ANALYSIS AND OPTIMIZE OF COMPOSITE LEAF SPRING FOR LIGHT WEIGHT VEHICLE

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ABSTRACT

In present scenario weight reduction is the main focus of an automobile manufacturer. Leaf spring is an important component for any automobile. Generally leaf spring is used for suspension purpose in heavy vehicles. These springs are mainly made of steel material which having more weight. In order to reduce weight, here composite leaf spring is used instead of steel leaf spring.

This topic describes design and static structural analysis of steel leaf spring and laminated composite leaf spring. The dimensions of an existing conventional steel leaf spring of a light commercial vehicle mini truck are taken and are verified by design calculations.

Static structural analysis of a 3-D model of conventional leaf spring is performed using ANSYS. Same dimensions are used in composite multi leaf spring using carbon/Epoxy and Graphite/Epoxy unidirectional laminates. The load carrying capacity, and weight of composite leaf spring are compared with that of steel leaf spring.

Keyword : Leaf spring, Mini truck, ANSYS Composite material

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1. Introduction:

A leaf spring is a simple form of spring commonly used for the suspension in wheeled vehicles. Originally called a laminated or carriage spring, and sometimes referred to as a semi-elliptical spring or cart spring A leaf spring takes the form of a slender arc-shaped and rectangular cross section. The center of the arc provides location for the axle, while tie holes are provided at either end for attaching to the vehicle body.For very heavy vehicles, a leaf spring can be made from several leaves stacked on top of each other in several layers, often with progressively shorter leaves. Leaf springs can serve locating and to some extent damping as well as springing functions. While the interleaf friction provides a damping action,

1.1 objective of study:

The objective of the study is to produce results which may help to rectify problems associated with light weight leaf spring in which to optimize existing tradition leaf spring with a new composite leaf spring. Optimization method applied for reduce weight and increase loading capacity of composite leaf spring.

a) To identified existing multi leaf spring and design it.

b) To calculate different loading condition on multi leaf spring and change material properties as light weight vehicle.

c) To make CAD model of composite leaf spring in Solid Works 2011.
d) To check behaviors of load on composite leaf spring with reference light weight.
e) To analysis of result for validation of existing leaf spring to new composite leaf spring in ANSYS.
f) To make comparison both data and optimize

1.2 ANALYTICAL CALCULATION AND CAD MODELLING OFCOMPOSITE LEAF SPRING:

Let t = thickness of plate, b = width of plate, and L = length of plate or distance of the load W from the cantilever end. We know that the maximum bending moment at the cantilever end **M=W.L**, And section modulus Z = I/y

Where $\mathbf{I = (b.t^3 / 12)}$ and Y = t/2 so $\mathbf{Z = b.t^2 / 6}$

The bending stress in such a spring $\mathbf{f = M / Z = (6W.L) / b.t^2}$

We know that the maximum deflection for a cantilever with concentrated load at free end is given by

$$\delta = W.L^3 / 3.E.I = 2f.L^2 / 3.E.t$$

We know that maximum deflection of a simply supported beam loaded in the centre is given by

$$\delta = W.L^3 / 3.E.I$$

Table 1 Variation of Bending Stress and Deflection with load

Sr. No.	Load (W) in N	Bending Stress (f) in N/mm2	Deflection (δ) in mm
1	1000	187	3
2	2000	373	6
3	3000	560	9
4	4000	747	1
5	5000	933	1
6	6000	1120	1
7	7000	1307	2
8	8000	1493	2
9	9000	1680	2
10	10000	1867	3

The length of the leave springs are calculated by using the formulas given below:
Length of smallest leaf = Effective length * 1/ (n-1) + Ineffective length
Length of next leaf = Effective length * 2 / (n-1) + Ineffective length
Length of $(n-1)^{th}$ leaf = Effective length * (n-1) / (n-1) + Ineffective length
Length of master leaf = 2L1 + 2 Π (d + t)

Table 2 Specifications of Steel Leaf Spring

Sr. No.	Specifications	
1	Total Length of the spring (Eye to Eye)	1120mm
2	Free Camber (At no load condition)	180mm
3	No. of full length leaves	2
4	No. of graduated leaves	8
5	Thickness of leaf	6mm
6	Width of leaf spring	50mm
7	Maximum Load given on spring	6685N
8	Young's Modulus of the steel	210000 (MPa)
9	Weight of the leaf spring	17.78 kg
10	Poisson's ratio	0.3

2. Solid Modeling

Fig 1 Solid model of steel leaf spring created in Solid Work 2011 and imported it's for analysis in ANSYS

Assumptions

1. All non-linear effects are excluded.
2.The stress-strain relationship for composite material is linear and elastic; hence Hooke's law is valid for 3.composite materials
4. The leaf spring is assumed to be in vacuum.
5. The load is distributed uniformly at the middle of the leaf spring.
6. The leaf spring has a uniform, rectangular cross section.

Materials for Leaf Spring:
Material Properties: Name : Mild steel
Yield strength: 5.5e+008N/m2
Tensile strength: 3e+007 N/m2
Elastic modulus: 2.6e+011 N/m2
Poisson's ratio: 0.266
Density : 7860kg/m3
Shear modulus: 30189e+008N/m2
Chemical Composition: EN 45 Materials

11 Specific Design Data

Here Weight and initial measurements of Mahindra "**Model - commander 650 di**"
light vehicle are taken
Gross vehicle weight = 2150 kg
Unspring weight = 240 kg Total sprung weight = 1910 kg Taking factor of safety (FS) = 1.4
Acceleration due to gravity (g) = 10 m/s²
There for; Total Weight (W) = 1910*10*1.4 = 26740 N
Since the vehicle is 4-wheeler, a single leaf spring corresponding to one of the wheels takes up one fourth of the total weight.
F = 26740/4 = 6685 N

Static analysis:

For the above given specification of the leaf spring, the static analysis is performed using ANSYS to find the maximum safe stress and the corresponding pay load. After geometric modeling of the leaf spring with given specifications it is subjected to analysis.
Nodes = 13085
Elements = 2302

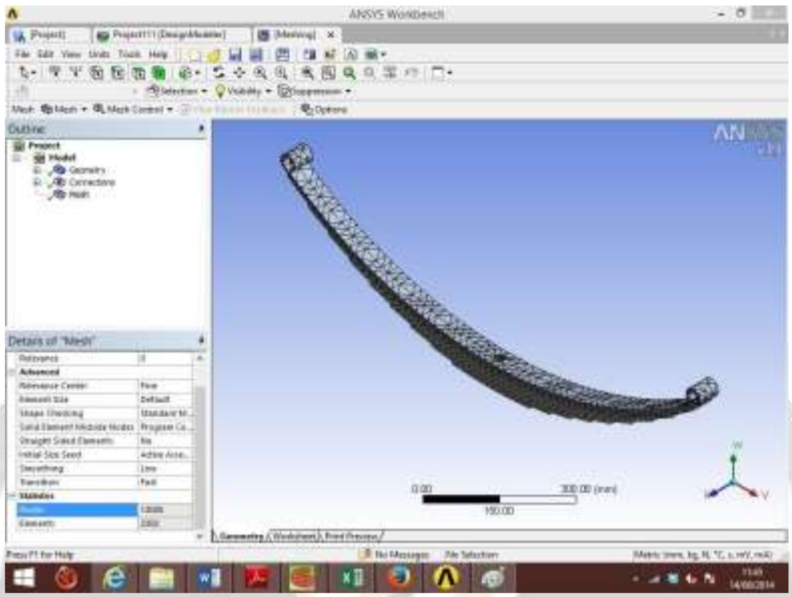

Fig 2 Meshing of Leaf Spring using static analysis

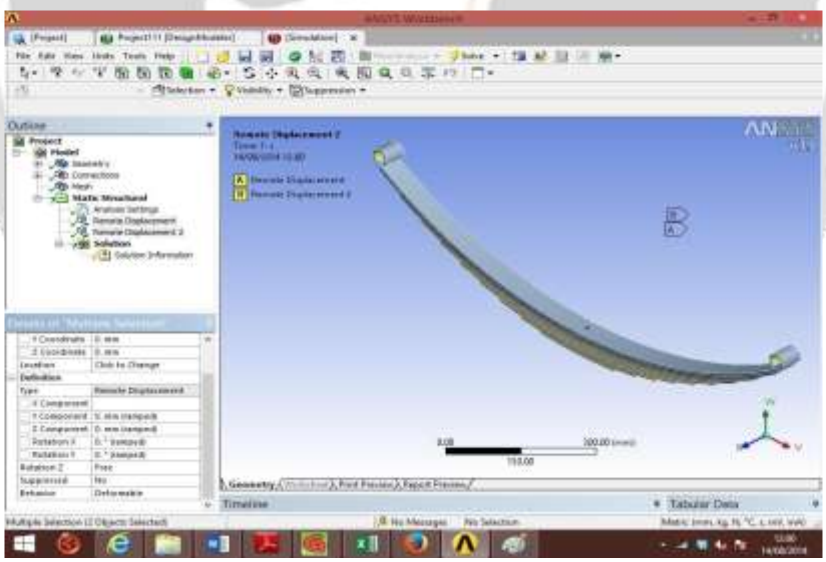

Fig 3 Boundary Condition of Leaf Spring using static analysis

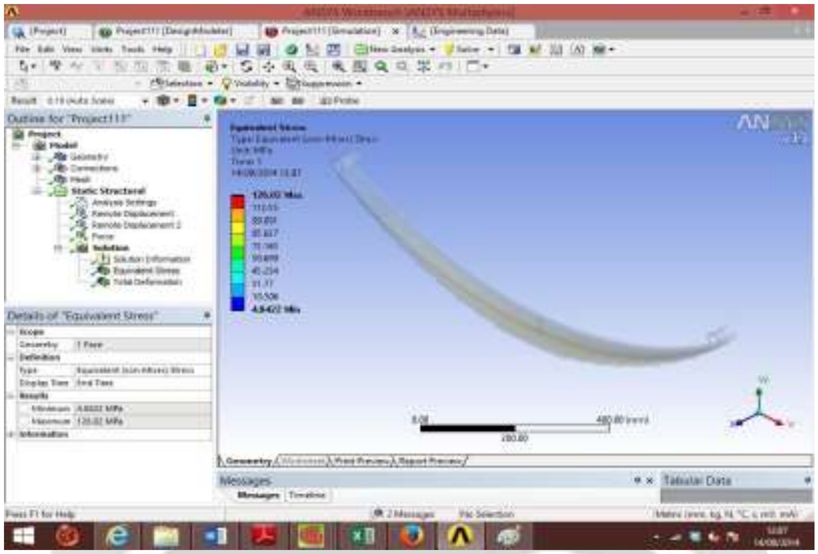

Fig 4 Vonmises Stress Result in ANSYS

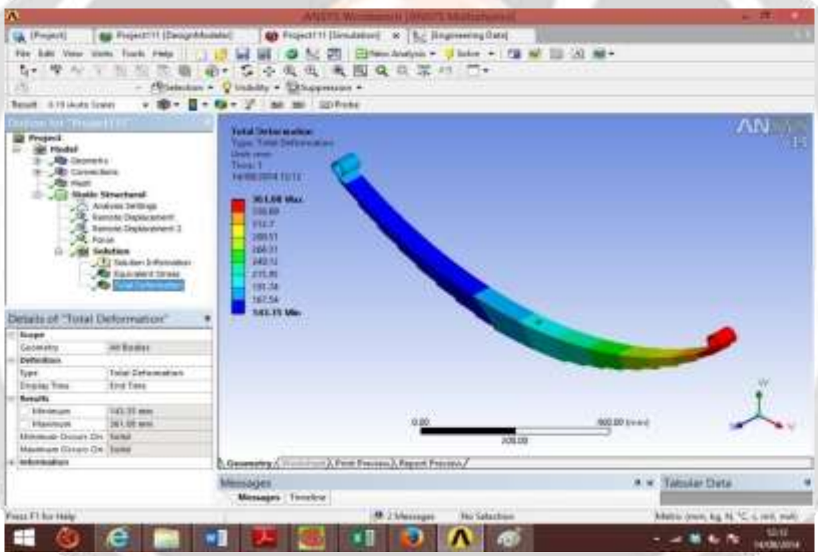

Fig 5 Deflection Result in ANSYS

Table 3 Variation of Von mises Stress and Deflection with load

Sr. No.	Load (W) in N	Von mises Stress (f) in N/mm2	Deflection (δ) in mm
1	1000	126.02	361.08
2	2000	252.04	722.17
3	3000	378.06	1083.3
4	4000	504.08	1444.3
5	5000	630.09	1805.4
6	6000	756.11	2166.5
7	7000	882.13	2527.6
8	8000	1008.2	2888.7
9	9000	1134.2	3249.8
10	10000	1206.2	3610.8

Table 4 Comparison between Theoretical and ANSYS for Von-mises Stress

Von mises Stress (f) in N/mm^2			
Sr. No.	**Load (W) in N**	**Theoretical**	**ANSYS**
1	1000	187	126.02
2	2000	373	252.04
3	3000	560	378.06
4	4000	747	504.08
5	5000	933	630.09
6	6000	1120	756.11
7	7000	1307	882.13
8	8000	1493	1008.2
9	9000	1680	1134.2
10	10000	1867	1206.2

CONCLUSION AND SCOPE FOR FUTURE:

In this study, the response of Composite Leaf Spring is determined i n p u t parameter identified. Basic design calculation of multi leaf spring includes different parameter of Composite Leaf Spring identified and calculation represent basic component‘s parameter geometric constraint form.

From the results obtained in the analysis, the following can be concluded:

Table 5 the displacement and stresses for same loading condition

Material	Von-mises stress (MPa)	Max. Shear Stress (MPa)	Total Deflection (mm)
Structural Steel(EN45)	126.44	21.96	37621
E-Glass/Epoxy	126.99	23.07	22128

Table 6 shows the Fatigue Analysis for same loading condition.

Sr. No.	Material	Life 1X109 (Minimum)	Damage Life 1X109 (Maximum)	Safety Factor (Minimum)	Fatigue Sensitivity (Nos. of Fill Point)
1	Structural Steel	20.797 Cycles	4.8085 X 107	0.031015	50-150% (25)
2	E Glass/Epoxy	1.3521 X 105 Cycle	7395.7	0.6788	50-150% (25)

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