROCESS:
3.1 *Selection of composite material*
The ability to absorb and store more amount of energy ensures the comfortable operation of a suspension system. However, the problem of heavy weight of spring is still persistent. This can be remedied by introducing composite material, in place of steel in the conventional leaf spring. From several studies it is found that the E-glass/Epoxy is better material for replacing the conventional steel as per strength and cost factor. The E-glass fiber is a high quality glass, which is used as standard reinforcement fiber for all the present systems well complying with mechanical property requirements. The material select is E-Glass (CSM and Woven Rowing)/Epoxy material.

Thickness of CSM and woven roving each lamina is 0.75 & 0.45 mm.

Epoxy resin = 500 gm (for each leave),Hardener = 50 gm (for each leave).

3.2 *Hand Lay-Up Procedure*
The total amount of glass fiber cloth needed to construct the composite leaf spring is calculated based on the dimensions of the existing metallic leaf spring and the thickness of each lamina. Then the glass fiber cloth is weighed on digital weighing machine. Corresponding equal to this weight epoxy resin is taken and hardener is added to it. Resin hardener mixture is mixed thoroughly and stirred, till a gel like appearance take place.

The glass fiber cloth is placed on a leveled surface and any air trapped between the cloth and surface is removed.

After the preparation of resin-hardener mixture it is applied on the entire surface of the cloth in order to wet it. The wetting is done equally by moving a hand roller on the cloth surface so that fiber should not separate from the cloth.

Then according to the dimension of the leaf spring the laminas are made by cutting the wetted cloth with a sharp cutter. Simultaneous laying of laminas on the mould is done to the required thickness of the

laminate; suppose we want to construct a 8 mm thickness laminate then 14 laminas must be layered up because the thickness of each lamina is 0.75 (CSM) & 0.4 (Woven Roving) mm in the present case. The entire fabrication procedure as shown in Figures 3.1 -3.7

Figure3.1: :Conventional Steel Leaf Spring

Figure 3.2: : Cutting the Glass Cloth for Required Dimensions

Figure3.3: : Fixing the Conventional Steel Leaf Spring

Figure3.4: : Applying wax on pattern

Figure3.5: : Mixing Epoxy Resin and Aluminium Powder .

Figure3.6: Laying the CSM and Woven

Figure 3.7: After Laying Composite Leaves

Figure 3.8: Dimensions marking

Figure 3.9: Specimen Cutting

Figure 3.10(a) Composite with aluminium particles

Figure3.10(b)Composite with E glass fibre specimens

4 TESTING METHODS:

All the mechanical testing methods that were carried out were based on American standard Methods (ASTM). There were five tests performed, namely Tensile Test (ASTM D638), Flexural Test (ASTM D790-03), Shear Test (IS 1998-1962), Charpy Impact Test (ASTM D270).

Specimens for the Tensile Test, Flexural Test, Shear Test and, Charpy Impact Test are cut on a band saw as per ASTM standards. The dimensional details of each type of specimen were presented in respective figures.

4.1 Specimen dimensions

- Tensile Test = 250x21x8MM
- Flexural Test= 56x14.5x8MM
- Shear Test = 35x6.5x8MM
- Charpy Impact Test = 55x10x8MM

5.RESULTS AND DISCUSSIONS:

5.1Tensile Test:

Tensile tests measure the force required to break a plastic sample specimen and the extent to which the specimen stretches or elongates to that breaking point. Calculations can be made from tensile test results are tensile strength (at yield and at break), tensile modulus, Strain, Elongation and percent elongation at yield and Elongation and percent elongation at break. The graphs were drawn for load vs Displacement. From the graphs after studying the behaviour of the curves the further results (Ultimate strength, load at breaking, percentage elongation) will be evaluated as per the standard procedure.

TABLE.5.1
E-GLASS/EPOXY COMPOSITE SPECIMEN

Input Data	Results
Specimen Type : Flat Specimen Width : 20.6mm Specimen Thickness : 8mm Cross Section Area : 148.732mm^2	Ultimate Load :29.320KN Ultimate Tensile Strength : 197.136N/mm^2

TABLE.5.2:
E-GLASS/EPOXY COMPOSITE WITH ALUMINIUM SPECIMEN

Input Data	Results
Specimen Type : Flat Specimen Width : 20.6mm Specimen Thickness : 8mm Cross Section Area : 148.732mm^2	Ultimate Load :25.440 KN Ultimate Tensile Strength : 173.486 N/mm^2

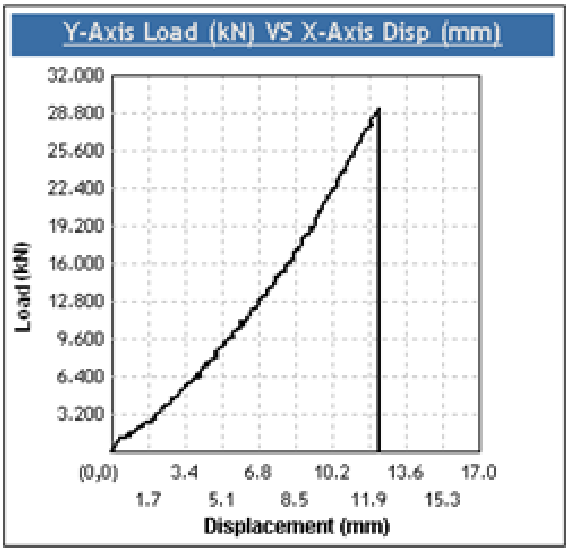

Figure5.1: E-Glass/Epoxy Composite Specimen Load Displacement Graph

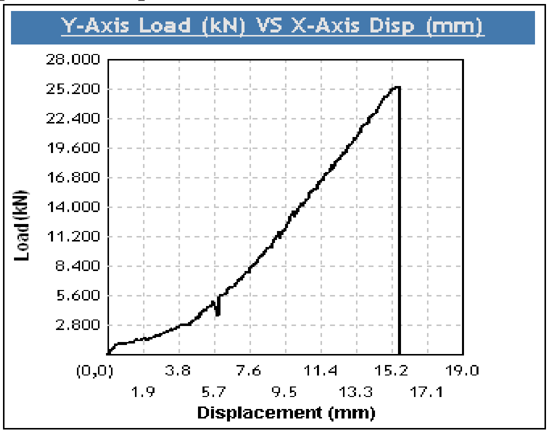

Figure5.2: E-Glass/Epoxy Composite with Aluminium Specimen Load-Displacement Graph

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CONCLUSIONS

For this present work E-Glass/Epoxy composite with aluminium multi-leaf spring is fabricated using hand lay-up composite fabrication technique. The fabricated E-Glass/Epoxy composite with aluminum leaf spring has given 72.23 % weight reduction and also 33.33% cost is saved compared to the existing conventional metallic leaf spring. After conducted the all tests it observed tensile strength, flexural strength, shear strength, impact strength and stiffness is increased in E-Glass/Epoxy Composite Specimens compared with the E-Glass/Epoxy composite with aluminum powder specimens. This may be due to the brittle nature of the epoxy resin.

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