International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 08|Aug 2019 www.irjet.net p-ISSN: 2395-0072

FABRICATION AND CHARACTERIZATION OF E-GLASS FIBER EPOXY AND FLY ASH COMPOSITES FOR AUTOMOBILE APPLICATIONS

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Abstract – *This project attempts to review and study the feasibility of implementation of the FRP composite material for fabrication of helical coil spring by using filament winding technique. For experimental work, three helical springs of rectangular cross section with different material such as epoxy as a matrix material and glass fiber with fly ash are the reinforcement are used. The different compositions are C1 (70% E-Glass fiber, 20% epoxy and 10% fly ash), C2 (60% E-Glass fiber, 30% epoxy and 10% fly ash) and C3 (50% E-Glass fiber, 40% Epoxy and 10% fly ash) for spring. It is found spring stiffness (K) of glass fiber, epoxy and flyash helical spring is greater than steel-coil spring with reduced weight. The composition C1 shows better compressive strength and stiffness than compositions C2 and C3.*

***Key Words*: Helical coil spring, Filament winding technique, E-Glass fiber, epoxy, Fly Ash, etc.**

1 INTRODUCTION

Spring are mostly designed to absorb and accumulate then energy, then release it. Designing of the springs, strain energy of the material is the key factor. Materials, which have lower modulus and densities, will be having greater ability of specific strain energy. Replacement of steel material by composite materials makes substantial weight reduction. With introduction of new materials, designs related and processing problems will also rise. Key reason is fiber reinforcement composite (FRP) are anisotropic materials. Hence, they are distinctive compared to traditional materials. Automobile manufacturers are putting massive effort reduce weight of vehicles to attain fuel economy.

1.1 Shock absorbers

The shock controls spring motion by damping (absorbing) energy from spring. Shock absorbs energy by forcing oil through valves so whenever it is stimulated. Takes lot of energy to push oil through valves so when spring is done pumping. Shocks also control reaction of body to road. Stiffer shock tends to transmit more road irregularities to driver but will also not pitch and roll as considerable as vehicle with softer shocks. Thus shocks, like springs, can be transformed to obtain a personalized ride.

Fig-1: Shock absorber

2 COMPOSITE MATERIALS

Composite material is recognized a material prepared from two or more constituent materials with expressively different physical or chemical properties.

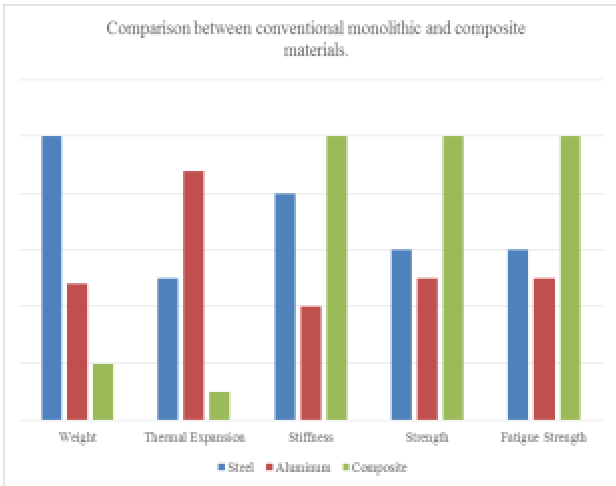

Fig-2: Comparison between conventional monolithic and Composite material.

2.1 Types of composite materials.

Composite materials are categorized based on reinforcement (Glass, carbon, aramid) used and matrix (Thermoset, Thermoplastic).

Arrangement of composite materials.

- Based on type of Matrix materials.
  - Ceramic matrix composite (CMC)
  - Polymer matrix (PMC)
  - Metal matrix (MMC)
- Based on Reinforcement
  - Fibre reinforcement polymer
  - Particulate composite
  - Structural composite

2.2 Fiber reinforced composites (FRP):

Composite fibers are substantial class reinforcements, anticipated circumstances and transfer strength to matrix Mainly, we have different types of fibres namely:

- Glass Fibers
- Carbon fibre
- Silicon carbide fibres
- High silica
- Quartz fibres
- Metal fibers and wires
- Graphite fibres
- Boron fibres
- Aramid fibres

2.3 Objectives of work

Objectives of the work is as follows:

- Recognize, define, and then recognize values some kind's springs with helical looseness coils extension springs.
- Identify are principals process springs, in what way to analyse drive existence captivated of coils.
- Selection are material of helical spring suspension.
- Select composite materials are E-Glass fiber, epoxy and flash.
- To prepare helical groove cutting on the wooden mould.
- By using Filament winding method.
- Fabrication and Experimentation helical spring, containing compatibility with permissible stresses.
- To construct suitable helical spring suspension for comfort driving.
- To determine compression stress, deflection, spring constant, fiber volume fraction.

3. LITERATURE REVIEW

- **Mr. Shrikant Devidas Sakhare, Miss. Araju Alam Patel. [1]** Conducted experimental on 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 fibre epoxy and carbon epoxy spring with the reinforcement of aluminium wire mesh. We take 50%epoxy and 50% glass fibres 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..
- **D Abdul Budan and T S Manjunatha. [2]** Determines the feasibility of replacing metal coil spring with composite coil spring. Three different types of springs were prepared using glass fiber, carbon fiber andocombination of lassi fiber and carbon fiber. Objective is to reduce weight of spring. According to investigational results, spring rate of carbon fiber spring is 34% more than glass fiber spring and 45% more than glass fiber/carbon fiber spring. Weight of carbon fiber spring iso18% a reduced amount than glass fiber spring, 15% less than Glass fiber/carbon fiber spring and 80% less than steel spring.

4. SELECTION OF MATERIALS FOR AUTOMOBILE APPLICATION

Manual possessions such density, young's modulus, and Compression strength, etc. E-glass fibre, epoxy and flyash.

Table-1: Properties of material.

Properties	E-glass fiber	Epoxy resin
Elongation	4.88%	2%
Density	2.5g/cc	1.2g/cc
Elasticity modulus	73 Gpa	3.45Gpa
Tension strength	2.5 Gpa	1.3 Gpa

4.1 Glass Fiber

Glass fiber is white in color its accessible is dry fiber fabric. There are type of glass fiber

- E-Glass: Respectable power
- S-Glass: - Get 40% developed power, which conceding properties at higher temperature.
- C-Glass:-Have deterioration resistance.
- QUARTZ:-Have less dielectric properties, good for antennae.

4.2 E-Glass Fiber.

E-glass fiber this is types of glass fibers alkali free, extreme electrically resistive glass prepared by alumina calcium borosilicate. E-glass is recognized its then industry has the general resolve fiber of it strong, electrical resistance. Commonly recycled fiber in fibre reinforced polymer combination manufacturing.

Fig-3: woven roving E-glass fiber

They are significantly more exclusive than E-glass. Its benefits contain increase toughness capacity of objects, less price, more chemical resistance, it's very good separating things. Negatives consist of decrease flexible strength, deprived linkage to polymers, more specific gravity, and sensitivity to abrasion less fatigue strength. E-glass fibre as elastic modulus of 72.5Gpa, possesses density are 2.55 g/cm^3.

4.3 Epoxy (Thermosetting).

Epoxy is used as matrix material for fabrication of composite. Comprehensive variation of drying agent aimed at epoxy resins is existing dependent on procedure its things necessary. Generally recycled smoking agents for epoxies comprise amines, polyamides, phenolic resins, anhydrides, isocyanates and polymercaptans. Selection its resin and hardeners rest on application, procedure certain, and things anticipated epoxy hardener scheme too distresses things of treated material. Using dissimilar kinds and extents of hardener which, incline to controller cross relation density varies construction.

Resin : - LAPOX L-12.

Hardener : - LAPOX HARDENER K-6.

Fig-4: Epoxy resin and hardener.

Lapox L-12:-

It is melted, unchanged epoxy resin for average thickness which container be recycled by numerous hardeners of creation Glass fiber reinforced combinations.
Hardener K-6:-

Less viscosity at scope temperature of drying molten hardener. Normally working of hand layup presentations.

Mixture is added to plastic composition to control curing action by taking part.

4.4 Fly ash

Fig-5: Fly ash

Fly ash, fine particulate waste material produced by pulverized coal-based thermal power station, is an environmental pollutant, it has potential to be resource material. It is used in cement, concrete and other cement based applications.

Generic name waste product due burning of coal or lignite in boiler of thermal power plant is crushed fuel ash. Milled fuel ash can be fly ash, bottom ash, pond ash or mound ash. Fly ash is pulverized fuel ash extracted from fuel gases by any appropriate process like cyclone parting or electrostatic precipitation.

5 TERMINOLOGY OF SPRING

1 Measurement of spring constant:

Spring constant is well-defined as ratio of force acting on spring to displacement of spring. Spring constant or spring rate is force essential to compress a spring by 1mm. Spring rates be influenced on rigidity modulus, number coil sand dimensions of spring.

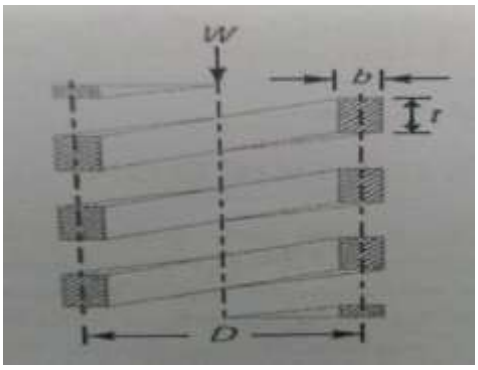

Fig-6: Spring of rectangular cross-section

Spring constant (k) $=\frac{W}{\delta}$

Where,
W = load (N), δ = deflection (mm)

2 Specific strain energy

It is distance moved by spring under action of load.

$$U=\frac{\sigma^2}{\rho E}$$

This designates that material with inferior young's modulus €, density (ρ) will developed specific strain energy under same stress (σ) condition.

3 spring deflection

Deflection and plays imperious role during design of helical springs. Deflection of helical compression spring for circular cross-section is calculated by formula

$$\delta=\frac{8WC^3n}{Gd}$$

Where W is Load, C is spring index D/d, is number of turns, G is modulus of rigidity and d is diameter of wire. Helical compression spring with rectangular cross-section is shown in fig. deflection of helical compression spring for circular cross section is premeditated by formula given below,

$$\delta=\frac{2.5WD^3n}{Gb^3(t-0.56b)}$$

5.4 Measurement of Fiber Volume Fraction:

1 Volume fraction (Vf):

Consider composite material that contain fibres and matrix material. Volume of composite material is equal to sum of volume of fibres and volume of the matrix.

$$V_f=\frac{vf}{vc}$$

$$V_m=\frac{vm}{vc}$$

$$V_f+V_m=1$$

$$V_c=V_f+V_m.$$

2 Density(ρ):

Density of composite material can be defined as ratio of weight of composite material to volume of composite material and is expressed as

$$\rho_C v_C=\rho_f v_f+\rho_m v_m$$

$$\rho_c=\rho_f\frac{vf}{vc}+\rho_m\frac{vm}{vc}$$

3 Weight Fractions:

Supercilious that composite material involves of fibers and matrix material, weight of composite material is equal to sum of weight of the fibers and weight of matrix. Therefore,

$$W_c=W_f+W_m$$

Where, Wc- weight of composite material

Wf – weight of fiber

Wm – weight of matrix

Wf + Wm=1

Wf $=\frac{wf}{wc}$ and

Wm $=\frac{wm}{wc}$

6. EXPERIMENTATION AND FABRICATION OF COMPOSITE SPRING

Select specific teak wood for making mould and then with help of lathe machine the thread on that wood and prepared mould for manufacturing the composite helical spring through Filament winding technique. Test specimens are for spring constant, compression test, fiber volume fraction.

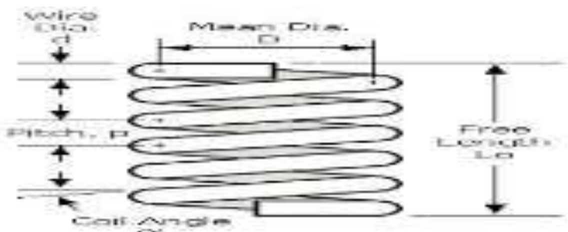

Fig-7: Terminology for rectangular cross-sectional spring

Table-2 Compositions for composite spring:

SI. No	E-Glass fibre	Epoxy	Fly ash
1	70%	20%	10%
2	60%	30%	10%
3	50%	40%	10%

6.1 Fabrication process

In composite spring fabrication the ratio of glass fiber, epoxy and fly ash are in used. First to arrangements of filament winding method by using lathe machine. Fabrication of three compositions of composite helical springs. Take wooden pattern to fixing in lathe machine. Mold relief cause Vaseline used in mold. As show in figure (8) Fiber wound over the wooden pattern as show in figure (9). All kinds of springs are fabricated through same method. Wooden pattern having profile of spring is arranged first by using lathe machine. There are three compositions are, C1 (70%E-Glass fibre, 20% epoxy, and 10% fly ash), C2 (60% E-Glass fibre, 30% epoxy and 10% fly ash) C3(50% E-Glass fibre,40% epoxy, 10% fly ash). Next the process of fabrication compositions mixed properly with in certain time. By using filament winding technic by manually to fill the wooden pattern mould. E-Glass fibre (woven roving like thread), epoxy and fly ash fixed properly wound over wooden pattern as show in fig (10). Next finally fabricated composite coil springs take it breakdown wooden mould as shown in fig (11) are fabrication spring atmospheric temperature for 24 hours. After removed excess resin on surface of spring is removed by filling. Break down wooden pattern cured spring is removed from the wooden pattern. To maintained fly ash composition but only change is E-Glass fiber and epoxy resin. The cured spring has the dimension of L=195mm, D_0=54mm, D=47mm, b=12mm, t=8mm and n=12.

Fig-8: Mould making

Fig-9: Arrangements filament winding method.

Fig-10: Fiber wound over the mould

Fig-11: Three different compositions of fabricated spring

7. RESULTS AND DISCUSSION

Fabrication of composite helical spring's objectives of work is to a light weight of the vehicle and to study their strength of materials and properties of materials. The composite springs using Glass/Epoxy resin and fly ash material combination has been fabricated using wooden pattern and finally we take result of composite spring by using conventional lathe machine.

Table-3: Comparison between steel spring and different compositions of composite springs.

Properties	Steel spring	Composition C1	Composition C2	Composition C3
Spring constant (N/mm)	4.5	5.98	5.18	5.28
Max	80	89	88	84

compression (mm)				
Load at Max. compression (N)	360	390.90	380.90	370.90
Weight of the spring (gm.)	602	280	220	180
Spring index	6.75	6.75	6.75	6.75
Failure load (N)	950	110	1000	950

7.1 Load V/S Deflection Curve for Composition (C1):

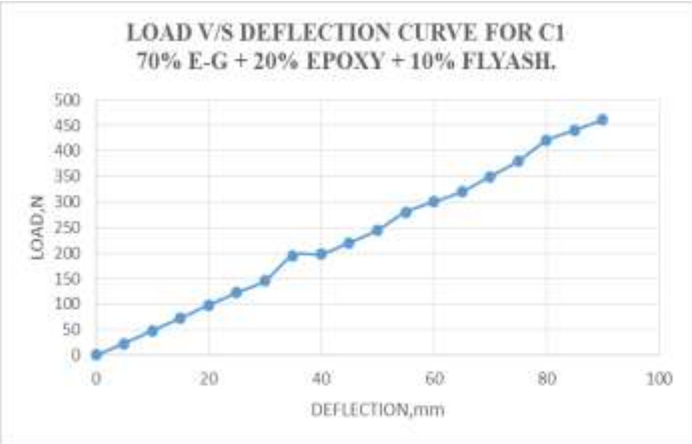

Chart-1: Graph of load –deflection of composition C1.

7.2 Load V/S Deflection Curve for Composition (C2):

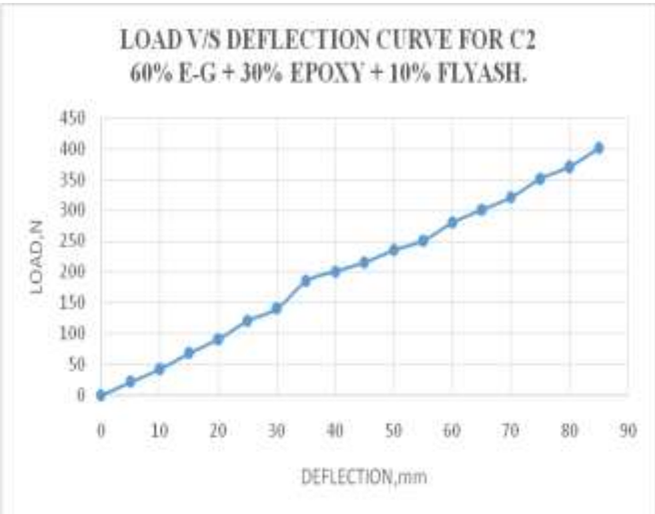

Chart-2: Graph of load –deflection of composition C2.

7.3 Load v/s Deflection Curve for Composition (C3):

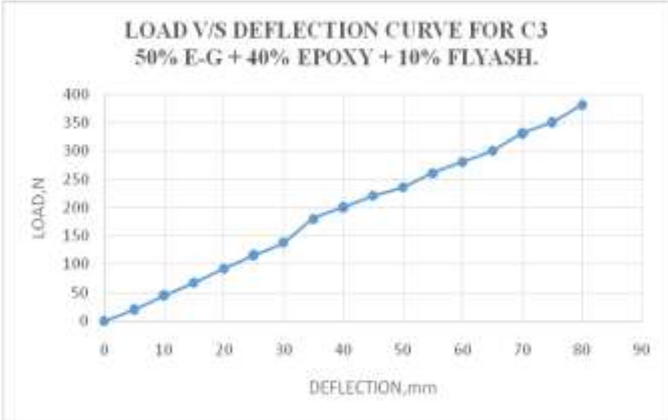

Chart-3: Graph of load –deflection of composition C3.

7.4 Load v/s Deflection Curve for Different Compositions for Composite Spring:

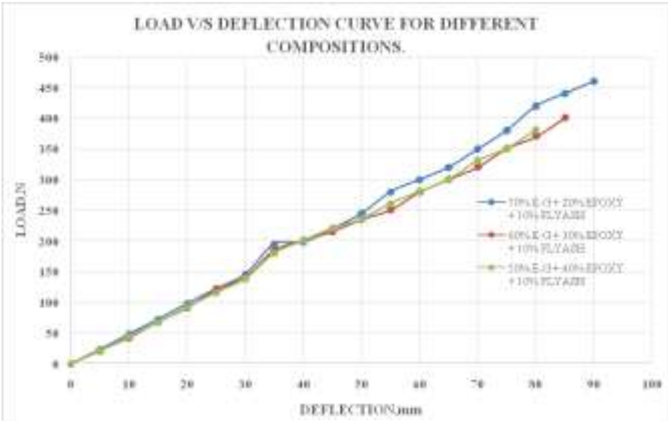

Chart-4: Graph of load-deflection of different compositions

CONCLUSIONS

- In this project, three types of compositions of composite helical spring have been developed, and which are less weight compare to steel spring and more stiffness.
- By the application of composite helical coil spring, the wooden mould have been prepared for composite spring. By using wooden mould composite spring have been fabricated by using E-glass fibre, epoxy and fly ash has a filler material.
- Filament winding technique were used for fabrication of composite helical springs with lathe.
- Composition C1 (70% E-Glass fibre + 20%Epoxy +10%Fly ash), it has more compressive strength and stiffness compare to other two compositions C2

(60% E-Glass fibre + 30% Epoxy + 10%flyash)and composition C3 (50%E-Glass +40%epoxy +10%flyash)

- Weight of the spring fabricated the fibres is less than steel spring. Materials cost of the composite spring is more than the steel spring. Than acceptable in the quantity of fuel protected by expending e-glass fiber spring now vehicles.

- Higher compressive strength and stiffness also more then the steel spring, fiber volume fraction, density is increases.

- Hence load substitute on the composite spring are lower than the steel spring, therefore fatigue load acting on the composite spring is less when compared to steel spring.

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