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Design, Manufacturing and Analysis of Composite Leaf Spring

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Abstract— Now-a-days it is necessary to conserve natural resources, economize energy and weight reduction. Weight reduction of vehicle has become the main issue in Automobile Industries. It can be achieved by introduction of better material, design optimization and better manufacturing process. The Automobile Industry has interest for replacement of Steel Leaf Spring with Composite Leaf Spring. Composite Material has High Strength and Stiffness to Weight Ratio. The Objective is to compare the Stresses, Deformation, Elastic Strain and Weight of Composite Leaf Spring with that of Steel Leaf Spring. The Material Selected is Glass Fibre Reinforced Polymer is used against Conventional Steel. The Leaf Spring was modelled in CATIA and analysis done in ANSYS Software.

Keywords— leaf spring, composite material, automobile, reinforced polymer, E-glass, Epoxy

I. INTRODUCTION

In the present scenario, to optimize the use of energy, weight reduction became one among the most focuses of automobile manufacturers. Weight reduction is often achieved by the introduction of higher material. Leaf springs are mainly utilized in suspension systems to soak up shock loads in automobiles like light automobiles, heavy duty trucks and in rail systems. They carry lateral loads, brake torque, driving torque additionally to shock absorbing. Leaf springs are having a plus that the ends of the spring could also be guided along a particular path because it deflects. The use of composite materials for suspension leaf spring reduces the weight of conventional multi leaf steel leaf spring by nearly 75%. This achieves the vehicle with more fuel efficiency and improved riding qualities. For more compliant suspension system (i.e. energy storage capability), the spring should absorb the vertical vibrations and impacts thanks to road irregularities by means of variations within the spring deflection in order that the P.E. is stored in spring as strain energy then released slowly. A material with maximum strength and minimum modulus of elasticity within the longitudinal direction is that the best suited material for a spring. As compared with those of steel the composite materials have more elastic strain energy storage capacity, efficient corrosion resistance, higher strength to weight ratio. Mono-leaf composite springs are replacing Conventional Multi-leaf steel springs. The development of composite materials and their related design and manufacturing technologies is one among the foremost important advances within the history of materials. Composites are the fabric utilized in various fields having exclusive mechanical and physical properties and are developed for particular application. Composite materials having a variety of benefits over other conventional materials like lastingness, impact strength, flexural strengths, stiffness and fatigue characteristics. Because of their numerous advantages they're widely utilized in the aerospace industry, commercial engineering applications, like machine components, automobiles, combustion engines, mechanical components like drive shafts, tanks, brakes, pressure vessels and flywheels etc. When two or more materials with different properties are combined together, they form a material. Composite material made up of strong load carrying material (known as reinforcement) mixed with weaker materials (known as matrix). The primary functions of the matrix are to transfer stresses between the fibres/particles and to protect them from mechanical or environmental damage where the presence of fibres or particles in a composite improves its mechanical properties like tensile strength, flexural strength, impact.

II. LITERATURE SURVEY

A material is that the combination of two or more materials that produce a synergistic effect in order that the mixture produces aggregate properties that are different from any of these of its constituents attain independently. this is often intentionally being done today to urge different design, manufacturing also as service advantages of products. abreast of those products spring is that the focus of this project that researches are running to urge the simplest material, which meets the present requirement of strength and weight reduction in one, to exchange the prevailing steel spring. Here researches on this area are well reviewed showing the rear ground of this project, as follows:

- A. Mr. Abdul Rahim Abu Talib et al. are worked on developing a composite based elliptic spring for automobile applications. After that using this conclusion they need change steel spring by material and analyze it with same loading condition. They concluded that, composite elliptical springs have more fatigue performance than steel. They considered light and heavy

trucks with steel elliptic spring for analysis of fatigue performance and weight reduction by using ANSYS software. The objective is to match the load carrying capacity, fatigue performance and weight savings of composite spring thereupon of steel spring . Also they need compared the finite element results of fatigue life and weight reduction with existing analytical and experimental result. The conventional steel spring and weight reduction ratio is achieved.

- B. Ashish V.Amrute, Edward Nikhil karlus presented work on design & assessment of leaf spring. Main objective of this work is to match the load carrying capacity, stresses and weight saving of composite spring thereupon of steel spring . Here the multi spring contains three full length leaves during which one is with eyed ends employed by a light-weight commercial vehicle. For analysis of spring Tata ace ex vehicle taken as prototype. This work deals with replacement of conventional steel spring of a light-weight commercial vehicle with composite leaves spring using Eglass/Epoxy. Dimensions of the composite spring are to be taken as same dimension of the traditional spring . The Theoretical and CAE results are validated by comparison between the two. From results it's proved that the bending stresses are decreased by 25.07% in composite spring means less stress induced with same load carrying condition. The conventional multi leaf spring weights about 10.27kg where the E-glass/Epoxy multi leaf spring weighs only 3.26 kg. Thus the weight reduction of 67.88% is achieved by using composite material rather than using steel material.
- C. Dev dutt Dwivedi and V.K.Jain had done Design and analysis of composite leaf spring. ANSYS14.5 has been used to conduct the analysis. Static structural tool has been used of ANSYS. A three layer composite spring with full length leave. E-Glass/epoxy composite material has been used. Conventional steel spring results are compared with the results obtained for composite spring . E glass or epoxy material is better in strength and lighter in weight as compared with conventional steel leaf spring. A wide amount of study has been conducted in his paper to research the planning and analysis of spring and spring fatigue life. Results demonstrate that composite spring deflection for a specific load is a smaller amount compared to standard spring . Stress generated in the developed leaf spring is lower than steel leaf spring. Composite (E-Glass/Epoxy) spring directional deformation is low compared to steel spring . Composite spring is lighter in weight compared to standard steel leaf.
- D. N. P. Dhoshi, Prof. N. K. Ingole and Prof. U. D. Gulhane have worked on analysis and method. In this paper, they consider trailer truck with seventeen-leaf steel spring for analysis of stress and deflection by using ANSYS 11.0 software. The objective is to match the load carrying capacity, stiffness and weight savings of composite spring thereupon of steel spring. Also they need compared the finite element results of stresses and deflection with existing analytical and experimental result and using this result they replace steel spring by composite material of E-glass/epoxy and analyze it with same loading condition for stresses and deflection. The dimensions and the number of leaves for both steel leaf spring and composite leaf springs are supposed to be the same. They consider design constraints were stresses and deflections. They concluded that, the composite spring have much lower stress and deflection than that of existing steel spring. Also they concluded that weight of composite leaf spring was nearly reduced up to 80% compare to steel leaf spring.

III.OBJECTIVE

A material is defined as a cloth composed of two or more constituents combined on a macroscopic scale by mechanical and chemical bonds. Typical composite materials are composed of inclusions suspended during a matrix. The constituents retain their identities in the composite. Normally the components are often physically identified and there's an interface between them. Many composite materials offer a mixture of strength and modulus that are either like or better than any traditional metallic materials. Because of their low specific gravities, the strength weight-ratio and modulus weight-ratios of those composite materials are markedly superior to those of metallic materials. The fatigue strength weight ratios also as fatigue damage tolerances of the many composite laminates excellent. For these reasons, fiber composite have emerged as a serious class of structural material and are either used or being considered as substitutions for metal in many weight- critical components in aerospace, automotive and other industries.

A. Principle

The suspension spring is one among the potential items for weight reduction in automobile because it accounts for ten to one-fifth of the unsprung weight. The introduction of composites helps in designing a far better suspension with better ride quality if it are often achieved without much increase in cost and reduce in quality and reliability. In the design of springs, strain energy becomes the main factor. The relationship of the specific strain energy can be expressed as

$$U = \sigma^2 / \rho E$$

Where σ is the strength,

ρ is the density and E is the Young's Modulus of the spring material

It is often easily observed that a material is having a lower modulus and a density will have a greater specific strain energy capacity. The introduction of composite materials made it possible to scale back the load of the spring without the reduction of a load carrying capacity and stiffness thanks to the subsequent factors of composite materials as compared to steel.

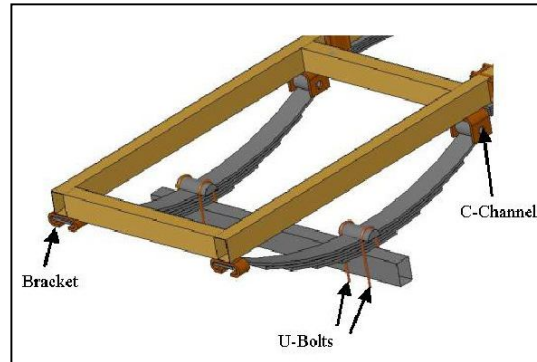


Fig.1: Arrangement of leaf spring in a car Model

An upturned spring eye is employed to connect the front end of semi-elliptic spring to the chassis frame, and a free end with a bracket constraining vertical motion to connect the rear end of semi-elliptic spring to the chassis frame.

A Composite in engineering sense is any materials that are physically assembled to make one single bulk without physical blending to form a homogeneous material. The resulting material would still have components identifiable because the constituent of the various materials. One of the benefits of composite is that two or more materials might be combined to require advantage of the great characteristics of every.

B. Types of Springs

- 1) Helical springs
- 2) Conical and volute springs
- 3) Torsion springs
- 4) Disc or Belleville springs
- 5) Special purpose springs
- 6) Laminated or leaf springs

IV. MATERIALS AND PROPERTIES

In Analysis of Leaf spring, we considered different materials for comparison to the conventional steel leaf spring. The selected materials are Epoxy glass, Epoxy carbon, Aluminum Alloy, and Titanium Alloy. Following are the material properties of selected materials are compared with the steel properties.

A. Steel

The material used for leaf springs is typically clear steel having 0.90 to 1.0% carbon. After the forming process the leaves are heat treated. The heat treatment of spring steel products has greater strength and thus greater load capacity, greater range of deflection and better fatigue properties E-Glass/Epoxy:

The main advantage of Glass fiber over others is its low cost as compared to other materials. It has higher strength, higher chemical resistance and better insulating properties.

B. Epoxy Carbon

The advantages of Epoxy carbon material include higher specific strength and modulus, lower coefficient of thermal expansion and higher fatigue strength than others.

C. Aluminium Alloy

Because it is more malleable and elastic aluminum is a very desirable metal, corrosion resistant and less denser than others.

D. Titanium Alloy

Titanium may be a material with combination of high strength, stiffness, toughness, rarity and better corrosion resistance provided by differ titanium alloys. It is the most useful and strongest metal available.

V. METHODOLOGY

We used a hand-lay-up method to produce the prototype of a single composite leaf spring. The constant cross section design is used which accommodate continuous reinforcement of fibres and quite suitable for hand lay-up technique. 40 layers of E-glass fibre of 0.4 mm thick each are used to achieve 12 mm thickness & 50 mm width of the designed leaf spring. The steps below are followed during prototyping:

- Preparing moulds as per the shape of the leaf spring and the setup.
- Preparing stiffener and clamping plates.
- Cutting fibres to desired dimensions.
- Applying wax/gel on the fibre side of the lower mould for ease of removal.
- Preparing mixture of epoxy resin and polyamine hardener.
- Apply the mixture just above the wax.
- Start laying up the first ply and apply the matrix on it again, repeat the same procedure up to the desired thickness.
- Apply the matrix well on the topmost layer and Cover the upper mould after the wax film is done on its fibre side.
- Put the stiffener on the covered mould and clamp tightly using the plates and c-clamps.
- Allow the composite leaf spring to cure enough at room temperature.
- Remove it from the set up and trim the excess material.

VI. CONCEPTUAL DESIGN

A. Modelling using CATIA

CATIA is the world's leading CAD/CAM/CAE software. This software gives you a wide range of integrated solutions. CATIA is the digital product definition, simulation and manufacturing tool of choice for leading manufactures and have been for more than 20 years. Its capabilities have been shaped around the needs of leading edge companies across the aerospace, defence and automotive, industrial equipment, energy and consumer goods industry sectors. CATIA (Computer Aided Three-Dimensional Interactive Application) started as an in-house development in 1977 by French aircraft manufacturer Avions Marcel Dassault, at that time customer of the CAD/CAM CAD software to develop Dassault's Mirage fighter jet. CATIA provides a broad range of applications for tooling design, for both generic tooling and mold & die. A rich catalog of industry-standard components is provided to automate tooling definition. Specific tools are also provided to address the needs of mold tool injection designers.

B. Elliptical Leaf Spring

Diagram shown below indicates a semi elliptical leaf spring. Number of springs are clamped together with the help of U clips. For the supports of all springs rounded clip is used. The main spring which is also the longest member of the band is made of rounded supports also known as spring eye on both sides to attach on vehicle chassis.

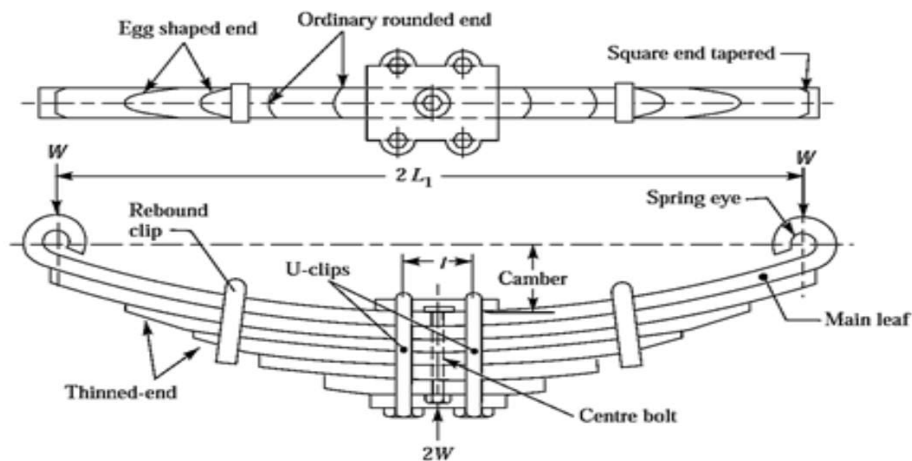


Fig 2 Schematic diagram



C. Design Specifications of Leaf Spring

Table no. 1 Design specifications

1	total length of the spring(eye to eye)	1120 Mm
2	free camber	180 mm
3	no of full length leaves	2
4	no of graduated leaves	8
5	thickness of the leaf	6 mm
6	width of the leaf	50 mm
7	young's modulus of the steel	210 gpa
8	Poisson ratio	0.3

D. Analysis Procedure of Leaf Spring

- 1) *Geometry*: First generate the geometric model of the leaf spring from CATIA into Ansys software.
- 2) *Define Materials*: Define a library of materials for Analysis. In this Analysis of leaf spring, selected materials are steel, Epoxy glass, Epoxy carbon, Aluminum Alloy, Titanium Alloy. Data for materials is available in Ansys software.
- 3) *Generate Mesh*: Now generate the mesh. This distributes the drawing into finite number of elements. After meshing is completed it will show the number of nodes and elements present in the drawing.
- 4) *Apply Boundary Conditions*: Simply supported boundary conditions are considered for the leaf spring. In this case both the ends of the leaf spring are given fixed support and the load on the leaf spring is applied at the bottom leaf in upwards direction.
- 5) *Obtain Solution and Generate Results*: Now obtain the solution for the stress, deformation and elastic strain and generate the results.

E. Introduction of ANSYS

ANSYS is used for finite element analysis (FEA) software package. To create geometry It uses a preprocessor software engine. Then for meshed geometry it uses a solution routine to apply loads . Finally it gives output as desired results in post-processing.

FEA is used almost all engineering design including mechanical systems and civil engineering structures.

In most structural analysis applications it's necessary to compute displacements and stresses at various points of interest. The finite element method may be a very valuable tool for studying the behavior of structures. In the finite element method, the finite element model is made by dividing the structure in to variety of finite elements. Each element is interconnected by nodes. The selection of elements for modeling the structure relies upon the behavior and geometry of the structure being analyzed. The modeling pattern, which is usually called mesh for the finite element method, may be a vital a part of the modeling process. The results obtained from the analysis depend on the choice of the finite elements and therefore the mesh size. Although the finite element model doesn't behave exactly just like the actual structure, it's possible to get sufficiently accurate results for many practical applications. The goal of meshing in ANSYS Workbench is to supply robust, easy to use meshing tools which will simplify the mesh generation process. These tools have the advantage of being highly automated alongside having a moderate to high degree of user control.

Advantages of FEA

- Visualization increases
- Design cycle time reduces
- No. of prototypes reduces
- Testing reduces
- Optimum design

The processes of performing ANSYS are often weakened into three main steps.

- 1) **Pre-Processing:** This step is most vital in analysis of spring . Any modeling software are often used for modeling of geometry and may be shifted to other simulation software for analysis purpose. After mesh generation (grid generation) is that the process of subdividing a neighborhood to be modeled into a group of small elements. Meshing is that the method to define and ending the model into small elements. In general a finite element model is defined by a mesh network, which is formed from the geometric arrangement of elements and nodes. Nodes represent points at which features like displacements are calculated. Elements are enclosed by set of nodes, and specify localized mass and stiffness properties of the model. Elements also are defined by the amount of mesh, which allowed regard to be made to corresponding deflections, stresses at specific model location. The common sort of mesh element utilized in ANSYS solver is hexahedral, tetrahedral and brick.
- 2) **Solver:** During preprocessing user has got to exerting while solution step is that the turn of computer to try to to the work. User need to just click on solve icon. Software carries out matrix formations internally, inversion, multiplication & solution for unknown. E.g. displacement & then after find out strain & stress for static analysis.
- 3) **Post-Processing:** The final step in ANSYS where results are analyzed. However, the important value of ANSYS simulation is usually found in its ability to supply accurate predictions of integrated quantities like find displacement and stresses. Post processing is study results, validations, conclusions & considering about what steps could be taken to improve the design.

Assumptions

Software to be used for ANSYS 15.0

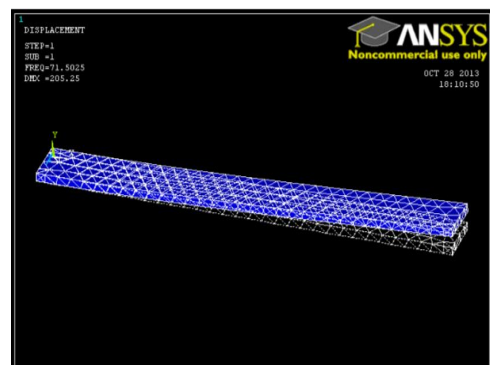
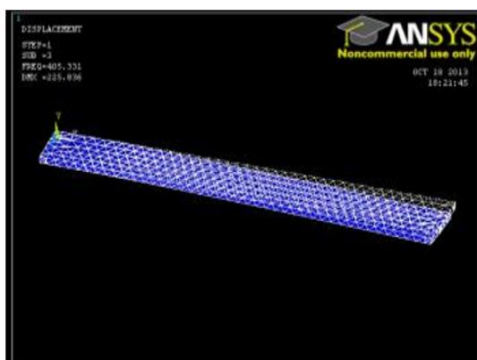
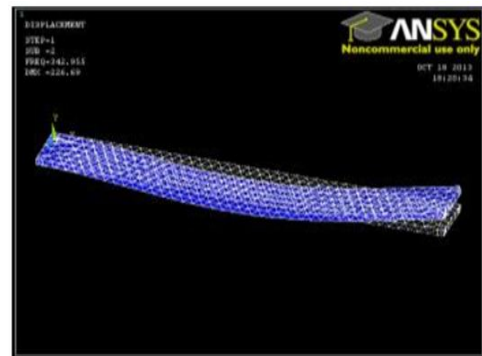
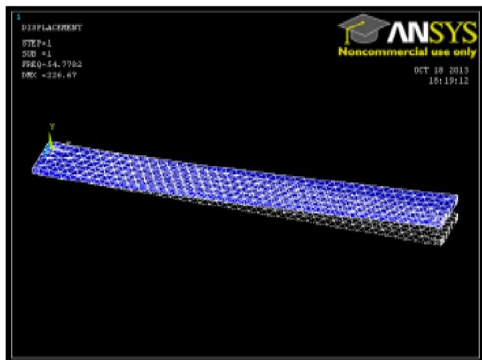
Model simplification for FEA.

Static analysis is considered.

VII. ANALYSIS OF COMPOSITE LEAF SPRING

As mentioned earlier, the power to soak up and store more amount of energy ensures the comfortable option of a suspension. However, the matter of heavy weight of spring remains persistent. This can be remedied by introducing material, during a place of steel within the conventional spring . Research has showed that the results of E-glass/epoxy, carbon epoxy were found with better characteristics for consuming strain energy. So, a virtual model of spring was created in ANSYS workbench then material is assigned to the model. These results are often used for comparison with the steel spring.

A. Structural Analysis



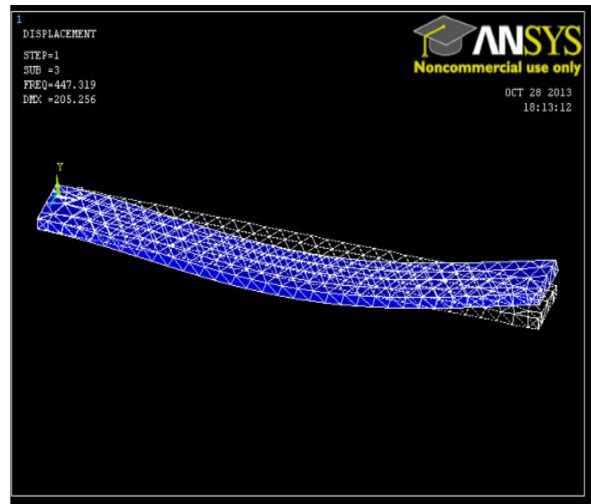


Fig 3. Different mode shape condition of various Compositions

B. Stress Analysis

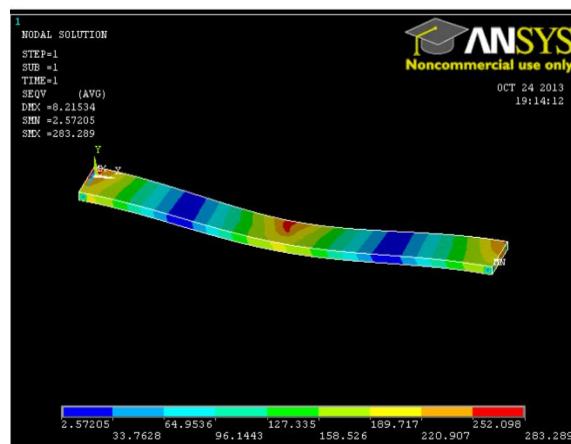
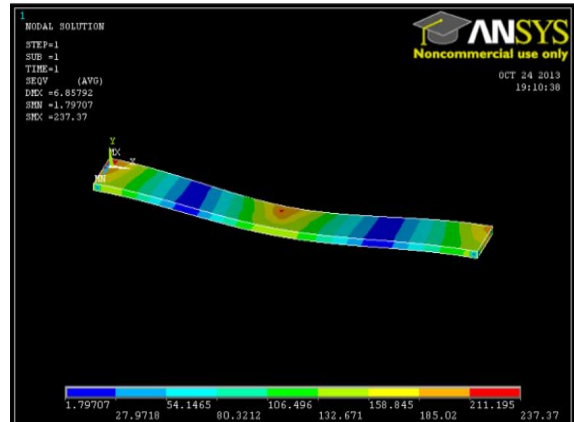
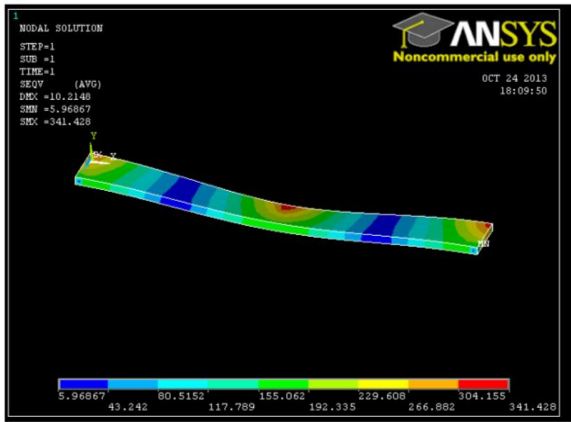


Fig 4. Stress analysis

VIII. RESULTS & DISCUSSION

The heading of the References section must not be numbered

A. Tensile test

The tensile test was carried out using a universal testing machine. The test specimen is prepared according to ASTM D standard.

B. Flexural Test:



Fig 5. Flexural test

The flexural test is carried out using the universal testing machine. The test specimen was prepared according to ASTM D standard.

C. Hardness Test

The test was conducted using Rockwell L- scale, which is especially for plastic materials, Bakelite and vulcanized rubber. The indenter chosen is of diamond. A load of 60 kg was used for the test.



Fig 6. Result of Experimental Work:

IX. RESULT DATA

A. Tensile Test

Table 3. TENSILE TEST

Sr. No.	Parameter	Specimen 1 (60 % & 40%)	Specimen 2 (40% & 60%)	Specimen 3 (70% & 30%)
1	F_{max}	6500	5280	3250
2	Tensile Strength	107 MPa	92.2 MPa	46 MPa

B. Flexural Test

Table 4. FLEXURAL TEST

Specimen 1

Sr. No.	Parameter	EXP (60 % & 40%)	FEA (60 % & 40%)
1	F_{max}	1000	1000
2	Bending Stress	442	341
3	Displacement	7.5	10.21

Specimen 2

Sr. No.	Parameter	EXP (40 % & 60%)	FEA (40 % & 60%)
1	F_{max}	800	800
2	Bending Stress	330	237
3	Displacement	7	6.81

Specimen 3

Sr. No.	Parameter	EXP (30 % & 70%)	FEA (30 % & 70%)
1	F_{max}	800	800
2	Bending Stress	330	213
3	Displacement	6.3	5.95

C. Hardness test:

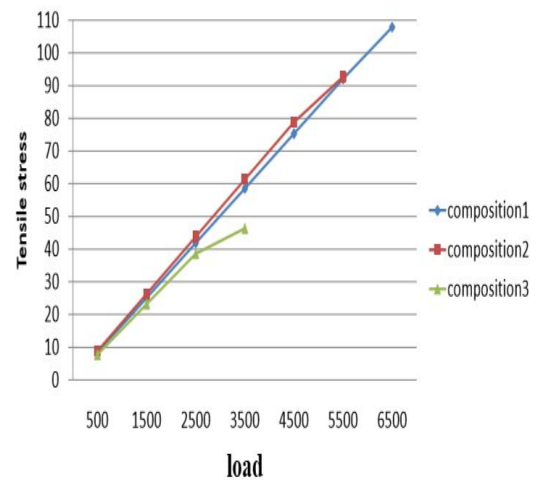
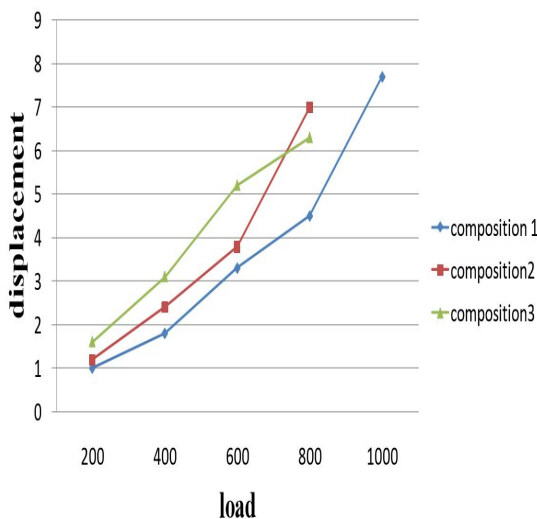
Table 5 Hardness test

Sr. No.	Specimen 1 (60 % & 40%)	Specimen 2 (40 % & 60%)	Specimen 3 (70 % & 30%)
1	5	4	3
2	4	3	3
3	5	3	4

X. ANALYSIS RESULTS

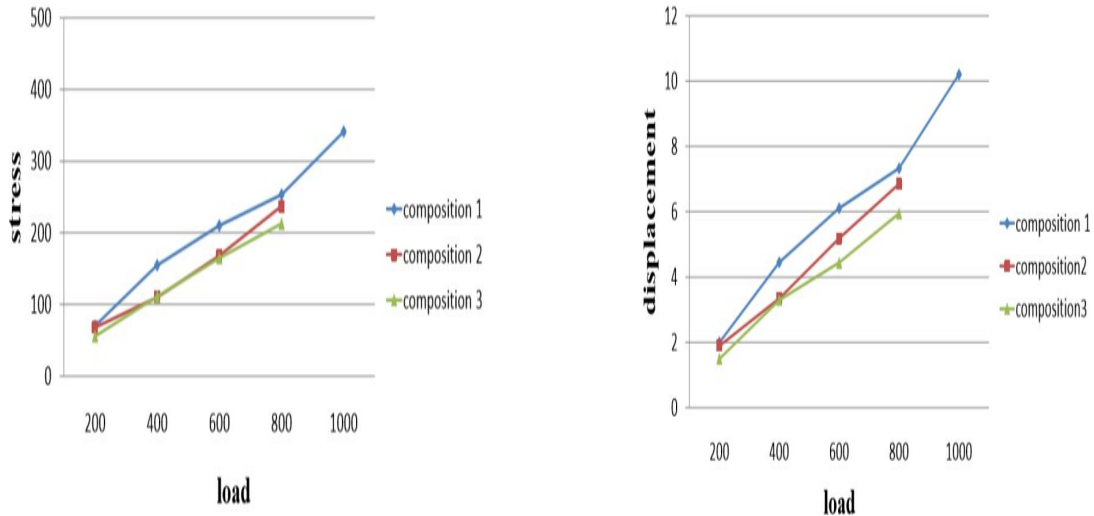
A. Experimental Analysis

Chart 1. Experimental Analysis:



B. FEA Analysis

Chart 2. FEA Analysis:



XI. CONCLUSIONS

Results are studied for above four parameters. It has been concluded that 60% E-glass and 40% Epoxy is better as compared to other two specimens. Tensile test, Flexural test and Hardness test were attempted for 3 specimens from which tensile strength are average of 80.06 Mpa whereas for Flexural test, bending stress is average of 367.33Mpa. For hardness test, Composite materials have more sustainability as compared to steel. We concluded that composite leaf spring is better option to replace conventional leaf spring. ANSYS 14.0 is used for meshing and analysis is effective, efficient and less time consuming than other method or solutions. Rather than this

XII. ACKNOWLEDGMENT

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REFERENCES

- [1] Abdul Rahim Abu Talib, Aidy Ali, G. Goudah, Nur Azida Che Lah, A.F. Golestaneh, "Developing a composite based elliptic spring for automotive applications", Materials and Design, 31, 2010, 475–484.
- [2] Mr. Anandkumar A. Satpute, Prof. S. S. Chavan, "Mono Composite Leaf Spring –Design and Testing", Indian Journal of Applied Research, Volume 3, Issue 7, 2013.
- [3] Ashish V .Amrute, et al., and (2013) Design and Assessment of Multi leaf spring International Journal of Research in Aeronautical and Mechanical Engineering Issn (Online): 2321-3051 Vol.1 Issue.7.
- [4] Dev dutt Dwivedi, V.K.Jain, (2016) "Design and Analysis of Automobile leaf spring"ISSN (PRINT): 2393-8374, (ONLINE): 2394-0697, VOLUME-3, ISSUE-1.
- [5] N. P. Dhoshi, Prof. N. K. Ingole, Prof. U. D. Gulhane, "Analysis and modification of leaf spring of tractor trailer using analytical and finite element method", International Journal of Modern Engineering Research, Vol.1, Issue.2, pp 719-722
- [6] Edward Nikhil Karlus, et al., (2014.) "Optimization of Mono Parabolic leaf spring"International Journal of Advances in Engineering & Technology, IJAET. ISSN: 22311963
- [7] K. K. Jadhao, DR. R. S. Dalu, "Experimental investigation & numerical analysis of composite leaf spring", International Journal of Engineering Science and Technology, Vol. 3, No. 6, 2011.



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