EXPERIMENTAL INVESTIGATION OF COMPOSITE SPRING DEVELOPMENT AND TESTING

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Abstract—*This work deals with learning the latest trends in automobile sector and improvement in materials for Shock absorbers which are nothing but the suspensions and the objective is to compare these suspensions made on composite materials with the mono suspensions in vehicles and to determine their improvisation and performance. Various tests are done and their results are observed under tabulation. The resultant graphs are obtained from MANUAL TESTING in Bangalore and their performances are compared. It is proved that the suspensions made by composite materials are stronger than other conventional materials. These advanced components play a vital role to protect the automotive from sudden impacts and shocks. Hence, materials of suspensions should be strong and therefore composite materials are encouraged as they are both strong and light weight. The results are calculated by design data with calculations being done and graphs drawn to obtain the optimum values.*

Keywords—Manual Testing; Shock Absorbers; Spring; Crucial Element; Performance and Graphs; Composites

1. INTRODUCTION

Suspensions, nowadays, need vast performance and thus they are required to be very strong. For this purpose, suspension systems are made using composite materials which are mainly S-Glass fiber and carbon fiber. The composite materials are further mixed with epoxy resin and made in the shape of a helical spring. Both theoretical and practical tests are conducted on it afterwards. A safe vehicle is the one that can stop and maneuver over a wide range of road conditions. To be able to stop and maneuver quickly there must always be good contact between the tires and the road. The suspension is responsible for keeping the tire firmly planted on the road [1]. The suspension also provides a comfort buffer between the rough road and the passenger cabin.

Some vehicles have struts instead of shocks. In reality, a strut is just a shock absorber built into a suspension link. The strut is generally replaceable as one unit. In this discussion, any reference to shock absorbers will also apply to struts. The figure 1 shows the composite spring which we manufactured [2].

Fig.1. Composite Spring

1.1 Springs

Springs isolate the driver from road imperfections by allowing the tire to move over a bump without drastically disturbing the chassis [2.4.8]. If the chassis remains fairly steady then the tires are better able to follow road contours. Springs are durable items and are easily inspected. If the ride height of a vehicle has decreased excessively or a coil/leaf has broken it is advisable to replace the springs in axle sets. Consumers also often change springs to alter their vehicle's ride and handling characteristics [2]. Spring problems are generally easy to identify.

1.2 Shock Absorbers

The shock controls spring motion by damping (absorbing) energy from the spring. A shock absorbs energy by forcing oil through valves whenever it is moved. It takes a lot of energy to push oil through the valves so when the spring is done pumping. Shocks also control the reaction of the body to road undulations [4,10]. A stiffer shock tends to transmit more road irregularities to the driver but will also not pitch and roll as much as a vehicle with softer shocks [3]. Thus shocks, like springs, can be changed to obtain a personalized ride.

1.3 Composite Materials

Composites are made up of individual materials referred to as constituent materials. There are two categories of constituent materials: matrix and reinforcement [3]. At least one portion of each type is required. The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions. The reinforcements impart their special mechanical and physical properties to enhance the matrix properties. A synergism produces material properties unavailable from the individual constituent materials, while the wide variety of matrix and strengthening materials allows the designer of the product or structure to choose an optimum combination

2. MATERIAL SELECTION

2.1 Selection Procedure

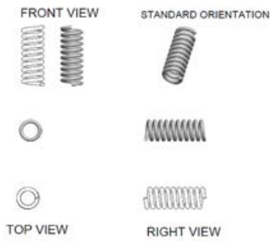
Material selected should be capable of storing more strain energy in helical spring. Based on specific strain energy of steel spring and some composite materials (Yucky, 1988), AR-glass/epoxy is selected as spring material having the mechanical properties given in Table. This material is assumed to be linearly elastic and orthotropic. Therefore the S- class Glass fiber material is selected.

2.2 Chemicals Used

S-glass fiber and carbon fiber are the main fillers used and they are mixed with epoxy resin and other required materials are mixed and fabricated.

3. FABRICATION

Filler materials are mixed with epoxy resin and they are heated up to 1440° C. This mixture is cooled and poured on a molded helix shaped material and then fabricated. The helix angle should be 15 to make it tough. Glass fibers are generally made by drawing from a metal [7]. The melt is formed in a refractory furnace at about 2550° F (1400° C) from a mixture that includes sand, limestone, and alumina. The melt is stirred and maintained at a constant temperature. It passes through as many as 250 heated platinum alloy nozzles of about 394µn(10µm) diameter, where it is drawn into filaments of needed size at high speeds of about 361mi/h(25m/s) [13]. These fibers are sprayed with an organic sizing solution before they are drawn. The sizing solution is a mixture of binders, lubricants, and coupling and antistatic agents; binders allow filaments to be packed in strands, lubricants prevent abrasion of filaments, and coupling agents give better adhesion between the inorganic glass fiber and the organic matrix [17]. The spring fabrication is shown in figure 2.Fibers are then drawn into strands and wound on a forming tube. Strands are groups of more than 204 filaments. The wound array of strands is then removed and dried in an oven to remove any water or sizing solutions.



(a)

Fig. 2. (a) Structure of Suspensions, (b) Fiber Wound Over the Mandrel

Diameter is 80mm and number of turns are 10 and its helix angle is 15 and wire diameter 20mm, pitch 35mm, spring index 4mm, allowable stress 630Mpa, spring constant 0.042KN/mm, Wahl factor 1.40375.

4. TESTING PROCEDURES

The testing process has been carried out at BISS TEST RESOURCES Bangalore. For reference, the detailed test report has been attached.

(a)

(b)

(c)

Fig. 3. (a)Test Specimen in the rig, (b) Testing of Helical Spring (Under Loading), (c) Testing of Helical Spring (Under Maximum Load)

5. VARIOUS TESTS CONDUCTED

- Compression test
- Hardness test
- Calculation of modulus of rigidity
- Energy absorbing capacity
- Stiffness test

5.1 Compression Test

Here suspensions are compressed and the amount of load they can withstand is calculated [13]. Composite materials have a high capacity to withstand load than mono suspension made on steel materials. Also, steel materials may get damaged with scratches but composite materials won't get affected due to their ability to withstand high load.

5.2 Hardness Test

Using the various methods like ROCKWELL HARDNESS METHOD, BRINELL HARDNESS METHOD AND VICKER'S HARDNESS METHOD, the hardness of the composite materials is measured. So these methods are done with diamond indenter and other materials and loads [11,15]. The composite materials have high hardness and can withstand high load and give excellent performance.

5.3 Calculation of Modulus of Rigidity

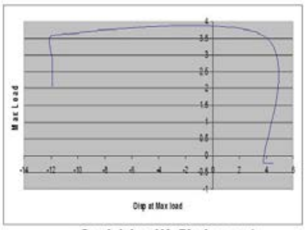
It comprises of compressing a material within its elastic limit. Shear force is of much importance in this calculation and so the test is carried out within its elastic limit for both the materials [16,13]. Then on comparing both the values composite is better than steel.

5.4 Energy Absorbing Capacity

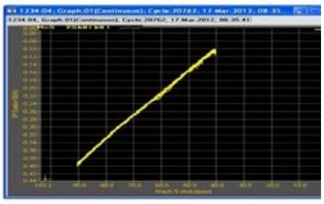
The most important test is how much energy a suspension can absorb and its storing capacity? So it is tested by a method in which both suspensions are fitted in vehicles with sensors to know its energy absorbing capacity and are allowed to run on frictional surfaces so that we can get the values which imply that composite has the higher capacity to absorb energy.

5.5 Stiffness

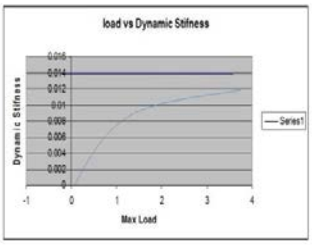
It is defined as load required in producing a unit deflection. We know that fiber has high stiffness and its stress and strain curve is high and yield point is high.



Graph 1. Load Vs Displacement



Graph 2.Load Vs Deflection



Graph 3. Load Vs Dynamic Stiffness

Figure 4: (a) Load vs Displacement

6. DISCUSSION

- The maximum displacement occurs at 3.8KN of load.
- Sharply after 3.8 KN of load fatigue failure occurs and the displacement gradually decreases.
- Then the specimen showed 1mm of fatigue crack at 10215th cycle.

7. COMPARISION OF BOTH THE MATERIALS

After various types of testing been conducted, there are more results noted and various readings and values are obtained and composite materials are more stronger and good and safe to use than other materials [15,18,19]. It has good properties and it is a future material for engineers. Steel materials can get scratches easily but composite materials don't get and it has good hardness, stiffness. Withstand high load and obeys hook's law and absorbs more energy and shocks and controls vibrations. The strength is good and it is more optical to use and also low cost and easily replaceable [4,5,7,9]. Composite materials made on suspensions have a long life and has high tendency in wear and tear resistance and good modulus of rigidity. Resistance over hot acids and it does not undergo any chemical reactions as steel so high chemical resistance and thermal resistance [9]. The comparison value is shown in the table1

TABLE 1. COMPARISON VALUE OF SPRINGS STRENGTH

Properties	Cost-Iron	S-Glass-Fiber
Hardness	120KgF	197 kgf
Stiffness	902 N/mm	1002N/mm
Compression	478MPa	630Mpa
Fatigue Test	2.5 KN	3.8KN
Modulus of Rigidity	80GPa	108GPa

8. CONCLUSION

The composite spring using glass fiber have been developed in this project they are lighter than commercially used spring (steel spring) and the stiffness achieved is better than steel spring composite. In order to improve reliability of the experimental results of spring were fabricated each and tests were conducted on the spring. The weight of the springs manufactured glass fiber roving is less than the steel springs. The cost of the glass fiber springs are 25% more than the steel springs. The selection of the glass fiber depends upon the cost and application of the spring which can be compensated by saving the fuel from weight reduction. In order to increase the stiffness of the spring the dimensions of the composite spring is to be increased which in turn increases the weight of the spring. Hence the application of the composite coil springs can be limited to light vehicles, which requires less spring stiffness, e.g. electric vehicles and hybrid vehicles. The manufacturing of the composite coil springs is also difficult and time consuming compare to steel spring, however with the use of CNC winding machine and automated process which can be made easy and also the manufacturing cost can be reduced if produced in mass.

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