Optimization of Vehicle Mono Leaf Spring By Using Composite Carbon Fibre Material

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Abstract- *Expanding rivalry and development in vehicle part will in general alter the current items or replace old items by new and propelled material items. A suspension arrangement of vehicle is additionally a territory where these advancements are completed consistently. More endeavors are taken so as to build the comfort of user. Proper parity of comfort riding characteristics and economy in assembling of leaf spring turns into a conspicuous need. Leaf springs are generally utilized as suspension framework in car vehicles. In this task, examination and exploratory approval of leaf spring was performed by changing from customary steel to composite material. Composite materials are exceptionally utilized in a few unique fields like aviation structure, marine, car, and so forth. Because of high quality they are generally utilized in the low weight applications and furthermore as an other for metals to diminish the material expense. FEA examination in Ansys was done by utilizing ACP apparatus (ACP Tool) where genuine composites layer demonstrating will be utilized to make fiber handle. Ordinary steel, carbon fiber, glass fiber and kevlar fiber material was contemplated. Carbon fiber mono leaf spring was prepared and compared with ordinary steel. we observed 80 percent weight reduction also cost benefit therefore we have recommended carbon fiber for for future items.*

I. INTRODUCTION

So as to save common assets and streamline vitality, weight decrease has been the primary focal point of vehicle makers in the present situation. Weight decrease can be accomplished principally by the presentation of better material, structure advancement and better assembling procedures. The suspension leaf spring is one of the potential things for weight decrease in autos as it represents 10% - 20% of the unsprung weight. This accomplishes the vehicle with more eco-friendliness and improved riding characteristics. The presentation of composite materials was made it conceivable to lessen the heaviness of leaf spring with no decrease on burden conveying limit and firmness. Since, the composite materials have increasingly versatile strain vitality stockpiling limit and high solidarity to weight proportion as contrasted and those of steel, multi-leaf steel springs are being supplanted by mono-leaf composite springs. The composite material offer open doors for considerable weight sparing however not generally are practical over their steel partners. The leaf spring ought to assimilate the vertical vibrations and effects because of street anomalies by methods for varieties in the spring avoidance with the goal that the potential Energy is put away in spring as strain vitality and after that discharged gradually. Thus, expanding the vitality stockpiling ability of a leaf spring guarantees a progressively consistent suspension framework. As indicated by the investigations made a material with greatest quality and least modulus of flexibility the longitudinal way is the most appropriate material for a leaf spring. Luckily, composites have these attributes. Weakness disappointment is the transcendent method of in-administration disappointment of many car segments. In the present work, a steel spring utilized in traveler autos is supplanted with a composite leaf spring made of glass/epoxy composites. The measurements for both steel leaf spring and composite leaf springs are viewed as the equivalent. The essential goal is to think about their heap conveying limit, solidness and weight reserve funds of composite leaf spring. At last, weakness life of steel and composite leaf spring is additionally anticipated utilizing life information

II. LITERATURE REVIEW

Senthilkumar and Vijayarangan [1] in there paper describes static and fatigue analysis of steel leaf spring and composite multi leaf spring made up of glass fibre reinforced polymer using life data analysis. Roselita Fragoudakis , Georgios Savaidis , Nikolaos Michailidis [2] study & investigates the microstructure, surface mechanical properties, and fatigue life of 56SiCr7 leaf specimens produced under serial conditions. The investigation occurs at different stages of the manufacturing process of the leaf springs; mainly heat treatment and surface treatment by shot peening. Hiroyuki Sugiyama , Ahmed A. Shabana , Mohamed A. Omar , Wei-Yi Loh [3] develop nonlinear elastic leaf spring model for multibody vehicle systems. In this investigation, a nonlinear elastic model of leaf springs is developed for use in the computer simulation of multibody vehicle systems. In the leaf spring model developed in this investigation, the distributed inertia and stiffness of the leaves of the spring are modeled using the finite element floating frame of reference formulation that accounts for the effect of the nonlinear dynamic coupling between the finite rotations and the leaf deformation.

Vinkel arora [4] did comparative Study of CAE and Experimental Results of Leaf Springs in Automotive Vehicles. The work is carried out on the front end leaf spring of a commercial vehicle. The objective of this work is to carry out computer aided design and analysis of a conventional leaf spring, with experimental design considerations and loading conditions. This conventional leaf spring model consists of 37 parts. The material of the leaf spring is 65Si7.The CAD model of the leaf spring is prepared in CATIA and analyzed using ANSYS. The CAE analysis of the leaf spring is performed for the deflection and stresses under defined loading conditions, using ANSYS. The experimental and CAE results are compared for validation. Using CAE tools the ideal type of contact and meshing element is determined in leaf spring model.

J.J. Fuentes , H.J. Aguilar , J.A. Rodriguez, E.J. Herrera [5] study the Premature fracture in automobile leaf springs. In this work, the origin of premature fracture in leaf springs, used in Venezuelan buses , is studied.

Keshavamurthy Y C, Chetan H S, Dhanush C & Nithish Prabhu T [6] have studied the design and finite element analysis of hybrid composites mono leaf spring. Recently the automobile industries are showing profound interest in the replacement of steel springs with of steel leaf spring and composite leaf springs. The objective of this paper is to study and compare the load carrying capacity and weight savings of mono leaf composite spring with that hence obtain the suitable spring of minimum weight proficient of bearing a given static load without failure. The design constraints are stress and deflection.

III .PROBLEM SPECIFICATION

Regular LMV are having stacked leaf spring having 4 to 5 layers, because of which assembling and material cost increments likewise palleting of layers there is rubbing between the plates and disfigurement of the plates. So the required due to darting veers off from the esteem. Along these lines to accomplish required solidness and creating single stack leaf spring.

IV .OBJECTIVES AND METHODOLOGY

- Selecting of composite material.
- Handling substance of composite material.
- Static Analysis to discover auxiliary quality and firmness of the spring.
- Analysis of spring by changing material for money saving advantage.

In this investigation, demonstrating and examination of leaf spring will be performed by utilizing Finite Element Method. The business limited component bundle ANSYS variant 16 will be utilized for the arrangement of the issue. The demonstrating of leaf spring will be finished utilizing Ansys Design Modeler. The reenactment part will be completed utilizing the Analysis programming, ANSYS. ANSYS ACP will be utilized for composite layer displaying for mono leaf and end eye will be demonstrated as basic 3D Solid component. With the Boundary obliges and the heap connected, the leaf spring is dissected and the qualities are organized. Firmness of spring from FEA will be determined and contrasted and trial solidness dependent on Tensile testing on UTM. Spring will be examined by changing material to composite. Customary steel to carbon fiber will be think about for weight decrease advertisement cost sparing.

Offices required (Testing Equipments/Software's):

- ANSYS DM(Design Modeler) will be utilized for displaying
- ANSYS16 will be utilized to Analysis
- Tensile Testing of Mono leaf spring

Structure Of Leaf Spring :

Counts:

We consider weight and introductory estimation of four wheeler "Maruti 800 " light vehicle are taken.

Weight of vehicle= 400Kg Maximum burden conveying limit = 5x80 =400Kg

Complete weight=400+400 = 800Kg

Increasing speed because of gravity (g) =9.81 m/s2 Therefore, Complete Weight (W') = 800 x 9.81 = 7848 N

Since the vehicle is 4-wheeler, a solitary leaf spring comparing to one of the wheel takes up one fourth of the complete weight.

Burden on each wheel is, W=7848/4=1962 N.

Thus, load on each eye of spring is 981N.

Material Selection:

The following are the material properties of the given leaf spring.

Table 1. Material Properties

Material Properties	Steel	Carbon fiber	Kevlar fiber	Glass fiber
Density (Kg/m^3)	7850	1600	1400	2580
Young's modulus (Pa)	$200x10^9$	$70x10^9$	30×10^9	34×10^9
Poisson's Ratio	0.3	0.1	0.2	0.2
Bulk Modulus (pa)	$1.6x10^{11}$	$2.9x10^{10}$	1.6×10^{10}	5×10^{10}
Shear Modulus (Pa)	$7.6x10^{10}$	$3.2x10^{10}$	1.2×10^{10}	0.2×10^{10}
Ultimate Compressive Strength (Pa)	0	$1.9x10^9$	5.7×10^9	4.5×10^9

V. FEA ANALYSIS

A.Geometry Modeling:

Computer aided design Modeling of any undertaking is a standout amongst the most tedious procedure. One can't shoot straightforwardly from the structure representations to Finite Element Model. CAD(Geometry) displaying is the base of any task. Limited Element programming will think about shapes, whatever is made in CAD model. Computer aided design displaying of the Leaf spring configuration is performed by utilizing Ansys Design Modeler programmingr programming.

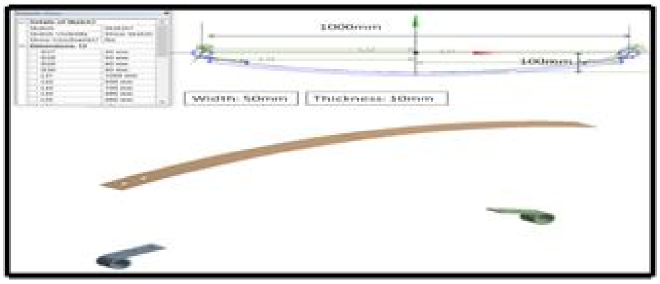


Fig.1 Leaf Spring Geometry

Table No.2 Leaf spring specification

Parameters	Value
Total length of the spring (Eye to Eye)	1000mm
Free camber (At no load condition)	100mm
Thickness of leaf	10mm
Width of leaf spring	50mm
Maximum load given on spring	1000N

ACP (ANSYS Composite PrepPost)

Composite materials are made by joining at least two layered materials, each with various properties. These materials have turned into a standard for items that are both light and solid. Composites furnish enough adaptability so items with complex shapes, for example, vessel structures and surfboards, can be effectively made.

ANSYS Composite PrepPost (ACP) is an include to ANSYS Workbench and is incorporated with the standard examination highlights. The whole work process for composite structure can be finished from plan to conclusive data generation therefore. The geometry of the tooling surfaces of a composite structure is the reason for examination and generation. In view of this geometry and a FE work, the limit conditions and composite definitions are connected to the structure in the pre-preparing stage. After a finished arrangement, the post-preparing is utilized to assess the presentation of the plan and cover. On account of a deficient structure or material disappointment, the geometry or overlay must be changed and the assessment is rehashed.

Composite later of 0.4mm was considered here fiber creation and total 25 layers were modeled to create thickness of 10mm spring.

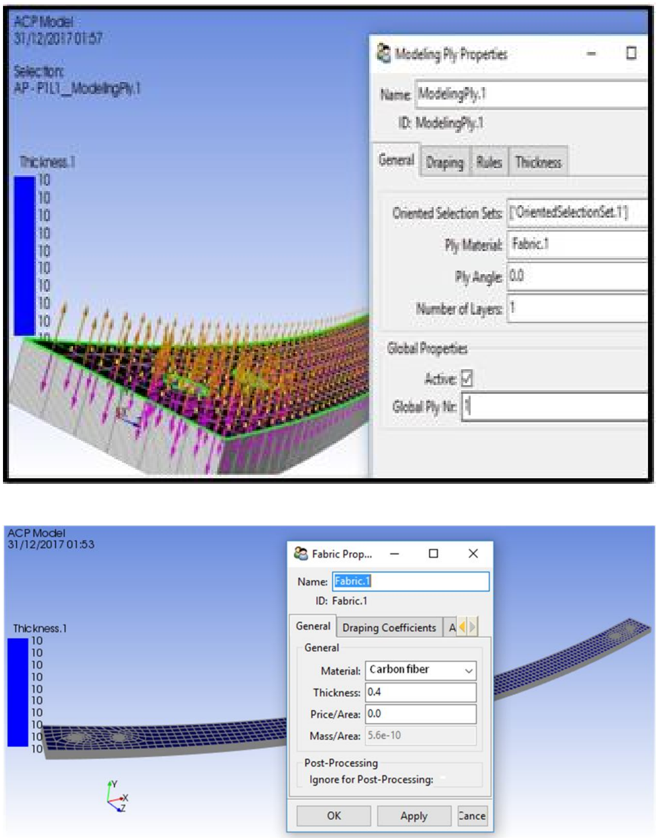


Fig. 2 Composite layer thickness

All composite layer modelled with fiber ply angle of Zero

D. Meshing.

Meshing section includes division of the whole of model into little pieces called components. This is finished by lattice. It is helpful to choose the free work since they has sharp bends, with the goal that state of the item won't modify. To work the plate the component type must be chosen first. SOLID185 is utilized here for lattice plates..

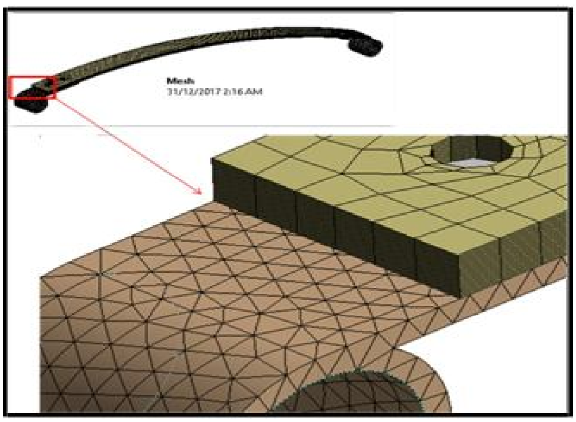


Fig.3FE Modeling details Nodes: 34846, Elements: 25085

Contact/Bolt Definition:

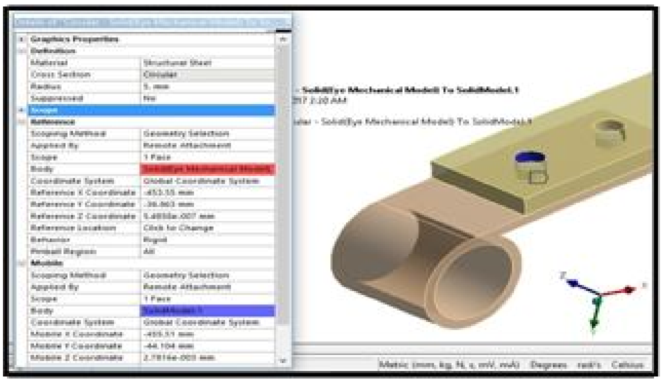


Fig.4 Bolt of dia. 10mm used for eye and spring connection.

Loads and Boundary Conditions:

One end of spring is constrained in all translational direction and other end only is free in spring axial direction. Load of 1000N is applied by using remote point.

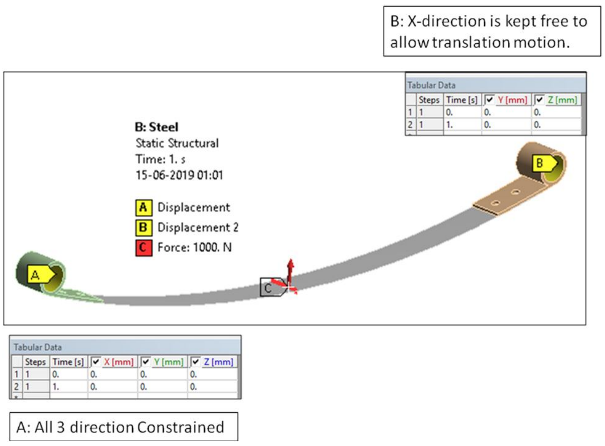
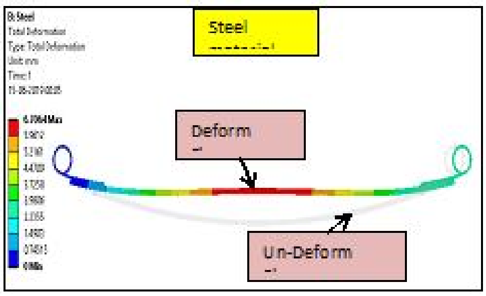


Fig. 5 Loads and Boundary Condition

VI. FEA RESULTS



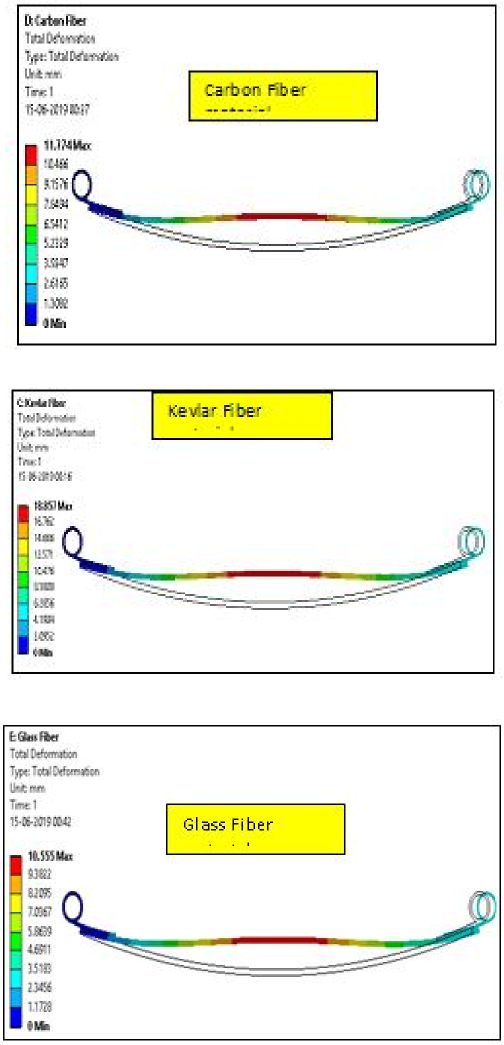
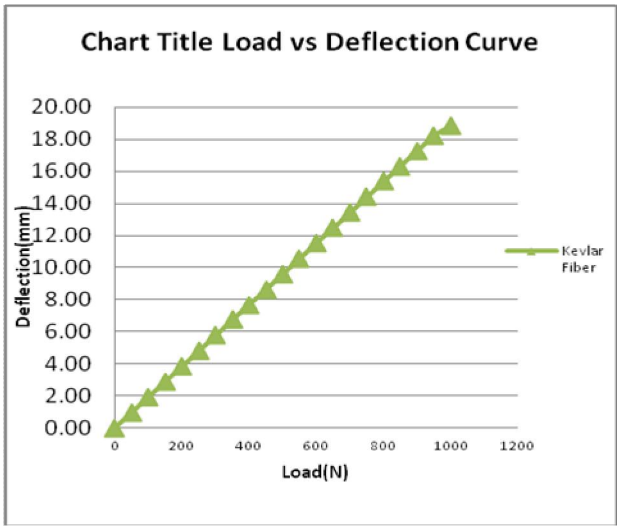
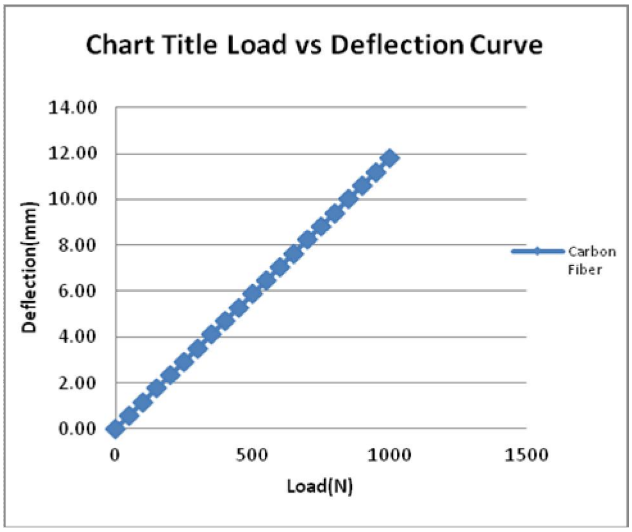


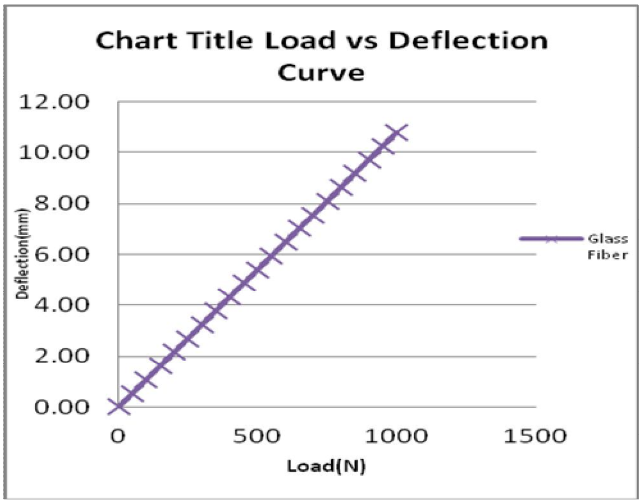
Fig. 6 Deformation Plot



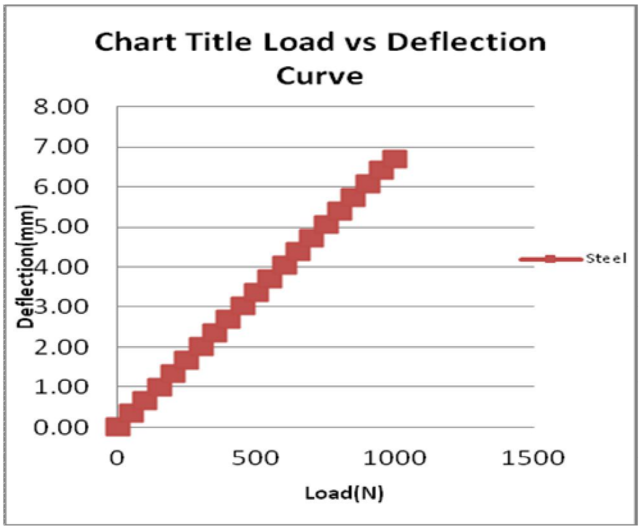
Graph 1. Load Vs Deflection Graph for Kevlar Fiber Leaf spring



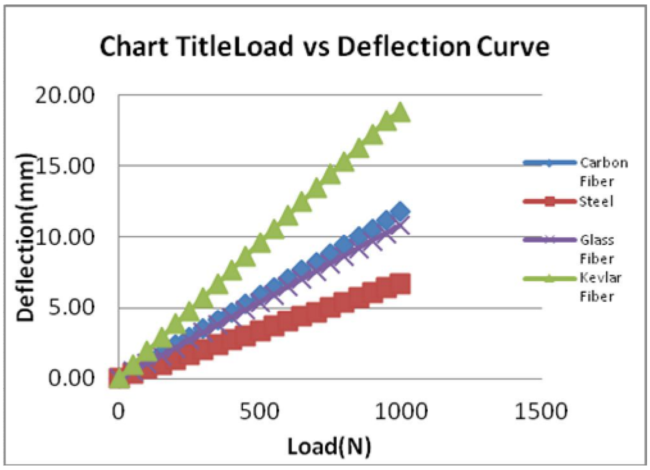
Graph 2. Load Vs Deflection Graph for Carbon Fiber Leaf spring



Graph 3. Load Vs Deflection Graph for glass Fiber Leaf spring



Graph 4. Load Vs Deflection Graph for steel Leaf spring



Graph 5.Comparison Load Vs Deflection Graph for all four material Leaf spring

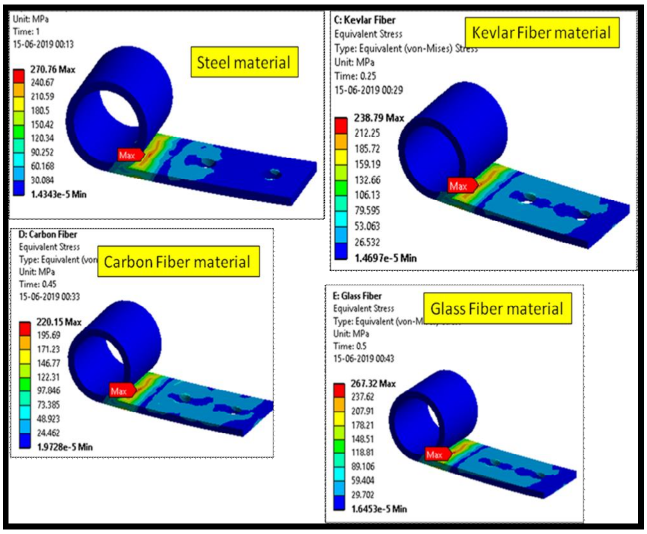


Fig.7 Stress Plot of Eye

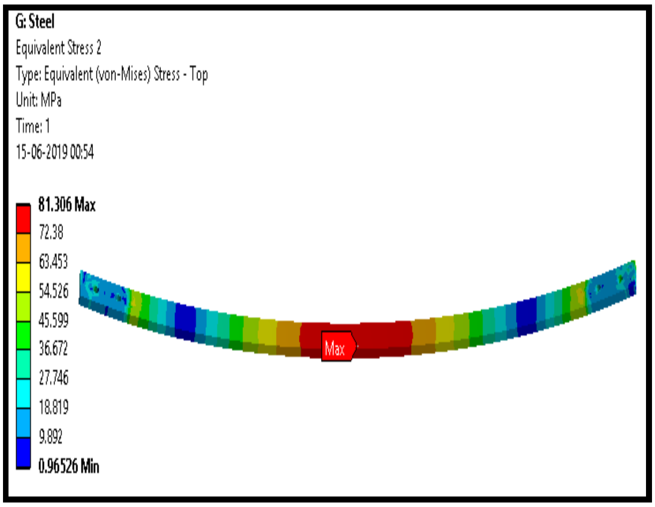


Fig.7 Stress Plot of composite plates

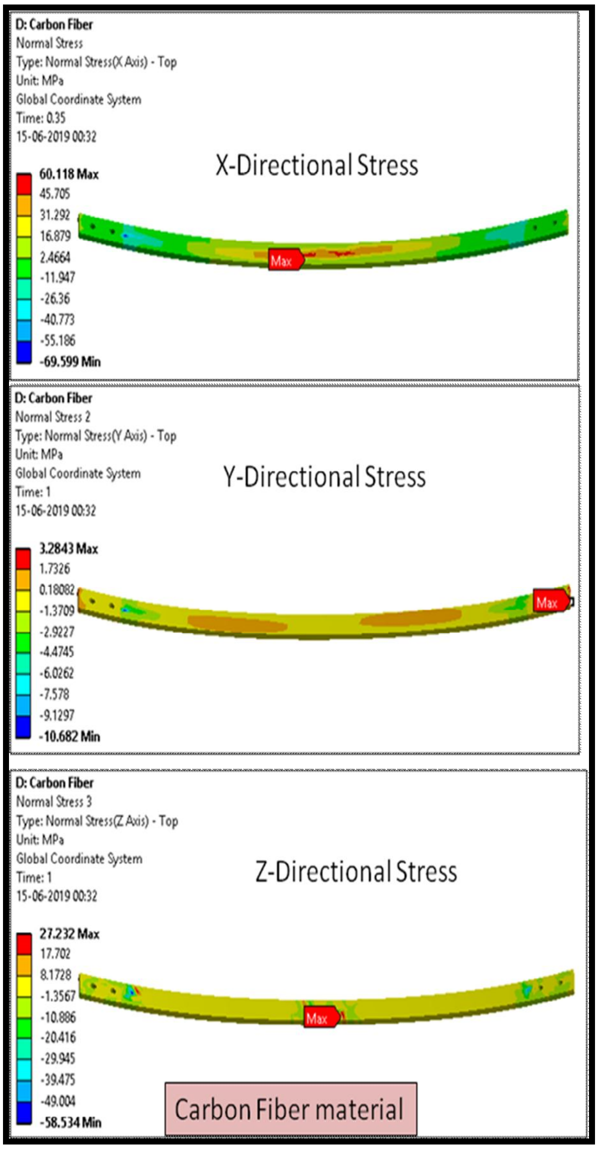


Fig.8 Stress Plot of carbon fiber composite plates

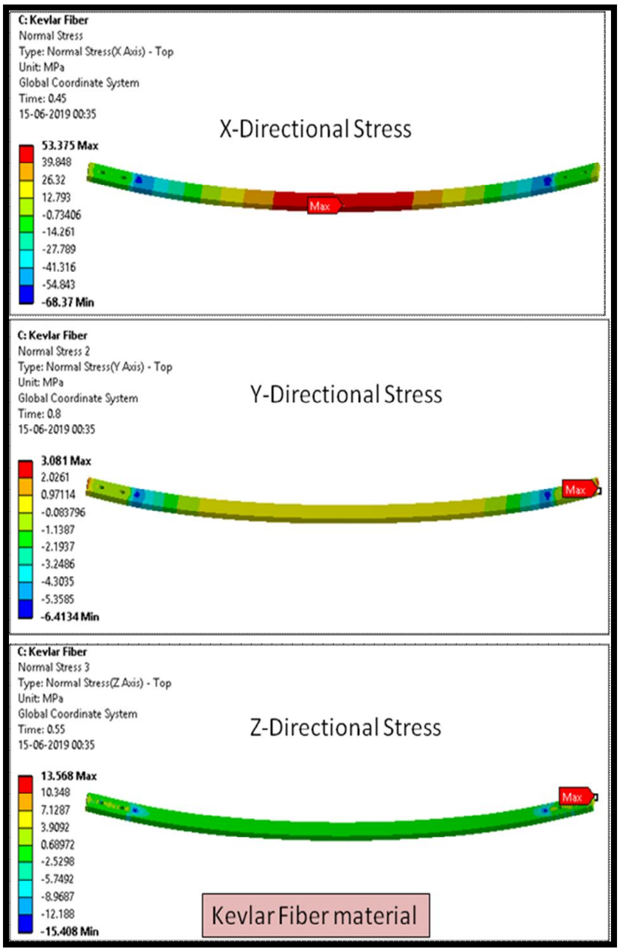


Fig.. 9. Stress Plot of Kevlar fiber composite plates

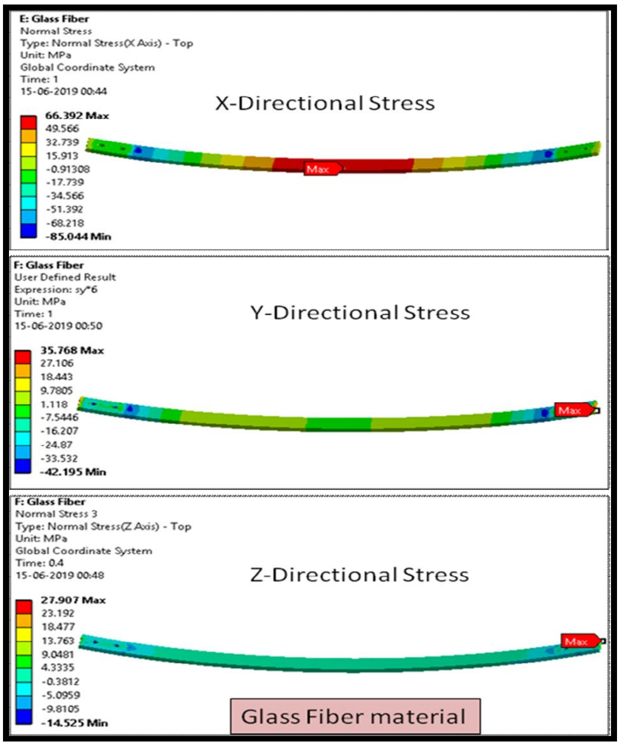


Fig.. 10. Stress Plot of Glass fiber composite plates

Table No. 3 Reduction in material mass

Material	Mass(Kg)		
	Leaf Spring	% Difference	Steel Eye
Steel	3.7826		4.7451
Carbon Fiber	0.77098	80%	
Kevlar Fiber	0.67461	82%	
Glass Fiber	1.54196	59%	

Table 4 Leaf Spring FEA Results

Leaf Spring FEA results		Composite Leaf Spring			Steel Eye
Material	Total Deformation(mm)	Normal Stress (MPa)			Von Mises Stress
		X-direction	Y-direction	Z-direction	
Steel	6.706	Von Mises Stress: 81.3			270
Carbon Fiber	11.777	60.118	3.2843	232	220
Kevlar Fiber	18.854	53.375	3.081	13.568	239
Glass Fiber	10.55	66.4	35.768	27.907	268

VII .EXPERIMENTAL WORK

Universal testing machine :-

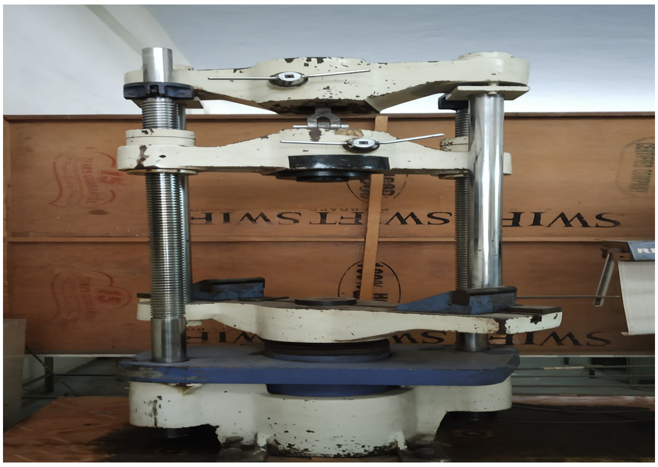


Fig: 8universal testing machine

An all inclusive testing machine (UTM), otherwise called a general analyzer, materials testing machine or materials test outline, is utilized to test the rigidity and compressive quality of materials. A prior name for a ductile testing machine is a tensometer. The "general" some portion of the name mirrors that it can perform numerous standard malleable and pressure tests on materials, segments, and structures (at the end of the day, that it is flexible).

Use:

Stress–strain bend indicating ordinary yield conduct for nonferrous composites.

1: True flexible utmost
2: Proportionality limit
3: Elastic farthest point
4: Offset yield quality

The example is set in the machine between the holds and an extensometer whenever required can consequently record the adjustment in check length during the test. On the off chance that an extensometer isn't fitted, the machine itself can record the removal between its cross heads on which the example is held. Be that as it may, this strategy not just records the adjustment long of the example yet in addition all other broadening/versatile segments of the testing machine and its drive frameworks including any slipping of the example in the holds.

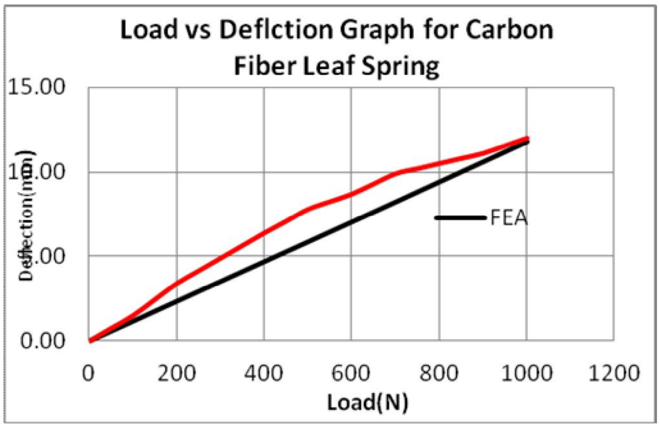
Table 5 Specification of UTM Machine

Company	Star testing system India
Model number	STS-248
Machine capacity	100 KN
Speed	3 mm/min
Cross head travel(excluding grips)	1100 mm
Throat mm	295 mm
Accuracy	±1%

Approval of FEA and Experimental outcomes by corresponding leaf spring twisting saw in FEA and contrasting and test estimated misshapening in tractable testing at 1000N burden is great.

Table 6. Comparison Of static Deformation in Experimental And Ansys Results

Carbon Fiber Leaf Spring	Experimental Results	ANSYS Results	Percentage Difference
Static Deformation(mm)	12	11.78	2%



Graph 6. Comparison of Load Vs Deflection Graph in FEA and Experimental for Carbon Fiber mono Leaf spring

Table 7. Load Vs Deflection in FEA and Experimental

Load(N)	Deflection(mm)	
	FEA	Experimental
0	0.00	0.00
50	0.59	0.75
100	1.17	1.50
150	1.76	2.45
200	2.34	3.40
250	2.93	4.15
300	3.52	4.90
350	4.11	5.65
400	4.69	6.40
450	5.28	7.10
500	5.87	7.80
550	6.46	8.25
600	7.05	8.70
650	7.64	9.30
700	8.23	9.90
750	8.82	10.20
800	9.41	10.50
850	10.00	10.80
900	10.59	11.10
950	11.19	11.55
1000	11.78	12.00

Load deflection cureve calculated in FEA and experimental has observed 5-6 % variation. The results are validated and hence we can conclude that the ANSYS results are reliable and can be applied for complicated analysis.

VIII. CONCLUSION

- For same burden (1000N) kevlar fiber gives most misshapening of 18mm whereas carbon fiber gives more mishappening of 12mm and glass fiber gives 11mm when contrasted with steel of 7mm.
- FOS of kevlar fiber are highest than carbon fiber , glass fiber and steel ,additionally weight to quality proportion of kevlar fiber is higher than Steel. 87% mass decrease is

watched for kevlar fiber spring contrasted with traditional steel spring.

- Kevlar fiber has the best results among all other materials but it is very expensive material than all other materials.
- After kevlar fiber the carbon fiber has better results than other materials in all the terms.
- Overall,carbon fiber has high solidarity to weight proportion when contrasted with the glass fiber and Steel, mass decrease of carbon fiber is more than that of glass fiber and steel, henceforth dependent on this examination we prescribed to utilize carbon fiber in future assembling of mono leaf spring..

IX. FUTURE SCOPE

- Effect of changing fiber edge on burden conveying limit.
- Effect of changing carbon rate in material sythesis on burden conveying limit.

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