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Investigation of Mechanical Properties of Composite Materials Used for Leaf Spring

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Abstract

This study presents the investigation of mechanical properties of composite materials. The aim of this thesis is static investigation consequences of existing leaf spring made of EN 45 steel material with three different sort of composite material leaf spring. There are the plan requirements to stress, deflection and weight decrease. The plan particular of composite material leaf spring is taken same as the regular steel leaf spring. Different types of composite material are used such as fiber glass material with epoxy resin, carbon/epoxy and Kevlar/epoxy material. This composite material leaf spring demonstrated on creo parametric 3.0 programming and, investigated it on ANSYS 14.0. Comparing with steel spring result with composite spring result we have seen that the wt. of the composite material leaf spring made of Kevlar/epoxy fiber, is diminished by 6.01%, by utilizing material E-glass/epoxy Fiber it is diminished by 59.1% and by utilizing material carbon/epoxy fiber it is diminished by 63.7%.

Keywords – Parabolic leaf spring, Mechanical properties, Composite materials, Creo,

1.Introduction

In present day, there are two significant issues in the automobile sector, for example, the fuel efficiency and emission gas guideline based on the Green house gas protocol. To defeat the new vehicles are being manufacturing by the automobile companies which directly can give the higher efficiency with minimum cost. One of the best methods to enhance the efficiency of fuel is to limit the weight of the automobile vehicles. The weight decrease can be perfect by utilizing good material, plan improvement and most effective way for manufacturing processes. The accomplishment of weight decrease with improvement in mechanical properties has made by composite material which is a generally excellent substitution material for traditional steel material.

A spring is an elastic object/body whose main objective is to stored energy (mechanically). A spring is a coil, leaf, volute and compression that stored potential energy when loaded either in the compression, extension or torsion. The application of spring is widely used in brakes when apply forces, clutches, and also used in the toys, clocks. Spring also controls the motions of the cams and followers by handling contact between two parts.

There are various types of leaf spring

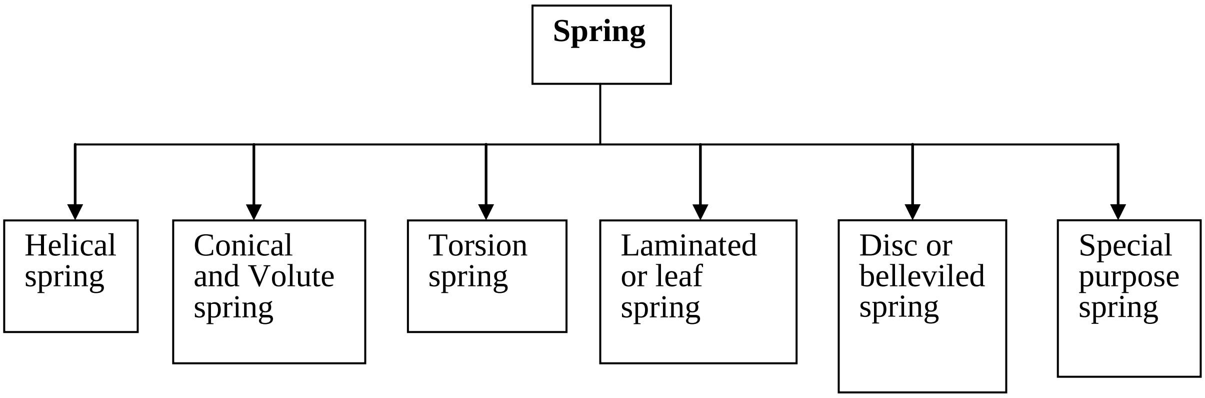

Figure 1. Springs

1.1 Laminated or Leaf Spring

A leaf spring is the oldest and simple form of spring generally used in the vehicles for the suspension. It is also called the name laminated and/or carriage spring. Technically it is also referred to elliptical, semi-elliptical and cart spring. In a rectangular cross-section a leaf spring taken in the form of slender arc shaped In the most widely recognized setup, the centre arc gives the axle location while loops formed either rear end to link the chassis vehicle. For exceptionally weighty vehicles, a leaf spring can be produced using a few leaves stacked on top of one another.

In current time the primary goal of automotive sector is to further develop a comfortable ride a suspension of leaf spring area need to focus. It is necessary a important part for weight reduction of the vehicles and it represents 10 to 25% of unsprung weight.

It is notable that springs are designed to absorbed energy (shocks) as well as vibration. To reduce the weight of spring without changing the load capacity and flexibility will only possible by the composite materials. The advantages of composite material are high strength weight ratio and also capacity of stored elastic energy as compared with the steel. As we know that material which have the more strain energy capacity will have the lower density and modulus. Thus composite materials are the superior which gives the high strength. The road irregularities will affect the spring and the primary function of spring is to absorb impact, vibration and shocks whereas when the deflection values are change the potential energy is stored in terms of strain energy and after some time it release step by step to maintain comfort. This work investigate the fatigue and static analysis of EN45 steel leaf spring (parabolic) and composite (parabolic). The composite material made up of FRP (Fibre reinforced polymer). In the present work we took the dimensions of the existing EN45 steel and composite leaf spring of Tata Ace light vehicle and also these dimensions are verified with the design calculation. In these study three layers of parabolic leaf spring is taken for EN45 steel and composite materials. The shapes of the leaves are parabolic while thickness is varying from neutral axis. This parabolic spring are light in weight and reduce friction (inter) vehicle.

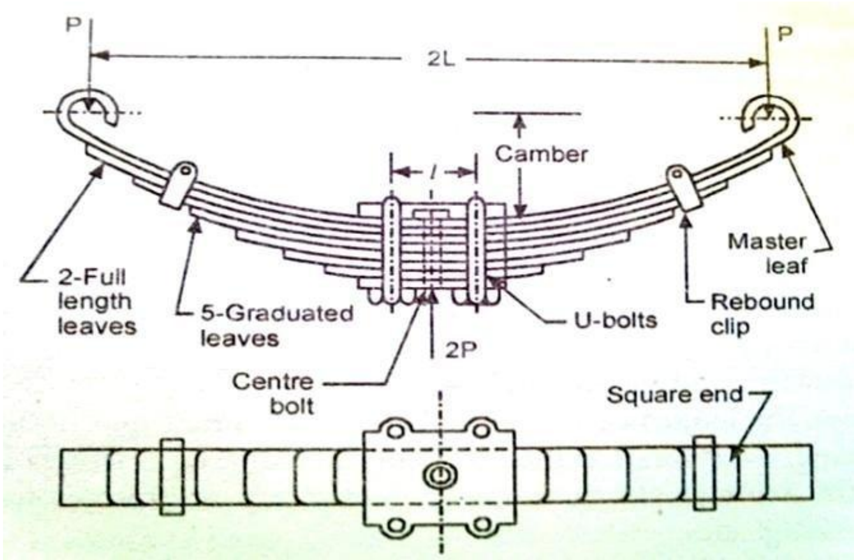

Figure 2. leaf spring

1.2 Leaf spring material

The material taken for superimposed springs is for the most part plain carbon steel having 0.80 to 1.0% carbon. The leaves of this superimposed spring are processes for heat treatment in the wake of shaping done. The hotness treated steel spring produces greatest strength. Materials establish around 55%-75% of the absolute vehicle cost and it is add to the presentation of the vehicle and the quality. Indeed, even a modest quantity in decrease of weight of the auto, may have a most extreme monetary effect. For weight decrease of the vehicle, the composite materials are demonstrated as appropriate substitutes in substitution of steel. Henceforth, it has been chosen for plan of leaf spring. The material utilized in assembling of leaf spring ought to have high malleability; high exhaustion strength, high flexibility and it ought to be creep safe. It basically relies on the help or condition under which it is utilized for example normal help, extreme assistance or light help. Serious help watches out for fast consistent stacking where the proportion of least to most extreme burden/stress is one-half or less, for example, in auto valve springs. Normal assistance includes the equivalent pressure range like serious help however through irregular activity, similar to vehicle suspension springs and motor lead representative springs. Light assistance includes springs which are exposed to loads that are rarely shifted and static, similar to wellbeing valve springs.

1.3 Composite Material

Last 3 decades composite materials like plastics and ceramics have great application in the various sectors and reinforced plastics i.e. fibre glass and FRP (Fibre reinforced polymer) have much attention in automobile sector. Present time most of the industries prefer composite materials because of the high strength weight ratio. Composite materials have 5 times higher strength than the aluminium and steel of same weight materials.

From the studied the various types of composites materials. The materials used in the study are carbon fibre and glass fibre fabric with reinforcement of matrix material like Epoxy resin (AW – 106) and hardener (HV – 953-IN). For testing the samples ASTM D638 standard is used. Tensile and

Flexural test have performed to find out the mechanical properties of mono leaf spring materials [1-3]. In this analysis C- glass fibre is used because it has a ability of corrosion resistant property. For optimizing the composite spring ANYSY software is used. While using the C-glass fibre it is observed that weight is reduced by 40% similarly the deformation and stress concentration is reduced by 76.39% and 50% than the steel. Apart from the weight reduction it is also reduced noise and vibration [4-7]. In this study a conventional material SAE 5160 steel is replace by carbon fibre reinforced polymer material to increase the strength of material and performance efficiency. Flexural Fatigue life is analyzed by the FE analysis. With the use of FE analysis author observed that weight of the composite material is 5.9kg less than the steel material and apart from the weight deformation is also seen lesser. Higher stiffness and more fatigue life than SAE 1560 steel material [8-14]. Author discussed the static analysis of spring with the use of ANSYS software. Here leaf spring not only use to absorb shocks but also used to reduce the vibration and gives the comfortable ride to customer. For analysis different specification is used to design and fabrication of leaf spring. With this specification the greatest safe load is 7700N [15-22]. design and analysis of the rear angle leaf spring of the Mahindra commander 650 DI is taken for analysis in this paper. Composite material such as GFRP (Glass fibre reinforced polymer) E-glass/epoxy is used. The objective of this paper is to reduce the weight of leaf spring. Design and analysis of the part is done in Pro-E and ANSYS 12.0 software. From the results it has been observed that 85% weight reduction of the composite leaf spring [23-25].

Most of the papers are based on the reduction of weight and increase the strength of leaf spring. Some of them are the carbon fibre and glass fibre with reinforcement like Epoxy resin and testing the samples ASTM D638 standard is used. Different mechanical test have performed. From the results carbon fibre epoxy and glass fibre epoxy gives greatest tensile strength and for weight reduction we have achieved the 69.4% and 75%. The several materials like EN45, Glass fibre, carbon fibre, reinforced such as epoxy, S-epoxy are used. Mathematical calculations are also there in the leaf spring and mono leaf spring is also design and analysed.

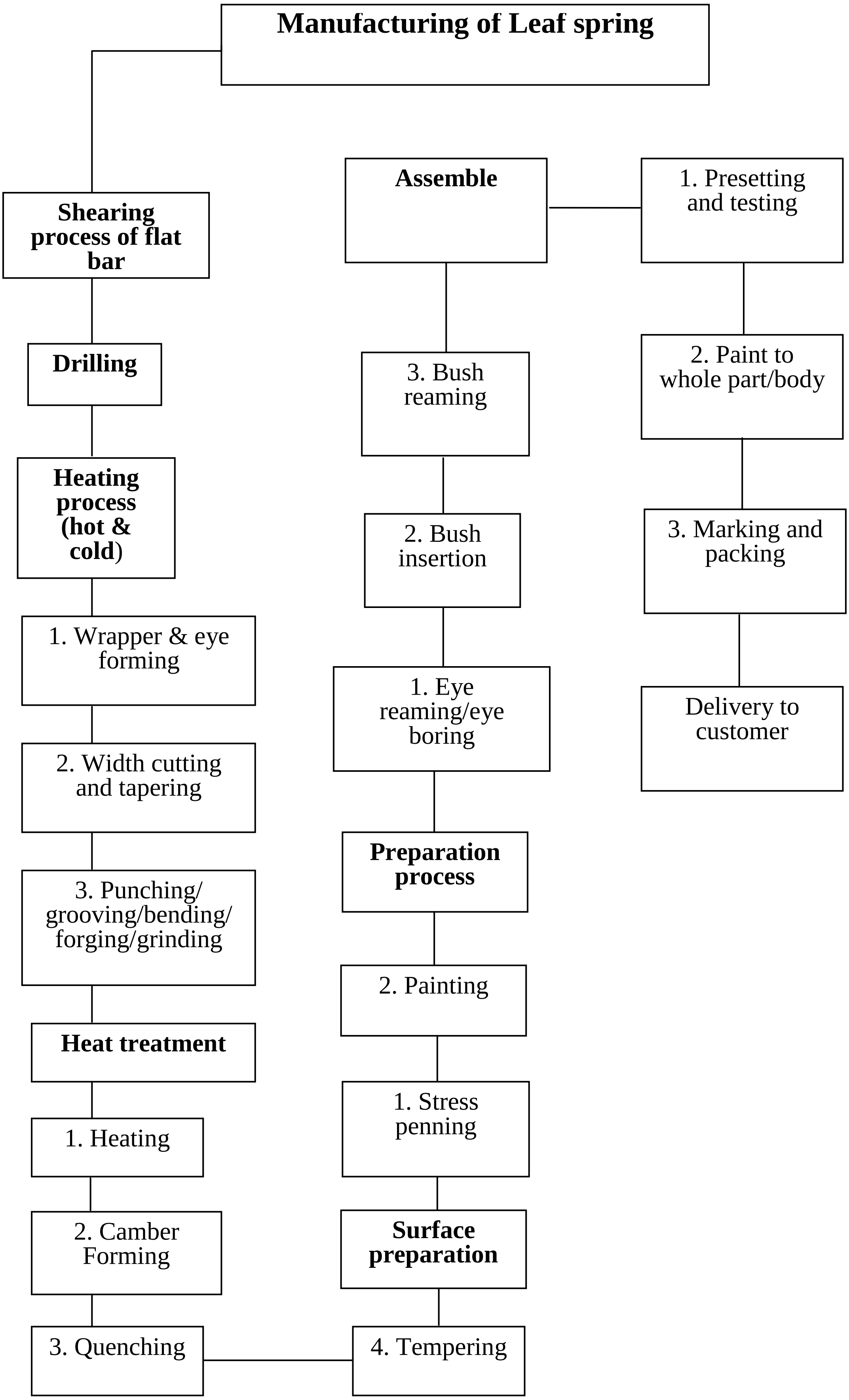

Figure 3. Manufacturing of leaf spring

2.Methodology

Design selection

The analysis in present work is carried out by assuming the leaf spring it as a simply supported beam. The beam is under both transverse shear stress and bending stress. Flexural rigidity is a one of the most important parameter in leaf spring design, and so it is also tested.

Constant Cross-Selection Design:

The cross-section area of the leaf spring remains constant along the length of but both the thickness of spring and width varies throughout the laminated spring. The constant cross-section design method is chosen due to the following reasons:

1. Mass Production Capability

2. Accommodation of continuous reinforcement of fibres:

As the cross-sectional area of leaf spring remain constant; therefore it is assumed that equal quantity of continuous resin and reinforcement fibres is used during manufacturing.

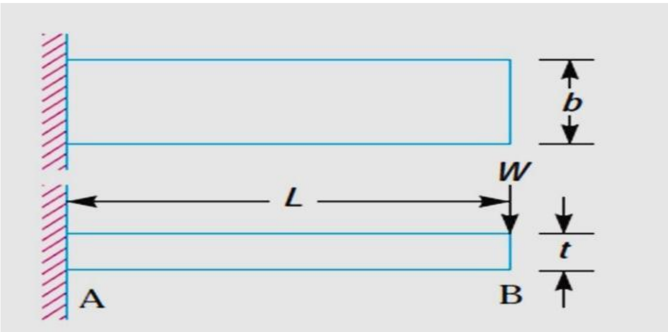

Figure 4. Flat spring cantilever type

Bending stresses (σ_b) & deflection are obtained by equations

W	Load acting on leaf spring
t	Thickness of spring
E	Young's Modulus
b	Width of spring
Y	Deflection of spring
L	Span length/length of plate
σ_b	Bending stress

Bending stress

$$\sigma_b = \frac{6 \times W \times L}{b \times t^2}$$

Deflection

$$y = \frac{4 \times W \times L^3}{E \times b \times t^3}$$

In Bending moment, the bottom fibre (strands) are compacted while the upper most fiber is in tension, however the shear pressure (τ) is zero at the external most filaments and greatest at the middle. Bowing burdens (σ_b) is zero at the middle and greatest at the external most fiber as shown below.

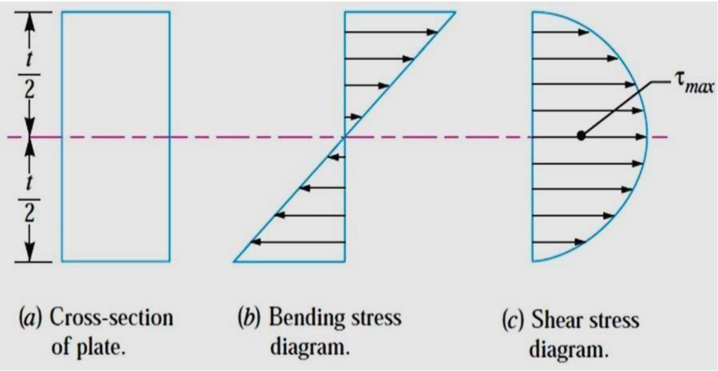

Figure 5. (a) Cross-section of plate (b) Bending stress (c) Shear stress diagram

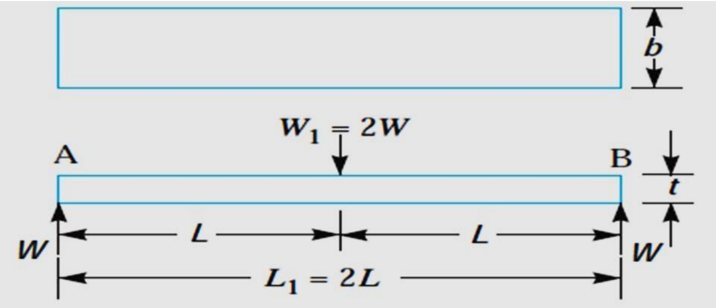

Figure 6. Flat spring simply supported beam type

The following above equations gives the bending stress and deflection of constant area of spring. At the support the bending is maximum. When the spring having a triangular plate structure then the stress is constant throughout the spring where as if this plate cut into strips and form one by another then it is called laminated leaf spring as shown in figure below.

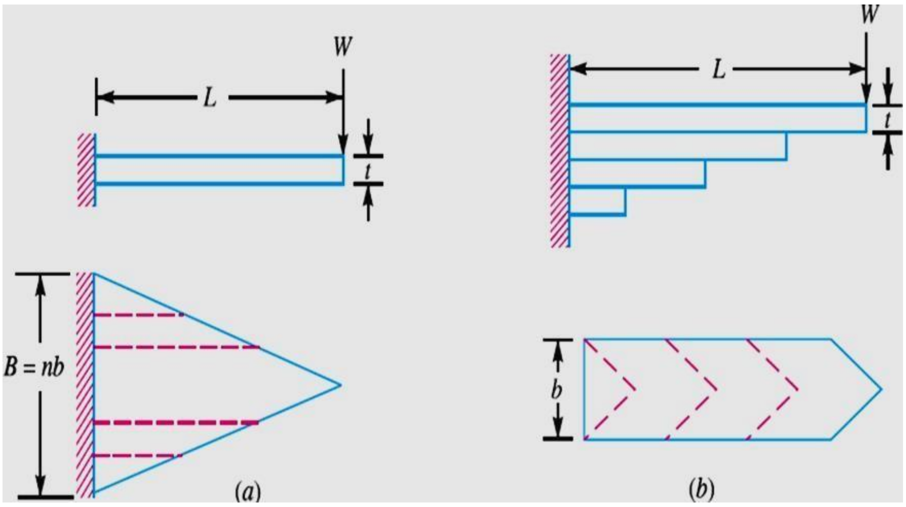

Figure 7. Laminated leaf spring

Bending stress

$$\sigma_b = \frac{6 \times W \times L}{n \times b \times t^2}$$

Deflection

$$y = \frac{4 \times W \times L^3}{n \times E \times b \times t^3}$$

Specifications of design

Here the Tata ace four wheeler are selected for initial weight and measurements.

Table 1 Specification data

S. No	Specifications	Values
1	Weight of vehicle	1200kg
2	Maximum load carrying capacity	1000 kg
3	Total weight = 1200 + 1000	2200 kg
4	Taking factor of safety (FS)	2
5	Acceleration due to gravity (g)	9.81m/s^2
6	**Total Weight**	**2200 × 9.81 = 21582N**

All the mathematical calculations for 4 wheeler of a single leaf spring are done and these calculations are for 1 wheel and it is taken for the 4 wheels.

$$21582/4 = 5395.5N$$

2W load than 2W = 5395.5 N, W = 2697.75 N
Total span length is 2L is 1072 mm than L = 536 mm, n = 3
Put all the values in above equations we get,
Maximum bending stress σ_b of spring is

$$\sigma_b = (6 \times W \times L) / (n \times b \times t^2)$$

$$\sigma_b = (6 \times 2697.75 \times 536) / (3 \times 60 \times 8^2)$$

$$\sigma_b = 753.12 \text{ N/mm}^2$$

Deflection (δ) of spring is given by

$$\delta = (4 \times W \times l^3) / (n \times E \times b \times t^{3)}$$

$$\delta = 129\, mm$$

Straight length of spring (L) = 1072 mm
Camber length of spring ratio is given by

$$\delta = 129 \text{ mm}$$

$$C = 0089 \times 1072$$

$$C = 95.4 \text{ mm}$$

Where C is called as Camber height of spring

The half piece of overlaid spring is thinking about for our plan and fixed from the one end since the spring is associated with the hub from focus. The testing of half part is adequate and the half measure of burden is considered for the plan however here we took all things considered to account over loadings of the vehicle and flexures of the covered spring.

L/2=536 mm

F = 2697.75 N

t =? b =?

Estimation for "t" and "b" aspects which are equipped for enduring the behaviour of loading of the traditional and composite explanatory leaf spring is the consequence of this plan.

Designing parabolic leaf spring

Table 2 Design data

Name	Data in mm
Length of the main leaf (L)	1072 mm
Length of the second leaf(L)	1072 mm
Length of the third leaf(L)	1072 mm
Width of leaf (b)	60 mm
Camber height (C)	95.4 mm
Tip inserts	50mm diameter
Centre rubber pad	100 mm × 50 mm × 5 mm
Thickness of leaves (t)	8 mm

2.1 Finite Element Analysis

The Finite Element technique is the tool used for the several analyses. This analysis is the high end computers as well as software used for the numerical mathematical techniques with the combination of the computer aided design (CAD) in the engineering fields. According to the definition of FEM is used for solving the mathematical differential equations of the model. FE method includes the boundary conditions, materials properties, geometry, loading state and body system. These body parts are discretized in EM method for investigation into the number of nodes and element for the numerical equations. To controlling the meshed body of the FE equations and these are resolve by the assembly of the equations for the linear systems which are defined in term {F} is nodal forces.

2.2 Stages of FEA

There are three stages of Finite Element Analysis

(i) Pre processing (ii) Solution (iii) Post processing

Pre processing: There are several points we need to follow

- **Modeling:** It is also called 3D model which allow the designer to create model/part, or test the part prior to production. Several software used to create part i.e. CATIA, CREO, SOLID EDGE, UNIGRAPHICS etc. to perform FEA.
- **Properties of materials:** In this section the materials are selected for the test the FEA on the geometry. Materials are selected from the material section incase materials are not available then we add new materials with mechanical properties in the section.

- **Import the part to FEA:** Geometry is import in IGES (Initial graphics exchange specification) to FEA.
- **Meshing:** It is the most important operation in FEA where several continuous irregular shapes are broke down into thousand of shapes of small pieces to determine the object. It is called element. When the more mesh is available in object than more accurate result are taken out.
- **Boundary condition:** To accomplish results shows limit (boundary) condition FE analysis it is the main phase of the preprocessing where final results are depend upon this condition. Subsequently this segment needs part of study to giving right limit conditions.

Solution: To solve this problem we have to give the boundary condition, defined the material properties and meshing size. In this segment we choose the input parameters like stress, strain, and deformation etc. to give the result in single analysis.

Post processing: Post-handling furnishes the instrument with simple to-utilize strong outcome perception Features. It gives a top to bottom perspective on information with representation devices like cutting planes, streamlines, contouring, line plots, data, and visualization. The different physical elements such as pressure, stress, strain are presented. This can be seen in the several formats i.e. graphs, animations, value etc.

2.3 Pro-E tool and modelling of parabolic leaf spring

PTC (Parametric Technology Corporation) is a 3D software corporation which gives the CAD/CAM/CAE different software namely Pro-E (Pro-Engineer). In the 28 Oct 2010 year the name was changed to “Creo” and also called the Wildfire 5.0 with the PTC’s announcement of Creo. For mechanical as well as Civil engineers it gives the 3D solid part modelling, assembly and finite element analysis etc. With the assistance of Pro/ENGINEER 2D drawing perspectives on the parts are naturally created counting, orthographic, isometric, helper, area, etc. We can utilize any predefined drawing standard documents for creating the drawing views.

We can show the model aspects in the drawing perspectives or add reference aspects at whatever point you need. The bidirectional cooperative nature of this product guarantees that any alteration made in the aspects in views consequently refreshes the model. Pro-E is a strong program used to make complex plans with an incredible accuracy. The plan expectation of any 3D model or a gathering is characterized by its speciation and its utilization. Pro-E can be utilized to catch the plan expectation of any intricate model by consolidating knowledge into the plan. Pro-E is an element based, parametric demonstrating framework with number of expanded plan also applications. In this work, 3D model of leaf spring are ready by 3-D demonstrating programming Pro-E after plan.

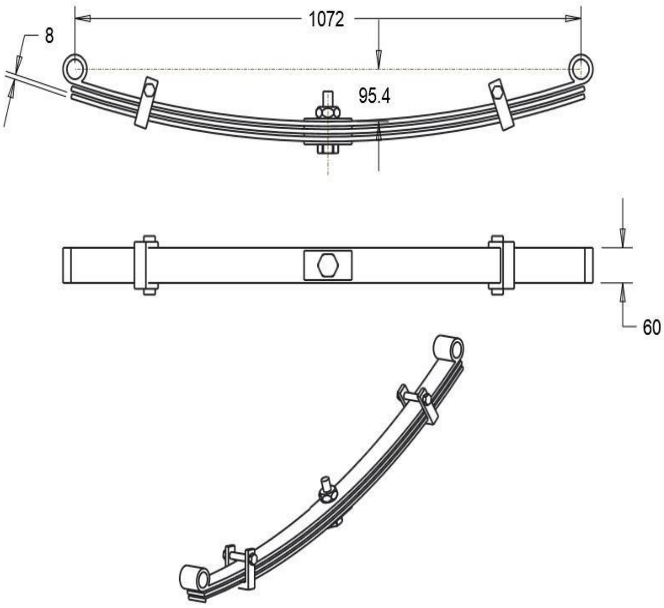

Figure 8. Parabolic leaf spring

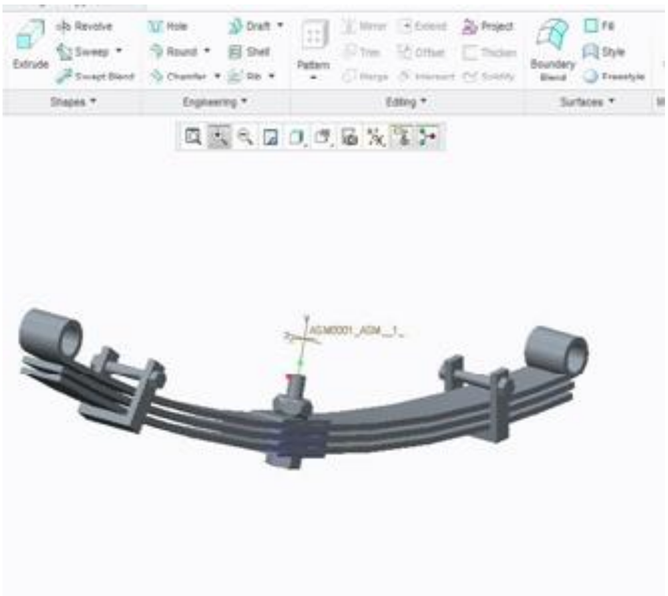

Figure 9. 3D Model design in Creo software

2.4 Properties of materials

In this analysis we have taken four different types of materials. The widely used material is steel EN45 and the other three is composite leaf spring. Table 3 to 6 showed the properties of Steel EN45 followed by other composite materials respectively.

Table 3 Properties of steel EN45

S. No.	Properties	Values
1.	Density	7860 kg/m^3
2.	Poisson's ratio	0.4
3.	Ultimate Tensile strength	1965 Mpa
4.	Ultimate yield strength	1515 Mpa
5.	Shear modulus	7.7003E+10 Pa
6.	Young's modulus	202 Mpa

Table 4 Properties of E-Glass Epoxy

S. No.	Properties	Values
1.	Density (kg/mm^3)	20.5
2.	Tensile modulus (X- axis), Pa	5.1E+10
3.	Poisson ratio	0.33
4.	Shear modulus, Pa	5.4E+09
5.	Tensile modulus (Y- axis), Pa	1.3E+10
6.	Poisson ratio	0.33
7.	Shear modulus, Pa	4.2E+10
8.	Tensile modulus (Z- axis), Pa	1.5E+10
9.	Poisson ratio	0.35
10.	Shear modulus, Pa	5E+08

Table 5 Properties of Carbon Epoxy

S. No.	Properties	Values
1.	Density (kg/mm^3)	1565.3
2.	Tensile modulus (X- axis), Pa	2.3E+12
3.	Poisson ratio	0.5
4.	Shear modulus, Pa	6.2E+11
5.	Tensile modulus (Y- axis), Pa	11E+12
6.	Poisson ratio	0.40
7.	Shear modulus, Pa	4.1E+08
8.	Tensile modulus (Z- axis), Pa	11E+11
9.	Poisson ratio	0.4
10.	Shear modulus, Pa	6.1E+12

Table 6 Properties of Kevlar Epoxy

S. No.	Properties	Values
1.	Density (kg/mm^3)	1435
2.	Tensile modulus (X- axis), Pa	9.600E+13
3.	Poisson ratio	0.4
4.	Shear modulus, Pa	2.525E+15

5.	Tensile modulus (Y- axis), Pa	1.154E+12
6.	Poisson ratio	0.4
7.	Shear modulus, Pa	2.609E+14
8.	Tensile modulus (Z- axis), Pa	1.145E+12
9.	Poisson ratio	0.45
10.	Shear modulus, Pa	2.602E+11

Table 7 Meshing size and stresses

S .No	Mesh size (mm)	Stress (MPa)
1.	**7.5**	**103.9**
2.	**7**	**109.9**
3.	**65.**	**128.9**
4.	**6**	**115.7**
5.	**5.5**	**143.8**
6.	**5**	**157.5**
7.	**4.5**	**152.6**
8.	**4**	**139.2**
9.	**3.5**	**160.2**
10.	**3**	**166.8**

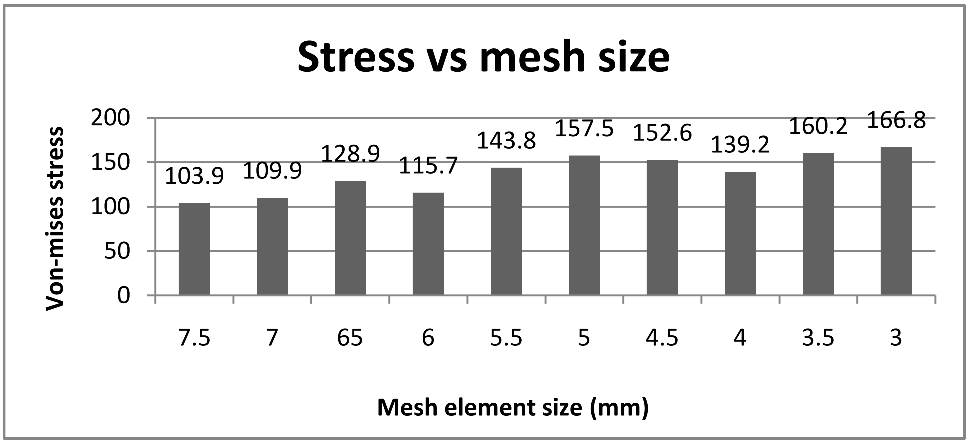

Figure 10. Von-mises stress and meshing size element (mm)

Here Tetrahedral an element is used because these tetrahedral elements are gives the accurate shape with least errors in meshing and our final shape is defined by less errors. According to the convergence test the size of the elements is 5mm for accurate meshing and in this process the total number of nodes and elements are 78959 and 26952 are generated. The figure showed the meshed leaf spring design. Fig. 14 and 17 showed the parabolic leaf spring design in different interfaces it gives the better results.

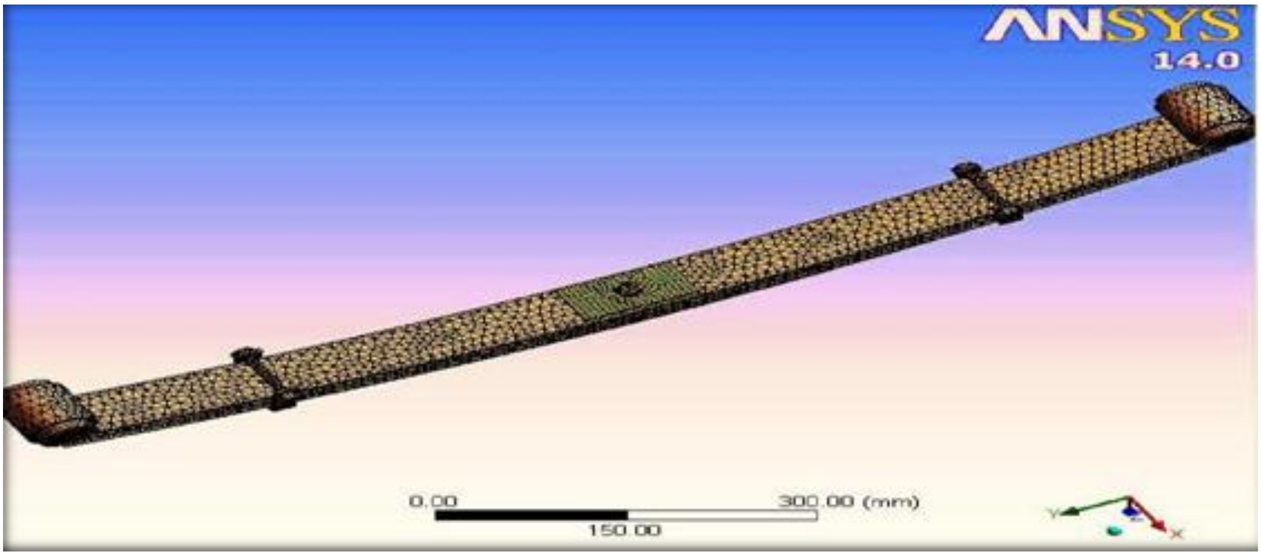

Figure 11. Meshed leaf spring

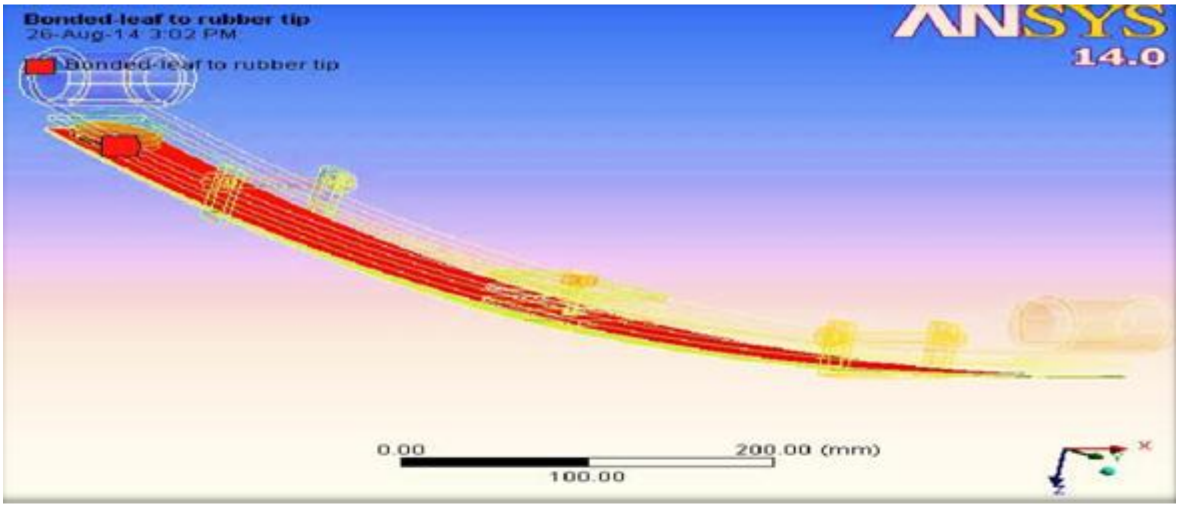

Figure 12. Contact between spring and tip

2.5 Loading and boundary conditions of spring

This leaf spring is fitted on the axle of the car vehicle and it is also called the eye of spring. This spring is joined at the front with the help of pin so that they can move without limitation. However the back part of the spring is fitted with the shackle of car body which is easy to move the shackle without any limitation.

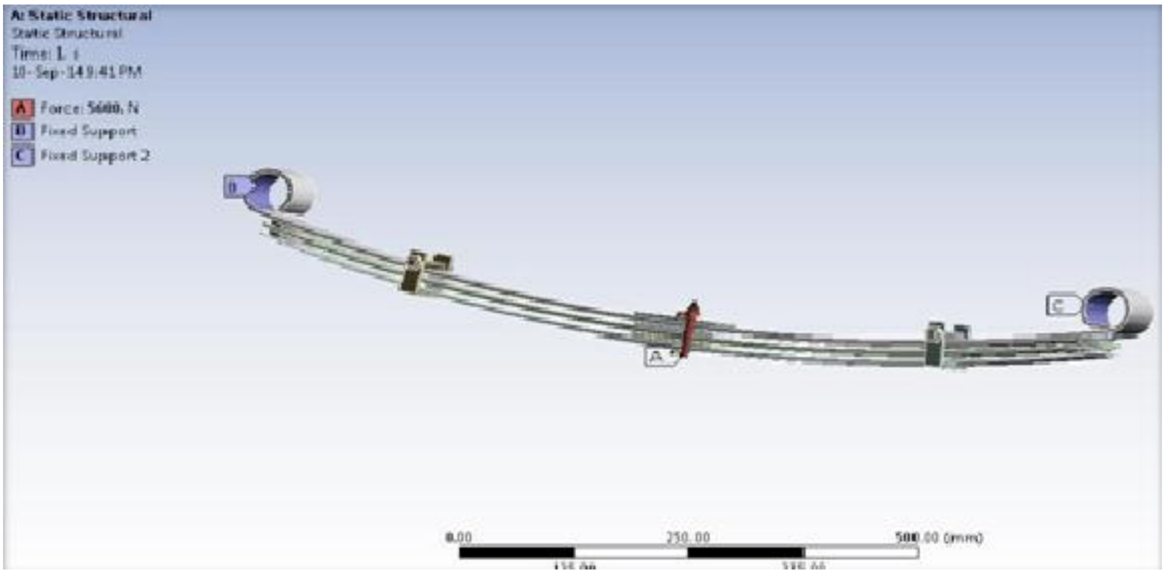

Figure 13. Loading condition of spring

2.6 Static analysis of spring

Four different materials are tested for von-mises stress in same loading and boundary condition and we see that the highest stresses are found in the steel spring is 323 MPa followed by the composite materials like E-Glass/Epoxy is 271 MPa, Carbon-Epoxy is 495 MPa, and Kevlar-Epoxy is 438.3 MPa are shown in Fig. 14, 15, 16, and 17 respectively. The deflection are found as same order as the von-mises stress i.e. the highest deflection are shows for steel spring 14 mm followed by the other composite materials E-Glass/Epoxy, Carbon-Epoxy, and Kevlar- Epoxy is 37 mm, 31 mm, 25 mm respectively.

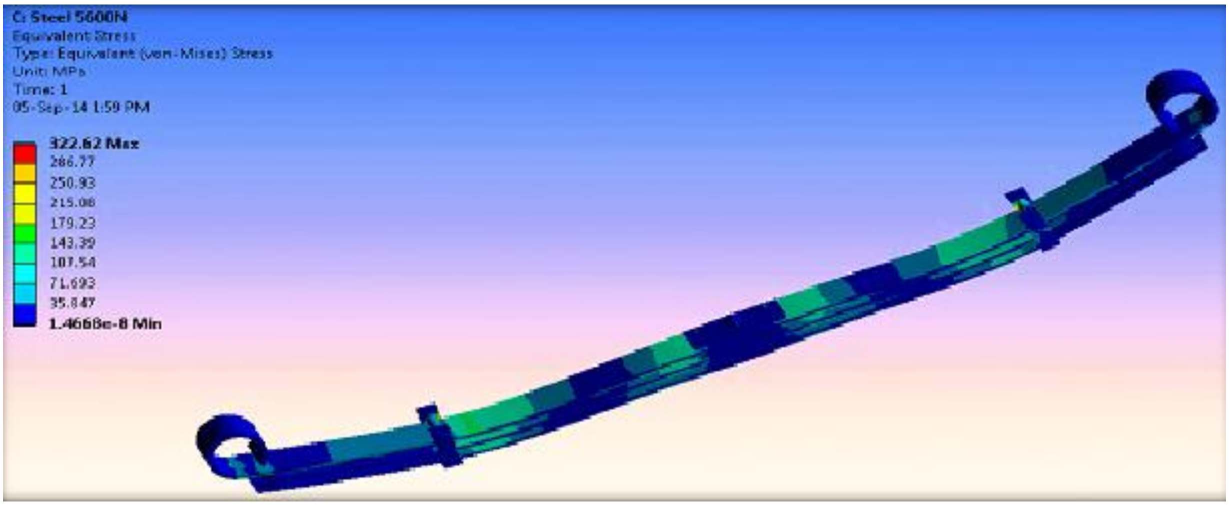

Figure 14. For steel spring Von-mises stress

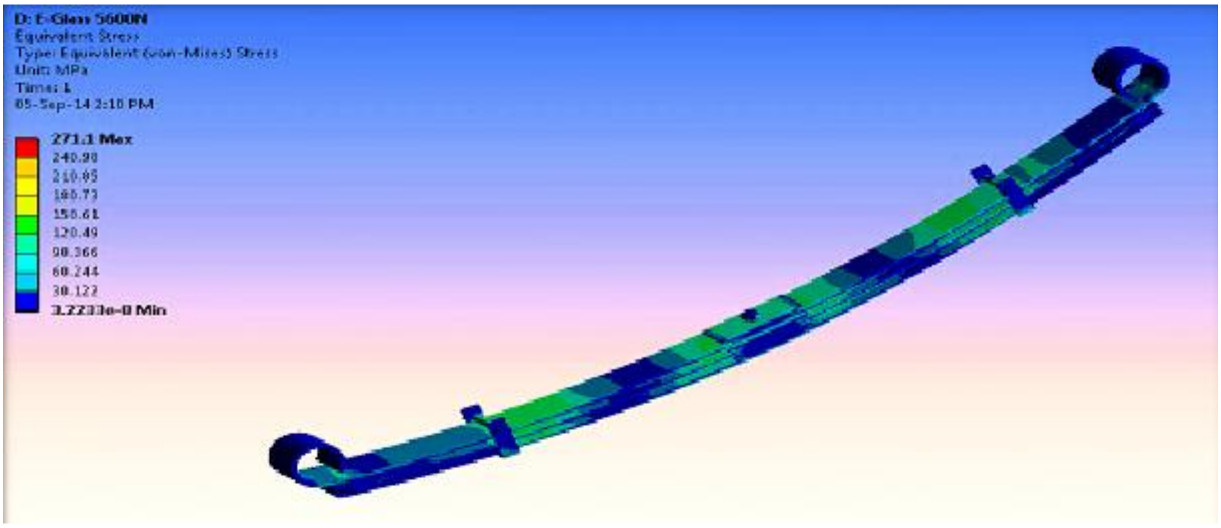

Figure 15. For E-Glass/epoxy spring Von-mises stress

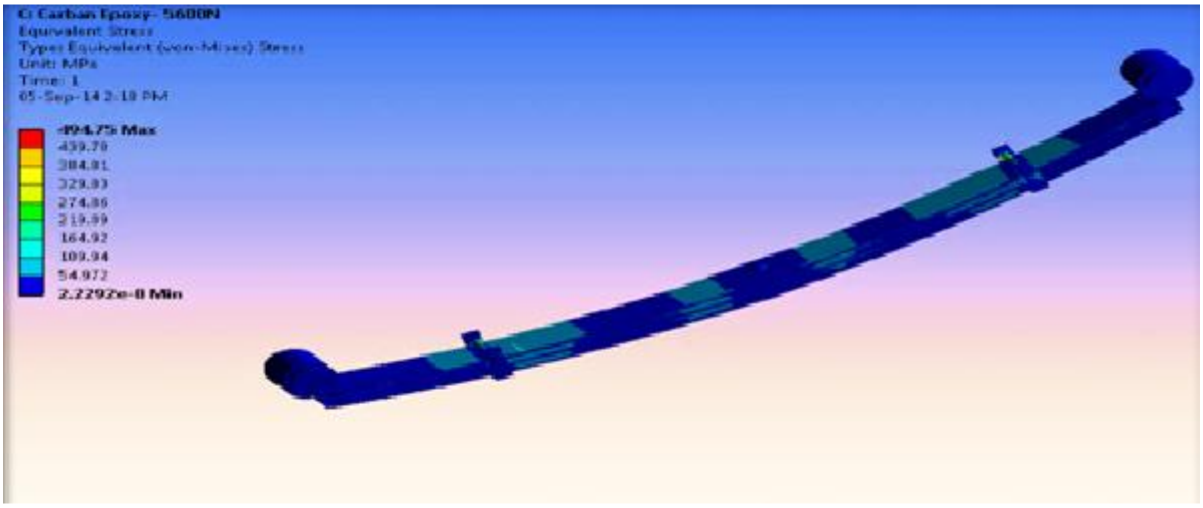

Figure 16. For Carbon/epoxy spring Von-mises stress

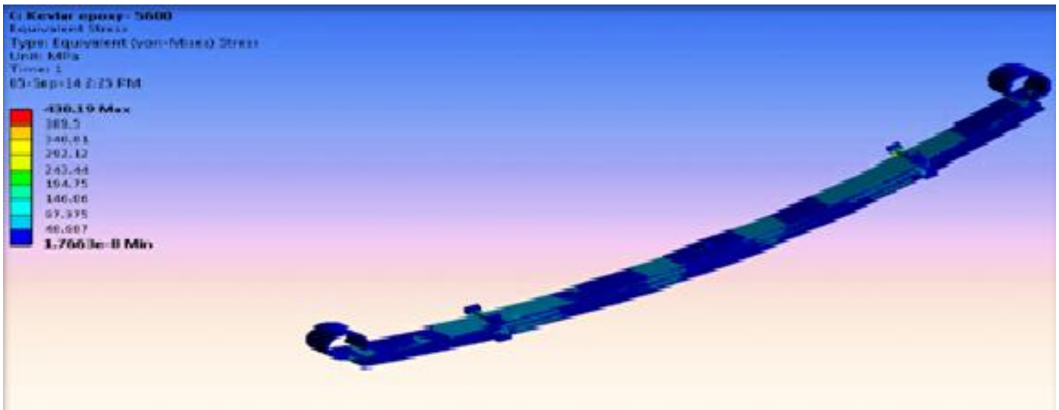

Figure 17. For Kevlar/epoxy spring Von-mises stress

2.7 Fatigue Analysis of spring

In this analysis, the Goodman, Gerber's, and Soderberg's theory as well as stress (mean) have been used. The outcomes are analyzed and the hypothesis (theory) which gives the least worth of life and the most noteworthy worth is picked to be best in the investigation of steel EN45 furthermore composite springs Loading information is picked as history information of SAE transmission furthermore is applied.

Life information investigation: This is completed by applying a heap of 500 to 5600N and the examination is finished by the previously mentioned four methodologies.

Mean pressure hypothesis approach: Using mean pressure bends, this hypothesis (theory) isn't liked for the existence information investigation of the leaf springs.

Assumptions-

Using the EN steel leaf spring and composite spring are design and modelled with static width and changing the thickness.

- Parameters like dimensions and boundary conditions of spring are similar of steel and composites.
- Fatigue life of spring are depend upon the FEM

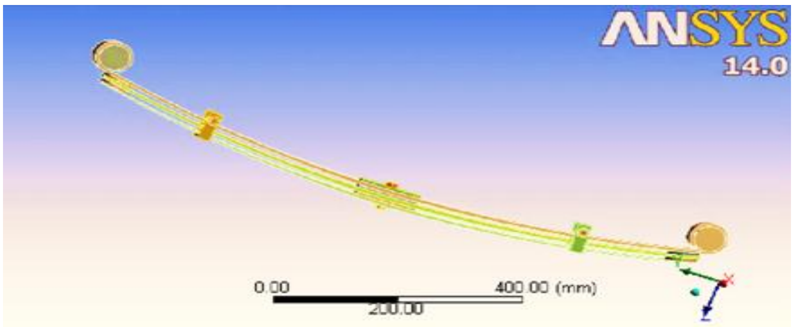

Figure 18. Fatigue input data in ANSYS

3. Results & discussion

Fig. 19 shows the stress vs load graph and it is easily seen that the when the load are increase than the stress in a materials are also increases. Here we find that the generally von-mises stresses are applied to investigate the design is carrying a load is perfect or not. If the most extreme measure of after effect of stress investigation produce in material is more noteworthy than the strength. In this research we have seen that the spring showed the highest stress at fixed ends. If the strength of spring is less than the yield strength than the design is safe for use. When the loads are in 500N than the spring showed the less strength and we constantly increase the load than values are also increase. The Kevlar/epoxy shows the highest stress value at 5600 N followed by the carbon/epoxy, E-glass/epoxy and steel as shown in Fig. 19 respectively.

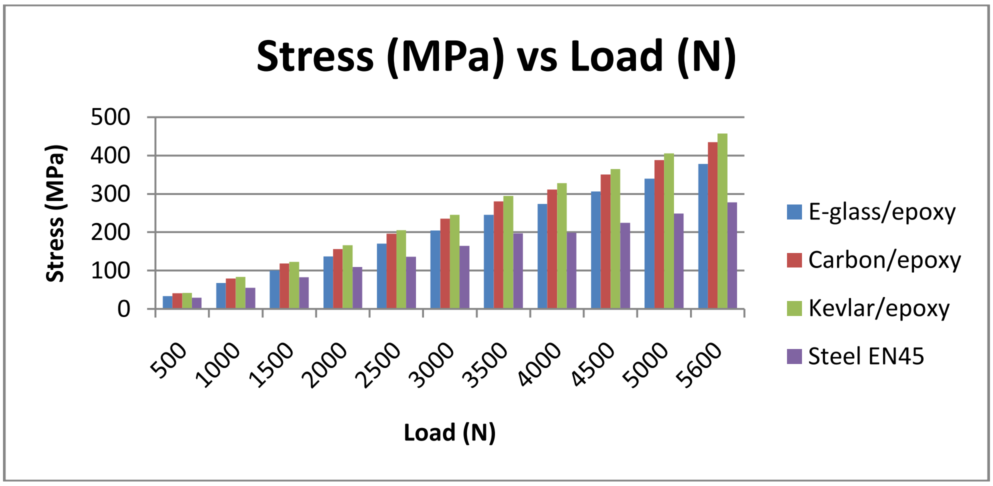

Figure 19. Stress vs Load

The subsequent load deformation is utilized to characterize the strength, fracture energy, and stiffness. It is seen that the deformity in composite material leaf springs is more prominent than steel overlaid spring conditions. E-glass/epoxy showed the highest deformation at all points because epoxy has the properties to resist the deformation when load applied. Steel shows the less deformation at all loads because ductile properties are less. The second position acquire in deformation is carbon/epoxy and Kevlar/epoxy.

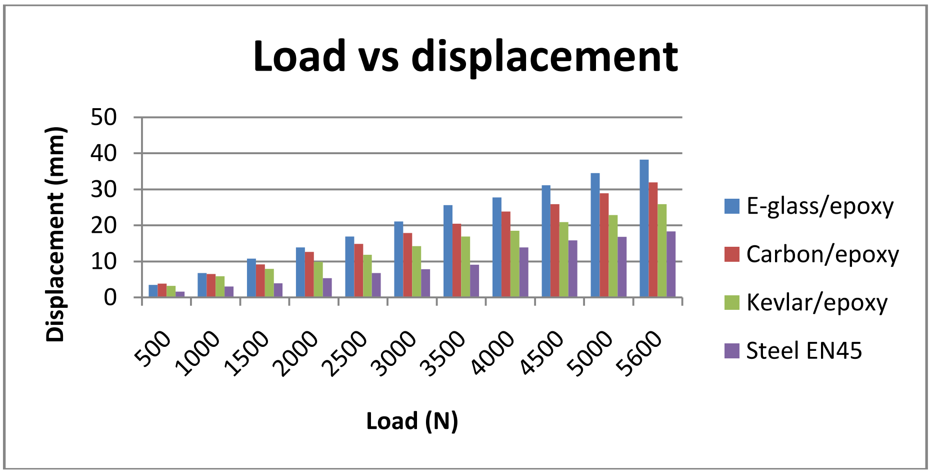

Figure 20. Load vs displacement

In Fig. 21 shows the when load increases from 500N to 5600 N then principal stress are also increase. In 500N load the lower principle stress are found in E-glass/epoxy and when the load goes to 5600 N then the highest principle stress are found for Kevlar/epoxy. In all position of loads the higher stresses are shown for Kevlar/epoxy followed by the carbon/epoxy, E-glass/epoxy, and last steel EN45 respectively.

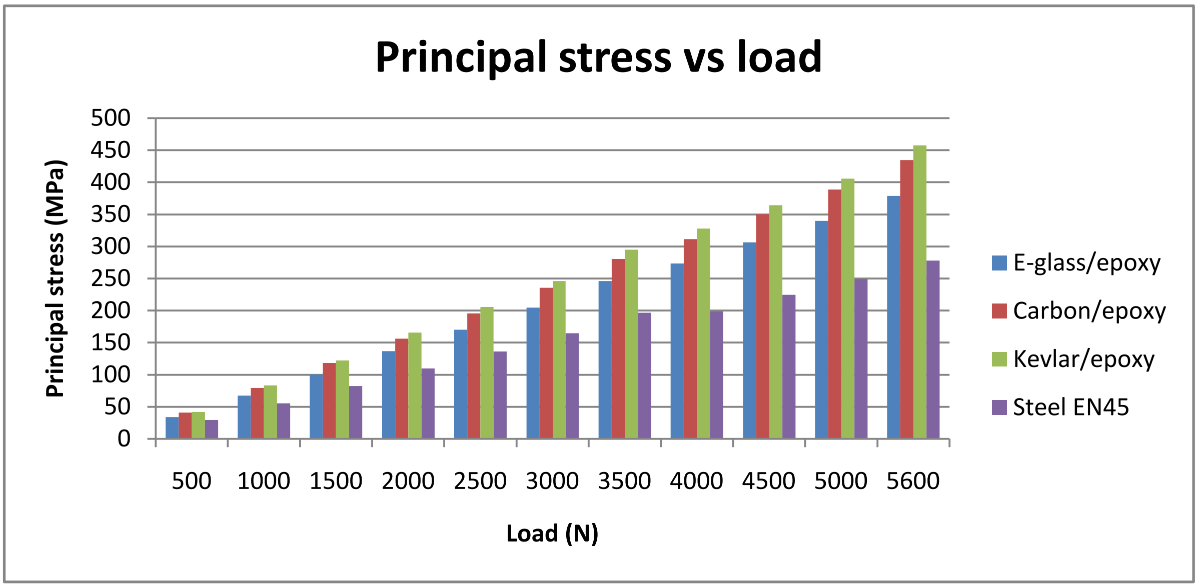

Figure 21. Principal stress vs load

Table 8 Comparison of weight

S. No.	Materials	Weight of spring	% wt. saving
1.	Kevlar/epoxy	4.885 kg	65.01 %
2.	E-glass/epoxy	5.674 kg	59.1 %
3.	Carbon/epoxy	5.12 kg	63.7 %
4.	Steel EN 45	13.35g	-

3.1 Fatigue analysis

To accomplish the exhaustion strength factor versus life diagram of fatigue, the information got from the investigation work which is known as the S-N outline. A property of material is depicted by Fatigue strength articulations; and as we probably are aware the strength (fatigue) is strength for a given number of cycles when the stress at which disappointment happens. The existence pattern of the composites and steelEN45 material at 5600N for various strength factors is displayed. We have seen that the fatigue strength of all spring is low when the strength factor of fatigue esteem is low. The existence pattern of the explanatory leaf spring expanded slowly up to exhaustion strength factor is 0.65, when exhaustion strength factor expanding past 0.65 the existence pattern of E-glass/epoxy and carbon/epoxy increases at high rate as contrasting with steelEN45. The most extreme existence of Kevlar/epoxy, steelEN45, carbon/epoxy, E-glass/epoxy at 5600N and exhaustion strength factor esteem is 1 life is 3516, 5163, 8155, and 8365 separately and low life is seen in number 8 of spring.

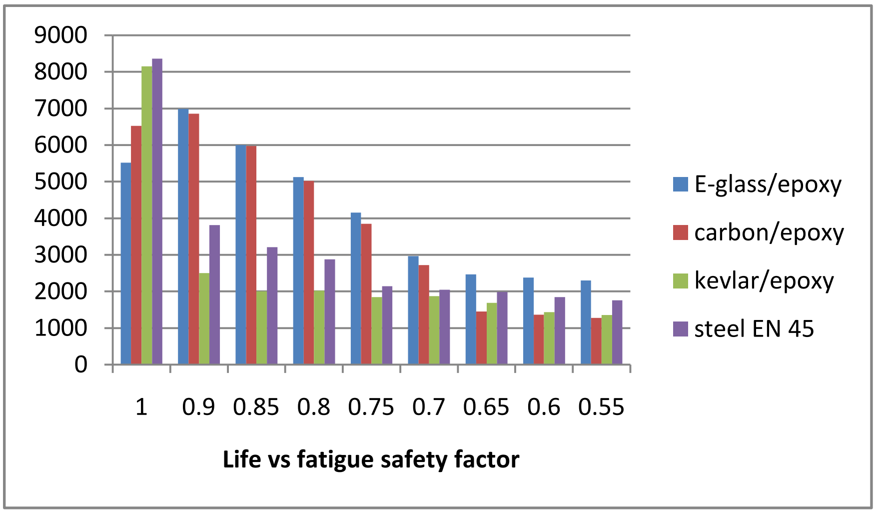

Figure 22. Life vs fatigue safety factor

3.2 Destruction

The destruction test for spring of different material is dissected with the assistance of Ansys-14 by applying the characterized limit conditions exhaustion harm is characterized as the plan life partitioned by accessible life. For the most part Goodman hypothesis is utilized for brittle material while Gerber hypothesis for ductile material. At a given plan life the fatigue Damage is a form plot of the fatigue harm. Fatigue destruction is characterized as the plan life separated by the accessible life. For Fatigue Damage, values more prominent than 1 indicate disappointment before the plan life is reached.

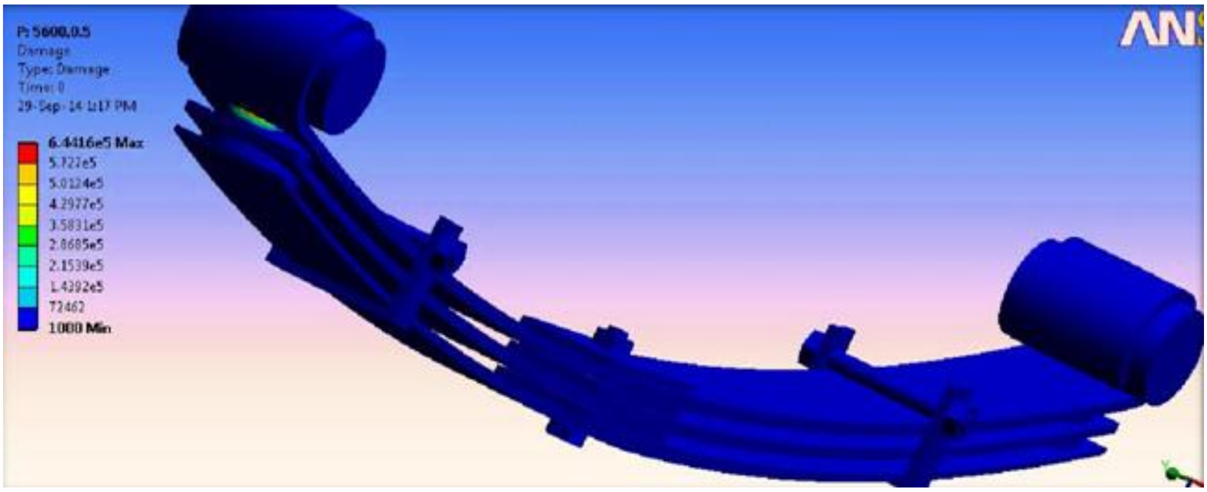

Figure 23. At 0.5 the fatigue damage of E-Glass/epoxy at 5600N

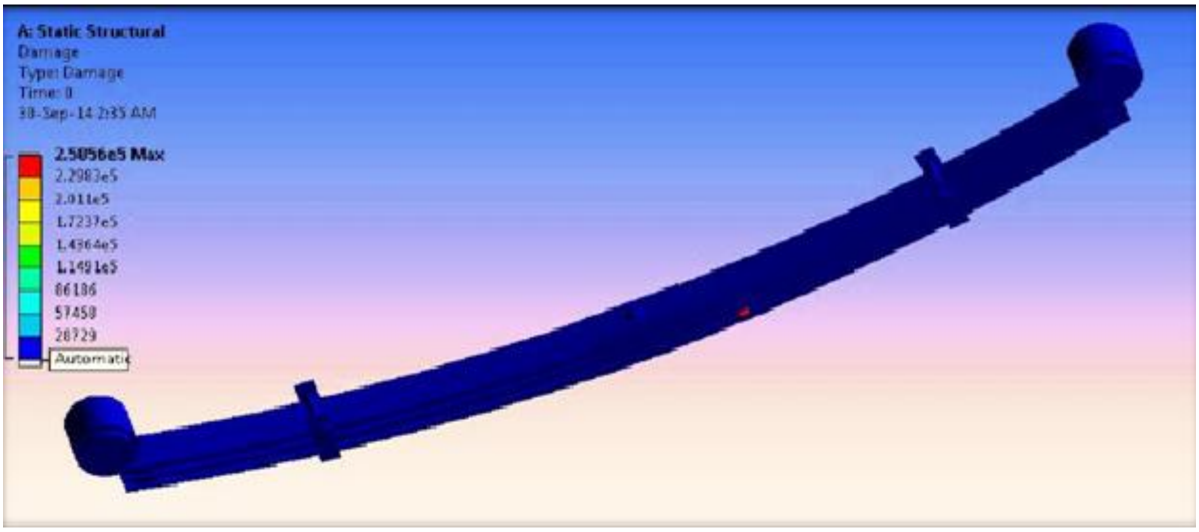

Figure 24. At 0.5 the fatigue damage of carbon/epoxy at 5600N

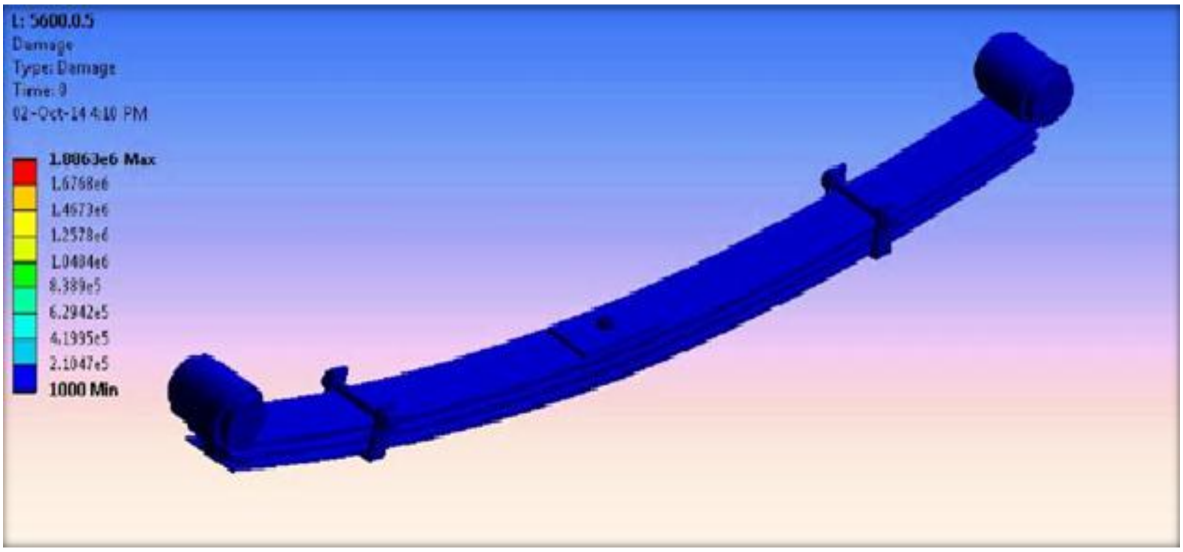

Figure 25. At 0.5 the fatigue damage of kevlar/epoxy at 5600N

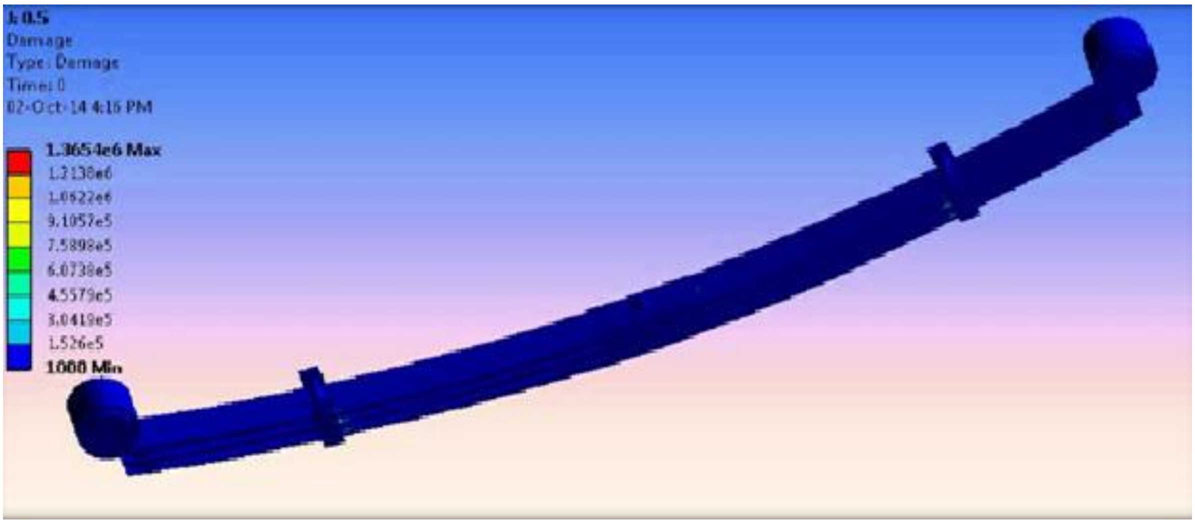

Figure 26. At 0.5 the fatigue damage of steel EN 45 at 5600N

4.Conclusion

In this analysis, parabolic leaf spring is taken and finding the mechanical properties for mini-loaded truck. The above analysis facilitates the designer to choose the suitable materials (E-glass/epoxy, Kevlar/epoxy, carbon/epoxy, and conventional steel EN 45) for the requirement of leaf spring. All the mathematical and theoretical calculations have been done for spring of different parameters such as span, camber, thickness, and number of leaves. The leaf spring is designed for the load carrying 5600 N and investigates the static as well as fatigue analysis of spring. The analysis also highlights the saving weight percentage of materials is reduced by 6.01 % for Kevlar/epoxy, 63.7 % for Carbon/epoxy, and 59.1 % for E-glass/epoxy as compared with the conventional steel EN 45 respectively. From the results we have found that for static analysis all the composite materials spring is much lighter than the steel EN 45 and maximum deflection are found for composite spring material than steel. The fatigue analysis are also investigate with the help of CAE too prediction. Deflection and strain energy are also more for composite materials than the steel. Researchers also choose the E-glass/epoxy materials for spring because it's stresses are less than the other two Kevlar/epoxy, Carbon/epoxy composite materials.

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