EXPERIMENTAL INVESTIGATION OF STATIC & DYNAMIC LOADING CONDITIONS FOR COMPOSITE HELICAL SPRINGS

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Abstract: In the present scenario Automobile and Aerospace manufacturing sector is concentrating much on reducing the total weight of the vehicles & airplanes thereby increasing fuel Efficiency and overall performance. In this direction fiber reinforced composite materials are effectively utilized. As these materials comparatively have better strain energy storage ability, high strength and less weight than conventional alloy material which have comparatively higher weight ratio. This research impart the focus on the possibility of replacing conventionally used Steel helical coil springs by fiber reinforced plastic helical coil springs.

In this research work we manufactured two helical springs of rectangular cross-section with different materials known as GLARE and CLARE to get which composite spring is better to replace with steel spring. Here we are going to manufacture glass fiber epoxy and carbon epoxy spring with the reinforcement of Aluminum wire mesh. We take 50% epoxy and 50% glass fibers for glass spring and 20% carbon, 30%glass, 50%epoxy for carbon spring .we concluded that cost of CLARE spring is 57% more than glass spring but the weight 13% less than GLARE spring and other factors of Clare spring are better than glass epoxy spring i.e. Shear stress, failure load. The specimen preparation and experiments were carried out according to ASTM standards.

Index Terms **- Helical coil spring, composite material, Glass fiber, and epoxy resin, shear stress, Fuel efficiency, weight.**

I. INTRODUCTION

In automobiles springs are crucial suspension elements which are necessary to minimize the vertical vibrations, impacts and bumps due to road irregularities and create a comfortable ride. For automobile suspension and industrial applications coil springs are commonly used. Two important issues in these days are the fuel efficiency and emission gas regulation of automobile. Reduce the weight of the automobiles by employing composite materials in the structure of the automobiles fuel efficiency can be increase. Because of weight reduction and corrosion resistance metal coil springs can be replaced by composite springs. Metal coil springs can't withstand high temperature. At high temperature where it is required to operate composite springs are used. Metal springs are very cheap to produce, they have several advantages and can be produced in almost all kinds of measures and in a very broad range of stiffness. The design and manufacture of composite springs are difficult, the composite materials are anisotropic in nature Hence the application of composite materials in springs is not yet popular. They are used for suspension system of in automobiles.

In today's vehicles for saving energy and improving the performance of the shock absorbers.

With light weight and high quality, composite materials have to be used. Now a days the more no of electric vehicles and hybrid vehicles are entering into the market in the present, it has become essential to go for the light components for improving the efficiency. Many researchers are actively involved in the study of composite springs because composite springs have some advantages over the metal springs. Unidirectional laminates, rubber core unidirectional laminates, unidirectional laminates with a braided outer layer, and rubber core unidirectional laminate with a braided outer layer they made the springs by such different material structures. In this study a spring from the two

wheeler is taken for replacement. Glass fiber and carbon are used for the manufacture of composite coil springs.

Weight savings, part consolidation, and improvement in NVH (noise, vibration and harshness) .This are the principal advantage of fiber reinforced polymer matrix composites for automobile parts. Lowers maintenance cost for automobile parts, enables the use of fiber reinforced polymeric composite.

Two types of springs were manufactured in this study with Woven Roving Fiber (WRF) and Thermoset polymer (Epoxy Resin) and Carbon + Glass fibers (compositions).These springs were tested for spring rate and other parameters. The results of composite show the feasibility of composite springs for light vehicle applications.

II. COMPOSITE MATERIALS

A composite material is one in which two or more materials that are different combined to form a single structure with an identifiable interface. The properties of that new structure are dependent upon the properties of the constituent material as well as the properties of the interface. In the more familiar world of metals, bonds forms because of the mixing of different materials at the atomic level, composites typically forms molecular bonds in which the materials retain their identity and mechanical properties. And where the metal alloys have isotropic characteristics. Composites have very selective directional properties to meet specific application needs. So composites are highly targeted engineering material consists of two or more distinct phases one matrix phases and another is dispersed phases.

III. NEEDS OF THE COMPOSITES:-

- Light weight
- Higher Operating Temperature
- Greater Stiffness
- Higher Reliability
- Affordability

IV. LITERATURE REVIEW

Yahya Kara[1]: In order to successfully reduce the weight of a helical spring it is possible to optimize the material parameters or to use alternative advanced materials instead of conventional engineering ones. Springs are used for vibration damping in mechanical systems and are generally made of steel. As an alternative source to material of steel springs in the scope of the study, mechanical behaviors of fiber reinforced polymer (FRP) composite helical springs have been investigated. The FRP composite material has made it possible to reduce the weight of helical spring without any reduction on load carrying capacity. Vehicle industries show interest in replacing conventional steel spring with FRP composite helical spring due to increasing competition and innovation in recent decades, which has advantages such as higher strength to weight ratio, higher stiffness, high impact energy absorption and lesser stresses. The study gives the brief look on the suitability of FRP composite helical springs on related mechanical systems. The objective of the present work is evaluation of the design, analysis and fabrication of FRP composite helical springs.

Ram Kishan Singh Anil Antony Sequeira[2]: In automobile sector due to the demanding need of rapid innovation and tough competition, the old products are reengineered by new product with composite materials. Regularly new innovations are carried out in suspension area of vehicles. Fiber Reinforced Material [FRP] components are the main interest of automobile industry for replacing the steel components due to “high strength to low weight” ratio. To reduce the weight and fuel consumption to some extent, automobile industries are using the Glass Fiber Reinforced Plastic [GFRP] open coil springs in suspension system of vehicle at the place of steel open coil springs. In this research, the properties of composite and steel helical spring are compared and the deciding factor is the stiffness to weight ratio. Spring geometry is modeled in CREO Software on other hand Finite Element method is used to analyze under different loading condition.

Finally steel spring has been replaced by two different composite helical spring including Carbon and Kevlar. **Ekanthappa J, G S Shiva Shankar, Amith B M and Gagan M [3]** :- In present scenario,

the automobile industry sector is showing increased interest in reducing the unspring weight of the automobile & hence increasing the fuel Efficiency. One of the feasible sub systems of a vehicle where weight reduction may be attempted is vehicle-suspension system. Usage of composite material is a proven way to lower the component weight without any compromise in strength. The composite materials are having high specific strength, more elastic strain energy storage capacity in comparison with those of steel. Therefore, helical coil spring made of steel is replaceable by composite cylindrical helical coil spring. This research aims at preparing a re-usable mandrel (mould) of Mild steel, developing a setup for fabrication, fabrication of FRP helical spring using continuous glass fibers and Epoxy Resin (Polymer). Experimentation has been conducted on fabricated FRP helical spring to determine its strength parameters & for failure analysis. It is found that spring stiffness (K) of Glass/Epoxy helical-spring is greater than steel-coil spring with reduced weight.

V. PROBLEM FORMULATION

By using above case studies, we can determined the selection of the materials manufacturing techniques and the testing specification. There was less work done in the composite spring. So above all papers books and journals are guided us to work direction. Based on the studies materials manufacturing techniques and the standard specimen dimensions for the testing has chosen.

VI. MATERIAL SELECTION

Based on the properties on the material we manufacture the two types of spring glass epoxy and Glass + carbon epoxy.

Table 1. Properties of material

Properties	E-glass fiber	Carbon Fiber	Epoxy Resin
Shear Modulus	30 GPa	50 GPa	1.6 GPa
Elongation	4.88%	1.3%	2%
Density	2.5 g/cc	1.8 g/cc	1.2 g/cc
Elasticity Modulus	73GPa	230 GPa	3.45 GPa
Tensile Strength	2.5 GPa	3.6 GPa	1.3 GPa
Specific Strength	-	2.70 GPa	36 MPa

VII. FABRICATION

For fabrication two steps are involved are as follows:-

Step 1:- Mold Making

Step 2:- Composite spring Fabrication

Step 1:- Mold Making

We select the specific wood for making mold and then with the help of lathe machine we do thread on That wood, and prepared the mold for manufacturing the composite helical spring is as shown in fig. (a)

Fig. (a)

Step 2:- Composite spring fabrication

In composite spring fabrication the ratio of hardener and resin are in 1:10. In the glass spring 50% glass fibers are used and remaining 50% epoxy. In carbon + glass spring 20% carbon fibers, 30% glass fibers and remaining 50% epoxy are used. For the fabrication following steps are involved.

- Composite springs were manufactured by the filament winding method.
- All the types of springs are manufactured by the same method.
- A mandrel having the profile of the spring is prepared first.
- Fiber is mixed with polymer and wound over the mandrel.

- Fiber is cured for 48 hours in atmospheric condition.
- Then the spring is separated from the mandrel

Table 2: Specification of Man drel		
Sr.no	Specification	Dimension
1	Length (L)	120mm
2	Mean Diameter (D)	52mm
3	Outer Diameter (d)	57mm
4	Number of turns (n)	7
5	Pitch (p)	20mm
6	Wire thickness (t)	5mm
7	Width of spring (b)	10mm
8	Helix angle	7.5 degree

VIII. TERMINOLOGY OF SPRING

Spring constant: - spring constant is defined as the ratio of force acting on the spring to the displacement of the spring.

$$\textbf{Spring constant (k)} = \frac{Applied\ load}{Change\ in\ Length}.$$

Spring Deflection: - It is the distance moved by spring under the action of load.

$\delta = \frac{w}{k} = \frac{w\varepsilon n D^3}{Gt^2b^2}$ Where, W: - Applied load, K:Stiffness

Shear Stress: $-\tau = \frac{kwD(1.5t+0.9b)}{b^2t^2}$. Where k: $-\frac{4C-1}{4C-4} + \frac{0.615}{C}$(Wahl's Factor)

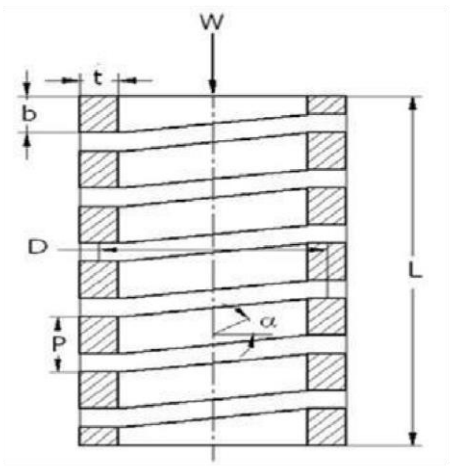
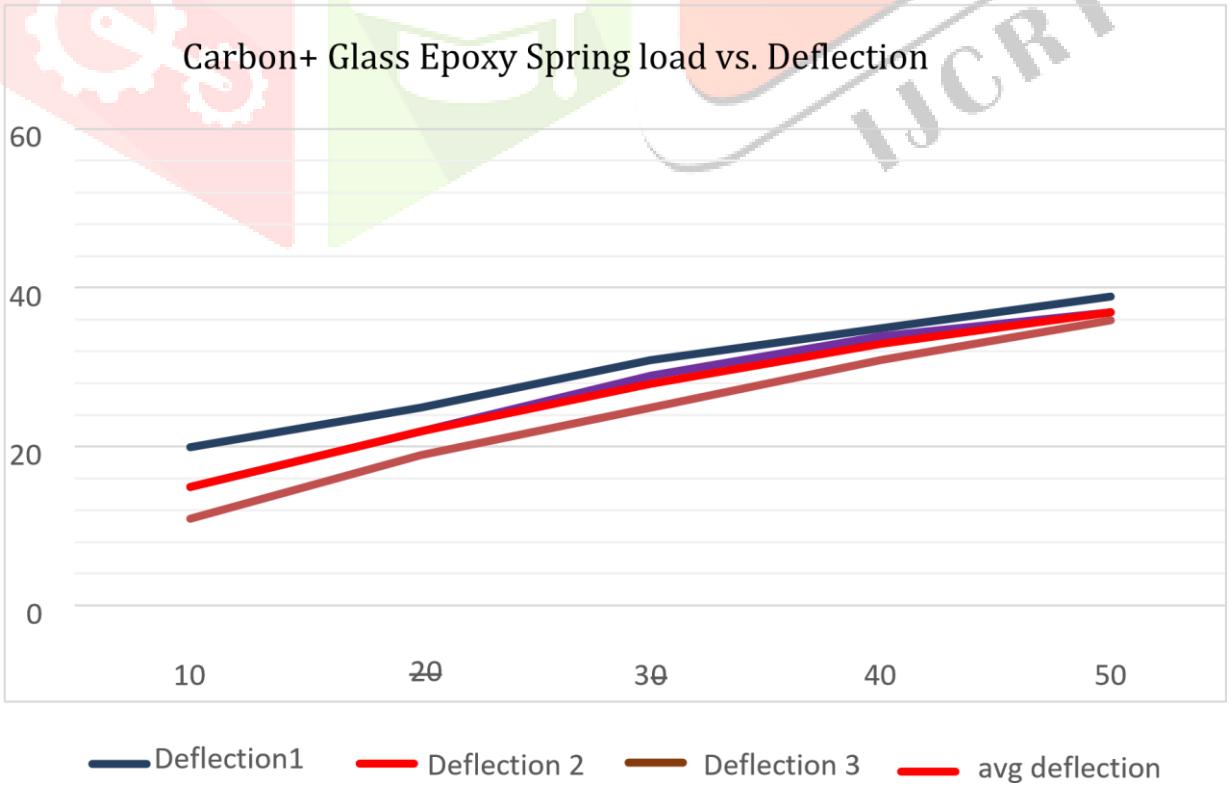


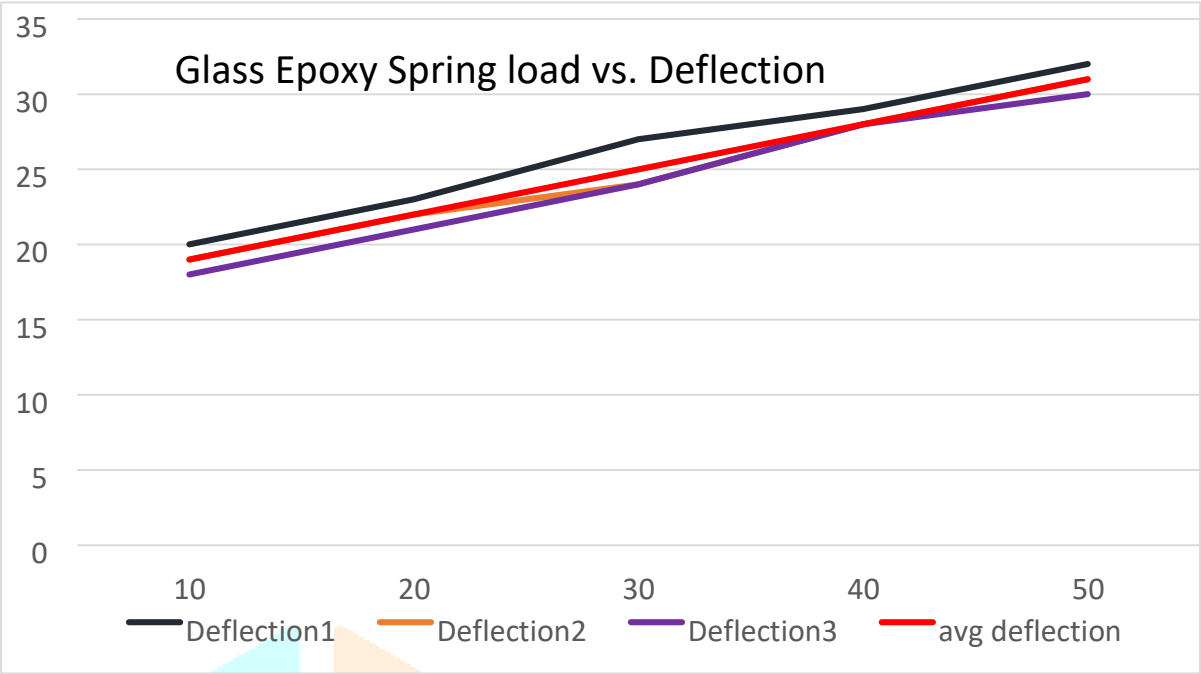
Fig.(b)

IX. TESTS AND RESULT OF SPRING

Table 3: Carbon +Glass Epoxy Spring Result					
Sr.no	load	deflection1	deflection 2	deflection 3	Avg. deflection
1	10	20	11	15	15
2	20	25	19	22	22
3	30	31	25	29	28
4	40	35	31	34	33
5	50	39	36	37	37

Table 4: Carbon +Glass Epoxy Spring Result					
Sr.no	load	deflection1	deflection 2	deflection 3	Avg. deflection
1	10	20	19	18	19
2	20	23	22	21	22
3	30	27	24	24	25
4	40	29	28	28	28
5	50	32	31	30	37





OBSERVATIONS

With the help of the terminology of spring and formulae following results are obtained.

Table 4: Results

Sr.no	Properties	Glass Epoxy Spring	Carbon + Glass Spring	Carbon + Glass Spring Efficiency (in %)
1	Spring Constant (N/mm)	11.77	10.9	-
2	Compression Strength (N/mm^2)	16	19	15.78
3	Maximum Compression (mm)	53	59	10.16
4	Shear Stress (N/mm)	111.47	127.42	78.65
5	Weight of spring (gm.)	74	64	13.5
6	Failure load (KN)	14	16	12.5

CONCLUSION

By using the deep study of composite material we decided to manufacture composite helical coil spring, in that design spring mould and then go to manufacture spring By using glass fibers epoxy and carbon +glass fiber epoxy we manufacture two springs and conclude that the carbon + glass fiber spring has compression strength 15.78%, maximum compression 10.16%, shear stress 5%, weight of spring 13.5%, failure load 12.5% better than glass fiber epoxy spring. The "Spring Winding" setup developed for the fabrication of helical spring is simple & cost efficacy.

REFERENCES

[1] Yahya Kara (2017) A Review: Fiber Reinforced Polymer Composite Helical Springs. J Mater Science Nanotechnol 5(1): 101

[2] **Anil Antony Sequeira*, Ram Kishan ,Singh, Ganesh K. Shetti[2016]** School of Engineering & IT, Manipal University Dubai Campus, Dubai, U.A.E., **Comparative Analysis of Helical Steel Springs with Composite Springs Using Finite Element Method,** Journal of Mechanical Engineering and Automation 2016, 6(5A): 63-70 DOI: 10.5923/c.jmea.201601.12

[3] Ekanthappa J, G S Shiva Shankar, Amith B M and Gagan M:-Gibson Ronald, "Chapter-1 Introduction in Principles of Composite Materials Mechanics"in Mc-Graw Hill Inc. 1984, pp1-33.

[4] Mehdi Bakhshesh and Majid Bakhshesh „Optimization of Steel Helical Spring by Composite Spring INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY SCIENCES AND ENGINEERING, VOL. 3, NO. 6, JUNE 2012.

[5] T S Manjunatha & D Abdul Budan, "Manufacturing andexperimentation of composite helical springs for automotivesuspension" ISSN 2278–0149, INTERNATIONAL JOURNAL OFMECHANICAL ENGINEERING AND ROBOTICS RESEARCH.Vol. 1, Issue.2, 2012.

[6] M.Venkatesan, D.Helmen Devaraj "Design and Analysis ofComposite Leaf Spring in Light Vehicle" ISSN 2249-6645,INTERNATIONAL JOURNAL OF MODERN ENGINEERINGRESEARCH. Vol.2, Issue 1, 2012.

[7] Ghodake A. P, Patil K.N. "Analysis of Steel and Composite Leaf Spring for Vehicle", ISSN: 2278-1684 IOSR JOURNAL OF MECHANICAL AND CIVIL ENGINEERING, Vol. 5, Issue 4, 2013.

[8] Mouleeswaaran Senthil Kumar, Sabapathy Vijayarangan"Analytical and Experimental Studies on Fatigue Life Prediction of Steel and Composite Multi-leaf Spring for Light Passenger Vehicles Using Life Data Analysis" ISSN 1392–1320 MATERIALS SCIENCE Vol. 13, Issue 2, 2007.

[9] G. Harinath Gowd and E. Venugopal Goud, "Static analysis of leaf spring",INTERNATIONAL JOU JOURNAL OF ENGINEERING SCIENCE AND TECHNOLOGY, Vol. 4, Issue 1, 2012.

[10] Lei Wang, Ke Wang, LingC, Yongwei Z, Chaobin H "Preparation, morphology and thermal/mechanical properties of epoxy/nanoclay composites" 2006. JyiJiinluo, Isaac M.Daniel, "Characterization and Modeling of mechanical behavior of polymer/clay nanocomposites" 2003.