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Design, Analysis and Fabrication of Composite Mono Leaf Spring

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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. The Automobile Industry has great interest for replacement of steel leaf spring with that of composite leaf spring, since the composite materials has high strength to weight ratio, good corrosion resistance. The material selected was glass fibre reinforced polymer (E-glass/epoxy). The design parameters were selected and analysed with the objective of minimizing weight of the composite leaf spring as compared to the steel leaf spring. The work also gives focus on the application of FEA concept to compare two materials for leaf spring and propose the one having higher strength to weight ratio. Two materials used for comparison are; conventional steel and composite E-Glass/Epoxy. The deflection and bending stresses induced in the two leaf springs are compared. The solid modelling of leaf spring is done in Catia and analyses using ANSYS. In addition to this experimentation is done on the UTM.

Keywords*—E-Glass fibre, Leaf spring, Catia, Ansys*

1. INTRODUCTION

Suspension system of any vehicles contains leaf spring to absorb jolts. 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. It carries lateral loads, brake torque, driving torque in addition to shock absorbing. The advantage of leaf spring over helical spring is that the ends of the spring may be guided along a definite path as it deflects to act as a structural member in addition to energy absorbing device. The vehicles must have a good suspension system that can deliver a good ride and good human comfort. It is observed that the failure of steel leaf springs is usually catastrophic. According to studies made for leaf spring the for weight reduction in automobiles as it leads to the reduction of un-sprung weight of automobile. The elements whose weight is not transmitted to the suspension spring are called the unsprung elements of the automobile. This includes wheel assembly, axles, and part of the weight of suspension spring and shock absorbers. The leaf spring accounts for 10-20% 0f the un-sprung weight. Material with maximum strength and minimum modulus of elasticity in the longitudinal direction is the most suitable material. To meet the need of natural resources conservation, automobile manufacturers are attempting to reduce the weight of vehicles in recent years. Weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing processes. In order to reduce the accidents, arising out of such failures conventional steel leaf spring can be replaced with gradually failing composite leaf springs. By doing this, the weight of the vehicle may also be reduced while maintaining the strength of the leaf spring. A composite material is nothing but permutation of two materials that produce an effect so that the combination produces combined properties that are different from any of those of its constituents. This is done purposefully in today's scenario to achieve different design, manufacturing as well as service advantages of product. In this paper leaf spring is representative of those products, for which automobile manufacturers are working to get best composite material that meets the current requirement of strength and weight reduction in one, to replace the existing steel leaf spring. The objective of the paper is to design leaf springs for deflection and bending stress made of steel and composite material.

2. OBJECTIVE

- To increase the breaking strength of automobile mono leaf spring.
- To carry out finite element analysis and experimental Investigation of mono leaf spring

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- To validation of experimental and FEA results.

3. PROBLEM STATEMENT

The hybrid leaf spring will be analysed so as to increase the strength of the Leaf Spring.

4. SCOPE

- It is possible to design the hybrid Leaf Spring using different materials like glass fiber/epoxy, Kevlar/epoxy with aluminum.
- By changing the stacking sequence, the design of composite Leaf Spring is possible to get different properties composite material for further work.
- Experimental work is carried out in laboratory condition, one can go actual road condition

5. SUSPENSION SYSTEM

The leaf spring suspension system is the oldest suspension system used for automobile device. The leaf spring system was used from 1970s production cars and many racers even prefer to utilize the leaf spring rear suspension design in their fabricated late model stock and modified race cars. The leaf spring supports some or all of the chassis weight and controls chassis roll more efficiently. Control axle dampening andbraking forces. Better maintaining wheelbase lengths under acceleration and braking

6. COMPOSITE MATERIAL

A composite is a structural material which consists of combining two or more constituents. The constituents are combined at a macroscopic level and are not soluble in each other. One constituent is called the reinforcing phase and another which is embedded is called the matrix. Advanced compositesare traditionally used in the aerospace industries, but now a days also use in automobile industries. Advance composite materials are Carbon, Graphite, Kevlar and Glass fiber with suitable matrixes is widely used because of their higher specific strength & higher specific modulus. Composite leaf springs are a fairly new component in racing that has been further refined recently. They are made of unidirectional E-glass fiber/epoxy composite material instead of steel. It has good mechanical properties for required design.

7. FABRICATION OF COMPOSITE LEAF SPRING

Typically, most common polymer-based composite materials, including fibreglass, carbon fiber, and Kevlar, include at least two parts, the industry, epoxy is used as a structural matrix material or as structural glue. Fabrication of composite leaf spring using hand layup process The constant cross section design is selected due to its capability for mass production, and to accommodate continuous reinforcement of fibers and also it is quite suitable for hand lay-up technique. Many techniques can be suggested for the fabrication of composite leaf spring. Composite leaf spring was fabricated using wet filament winding technique. In the present work, the hand lay-up process was employed

8. MATERIAL USED

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Fig.1 Glass fibre

Fig.2 Epoxy resin

9. DESIGN OF LEAF SPRING

Weight of Vehicle = 1615 Kg

Maximum Load Carrying Capacity =
535 Kg Total Weight = 1615 + 535
= 2150 Kg
Taking F.S. = 2 & Acceleration due to gravity =
g = 10 m/s2 Total Weight = W = 2150*2*10 =
43000N

Since the vehicle is 4-wheeler a single leaf spring corresponding to one of the wheels takes up ¼ th of the total weight. F = 43000/4 = 10750 N
Measured data of the four-wheeler vehicle:

Leaf Span of the Load free Curved leaf spring (L')
= 1016mm Straight Length of Leaf Spring (L) =
1040mm

C = 0.089, C = 90.424mm

$\overline{L}$ = 0.089, C = 90.424mm
$'$

C

$\overline{L}$
$'$

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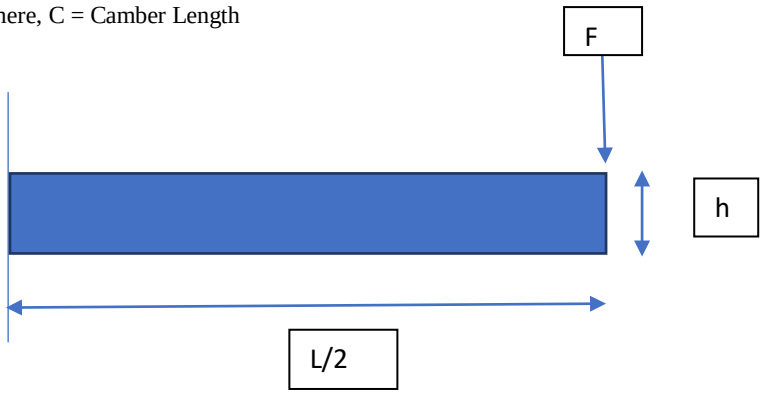
Where, C = Camber Length



L/2 = 520mm, F=10,750N, h =? b =?

We Know that,

For Cantilever Beam –

Maximum Stress $= \frac{W*L}{Z}$

$= \frac{F*L}{I/Y}$

$= \frac{F*L*Y}{I}$

$= \frac{F*L*h}{2*b*h3/12}$

Maximum Deflection $= \frac{W*L^3}{3*E*I}$

$\sigma \max = \frac{6*F*L}{b*h2}$ ..... (1)

$= \frac{F*L3}{3*E*b*h3/12}$

$\delta \max = \frac{4*F*L^3}{E*b*h3}$ ..... (2)

For Torsional Moment, as both ends are hinged the effective length will be considered as L = 2/3 Le By solving Equation 1 & 2 we get,

$h = 2/3 * \frac{\sigma \max * L2}{E*\delta max} * 3/2$

$h = \frac{\sigma \max * L2}{E*\delta max}$

σ max = 473MPa, δ max =

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105mm h = 23mm
From equation 1 we get,

$$b = \frac{6*F*L/2}{\sigma \max *h2}$$

b = 134mm

Bending Stress Calculations (σb):

$$\sigma b = \frac{M*y}{I}$$

Where, M = Bending
Moment Y = h/2
I = Moment of Inertia

$$M = \frac{F*L}{2} = 5590 \text{ Nm}$$

$$I = \frac{b*h3}{12} = 1.36*10\text{-}7 \text{ m4}$$

Y = h/2 = 23/2 = 11.5mm = 11.5*10-3 m

By putting all the values in equation of bending stress we get, $\sigma b = 472.68*10^6$ N/m2

10. EXPERIMENTAL TESTING

The UTM (Instron 1342) is a servo hydraulic fluid-controlled machine, consists of a two column dynamically rated load frame with the capacity of load up to 100kN (dynamic), hydraulic power pack (flow rate 45 litre/minute) and 8800 Fast Track 8800 Controller test control systems is stand alone, fully digital, single axis controller with an inbuilt operating panel and display. The controller is fully portable and specifically designed for materials testing requirement. This controller has position, load and strain control capability. The software available with the machine are: (a) Merlin Testing Software for Tensile Test (b) da/dN Fatigue Crack Propagation Test. (c) Kic Fracture Toughness Test. (d) Jic Fracture Toughness Test.

The three-point bending tests were conducted on a universal testing machine. The load−displacement curves were obtained from the experiments. Figure 19 shows the schematic diagram for the three-point bending tests. The peak load F could be obtained from the three-point bending tests, and the bending strength R was calculated using Eq. (1).

$$= \frac{3Fl}{2bh^2}$$

where l is the size of the span, b and h are the width and thickness of the specimen, respectively, and F is the peak load during the test.

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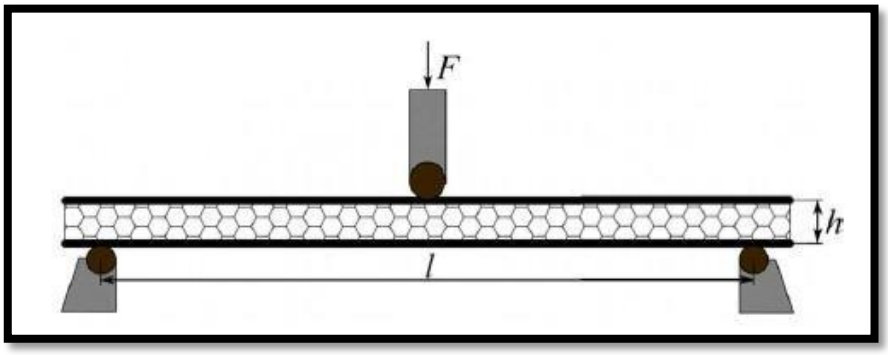

Fig 3. Schematic of 3-point bending test.

CONCLUSION

- As automobile world demands research of reducing weight and increasing strength of products, Composite material should be up to the mark of satisfying these demands. As leaf spring contributes Considerable amount of weight to the vehicle and needs to be strong enough, a single e-glass/epoxy Composite leaf spring is designed and analysed following the design rules of composite materials.
- The composite leaf spring was fabricated and tested. The Experimental results are compared with the existing steel leaf spring. The report proves that the composite material chosen (glass-fibre) can withstand the maximum load, the maximum deformation, and the maximum stress and can be used to create compact suspension systems.

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