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SIMULATION OF PARABOLIC LEAF SPRING FOR HEAVY COMMERCIAL VEHICLE USING FEA

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ABSTRACT
Leaf springs are special kind of spring used in automobile suspension system mostly. The automobile industry has shown increased interest in the replacement of steel spring with fiber glass composite leaf spring because of high strength to weight ratio. Composite materials have different properties which are attracting researchers and being solution of such issue. This work is carried out on a multi leaf spring having 12 leaves used by a heavy commercial vehicle. It includes five full length leaves in which one is with eyed ends and seven graduated length leaves. Dimension of the composite leaf spring are to be taken as same dimension of the conventional leaf spring. The FE model of the leaf spring has been generated in Creo 2.0 and imported in ANSYS-15 for finite element analysis, which are most popular CAE tools. The objective is compare the load carrying capacity, stress, deflection and weight saving of composite leaf spring with that of steel spring.

KEYWORDS: Leaf spring, composite and finite element analysis, FEM, CAE tools.

INTRODUCTION
Leaf springs are one of the oldest suspension components that are still frequently used, especially in Commercial vehicles. Leaf spring is one of the key components of vehicle suspension system. Increasing competition and innovations in automobile sector tends to modify the existing products or replacing old products by new and advanced materials. Leaf springs are mainly used in suspension systems to absorb shock loads in automobiles like light motor vehicles, heavy duty trucks and in rail systems. To meet the needs of the natural resource conservation, energy and economy, recently the automobile manufacturers have been attempting to minimize the weight of the vehicle.
A composite material is the combination of two or more materials that produce a synergistic effect so that the combination produces aggregate properties that are different from any of those of its constituents attain independently. This is intentionally being done today to get different design, manufacturing as well as service advantages of products. Upon those products leaf spring is the focus of this project for which researches are running to get the best composite material, which meets the current requirement of strength and weight reduction in one, to replace the existing steel leaf spring.
Multi leaf springs used in automotive vehicles normally consists of full length leaves and graduated length leaves. The specimen under this research work consists of twelve leaves, two eye pins, total five full length leaves including two eye pins, seven graduated leaves, clamping device, centre bolt with nut etc. CAE tools are being used to analyze the robustness and performance of components and assemblies of alloy steel and composite materials. The finite element analysis (FEA) is a computing technique that is used to obtain approximate solutions to the boundary value problems in engineering. It uses a numerical technique called the finite element method (FEM). Using FEA Multi leaf spring is modeled using the discrete building blocks called elements. Each element has some equations that describe how it responds to certain loads. The sum of the response of all the elements in the model gives the total response of the design. CAE depends upon actual assumptions of the assembly which acts as input data. CAE has become an important technology with benefits such as lower costs and a shortened design cycle. Studies say that any design professional can save

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approximate 30% of time and cost by using CAE tools. In future CAE system will be major information provider to help design professionals in decision making.

MATERIALS AND METHODS

Geometrical Parameters of leaf spring

Geometrical parameter of heavy commercial vehicle which is directely measured by vehicle leaf spring.

Table 2. Geometrical Parameters of leaf spring

Parameter	Value
Total Length of the spring (Eye to Eye)	1210mm
No. of full length leave with (Master Leaf)	05
No. of graduated length leave	07
Thickness of leaf	12 mm
Width of leaf spring	80 mm
Camber	213 mm
Length of ineffective length of spring	285 mm

Mechanical properties of the material

Mechanical properties of leaf spring which is used for analysis.

Table 2. mechanical properties of material

Materials Parameters	AISI 6150 Steel	Ti-6Al-4V alloy	S-Glass Fiber Composite
Density	7850 kg/m^3	4420 kg/m^3	2480 kg/m^3
Young's Modulus, E	210 GPa	108 GPa	87.9 GPa
Poison's Ratio	0.28	0.32	0.23
Ultimate Tensile Strength	1005 MPa	895 MPa	4575 MPa
Tensile Strength, yield	969 MPa	818 MPa	---

View and assembly of leaf spring:

Fig.1 CAD model of parabolic leaf spring

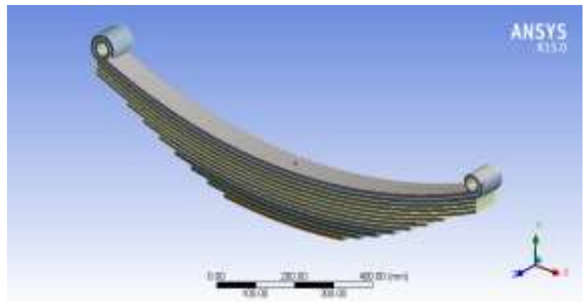

Fig. 2 model leaf spring for ANSYS analysis

Finite Element Analysis:

The study has been carried out on a multi-leaf spring consisting of Twelve leaves used by commercial vehicle. Multi-leaf spring of given specification is subjected to Static structural using ANSYS to find the stresses, pressure and deformation. The main aim of this analysis is to study the multi-leaf steel leaf spring and verification of the results within the desirable limits. The general process FEA is divided into three phases, Pre-Processor, Solution and Post-Processor. Virtual modelling of the leaf spring is done by Creo 2.0 and is imported to ANSYS 15.0workbench. response analysis with three different materials, namely AISI 6150 Steel, Ti-6Al-4V alloy and S-Glass Fibre Composite.

Meshing and Boundary Condition:

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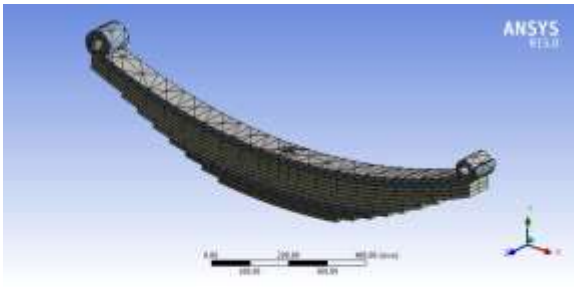

Fig. 3 meshing of parabolic leaf spring

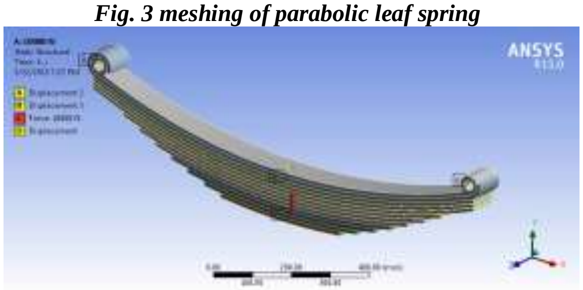

Fig. 4 boundary condition of leaf spring

RESULTS AND DISCUSSION

First of all calculated bending stress and deformation by analytical method for alloy steel and after that Using ANSYS 15, Static analysis is carried out after applying the boundary conditions. The maximum von-mises stress, maximum deformation and maximum pressure in AISI 6150 steel, Ti-6Al-4V alloy and S-Glass fiber composite calculated and comparing the results:

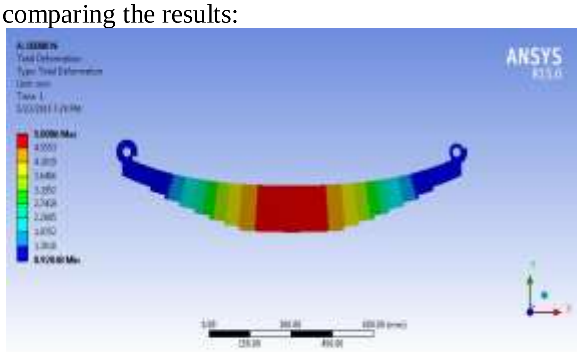

Fig.5 deformation of AISI 6150 steel at 10 KN

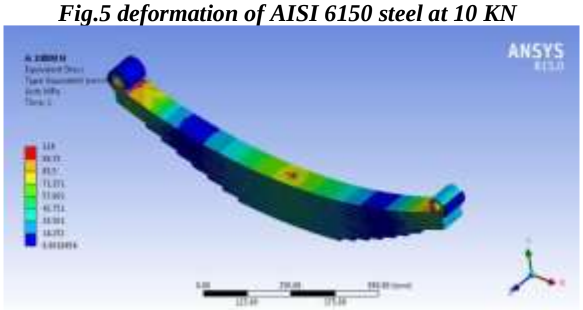

Fig.6 Von-mises stress of AISI 6150 steel at 10 KN

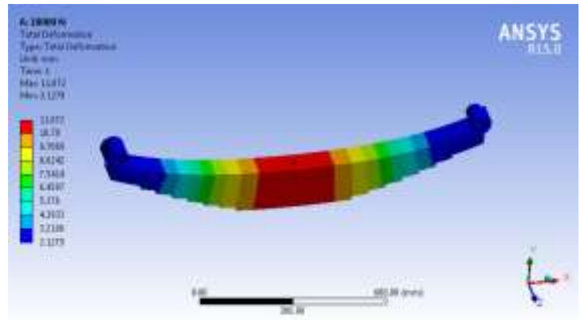

Fig.7 deformation of S Glass Fiber composite material at 10 KN

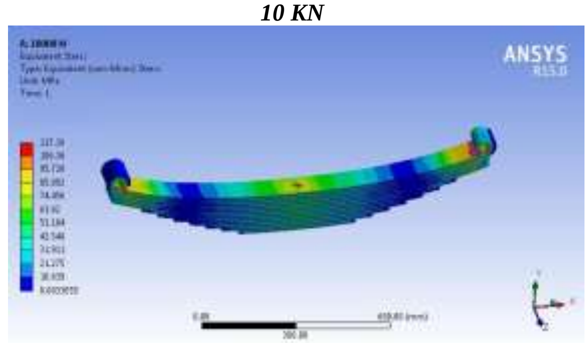

Fig.8 Von-mises stress of S Glass Fiber composite material at 10 KN

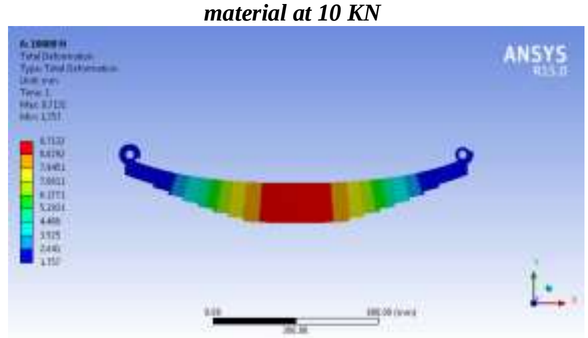

Fig. 9 deformation of Ti-6Al-4V Alloy at 10 KN

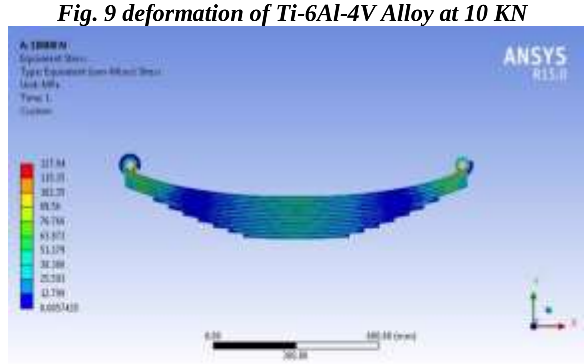

Fig. 10 Von-mises stress of Ti-6Al-4V Alloy at 10 KN

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Formulae:

Now Maximum Bending stress of a leaf spring

$$\sigma = \frac{18 \times w \times L}{b \times t^2 \, (2n_G + 3n_f)} \quad (1)$$

For determination of doformation:

$$\partial = \frac{12 \times w \times L^3}{E \times b \times t^3 \, (2n_G + 3n_f)} \quad (2)$$

Table 2: deformation and stress of AISI 6150 Steel by analytically

Sr.no.	Load(KN)	Stress(MPa)	Deformation (mm)
1	10	125.26	7.16
2	20	250.04	14.33
3	30	375.80	21.49
4	40	501.06	28.66
5	50	626.34	35.82
6	60	751.61	42.99

Table 3: comparing the deformation of different materials

Sr no.	Load (KN)	Deformation in AISI- 6150 Steel (mm)	Deformation in Ti-6Al-4V Alloy(mm)	Deformation in S Glass-Fiber composite (mm)
1	10	5.086	9.713	11.872
2	20	10.022	19.435	23.751
3	30	15.037	29.146	35.603
4	40	20.052	38.830	47.394
5	50	25.064	48.467	59.097
6	60	30.075	58.043	70.683

Table 4: comparing the Von-mises stress of different materials

Sr. no.	Load (KN)	Stress in AISI - 6150 - Steel (MPa)	Stress in Ti-6Al-4V-Alloy (MPa)	Stress in S Glass Fiber -Composite (MPa)
1	10	113.83	127.94	117.36
2	20	227.51	255.47	272.69
3	30	341.15	382.69	305.06
4	40	454.26	509.23	465.60
5	50	567.93	635.75	580.43
6	60	681.01	760.56	694.56

Table 5 (%) weight saving of different materials compare with AISI 6150 steel

Material	Weight of parabolic leaf spring (kg)	Percentage(%) weight saving
AISI 6150 Steel	87.92	------
Ti-6Al-4V Alloy	49.50	43.68%
S Glass fiber composite	27.77	68.41%

CONCLUSION

In the present work, a leaf spring is designed for heavy Commercial vehicle for the load of 58860 N. The data is collected from direct measurement from the specifications the model. The calculations are performed for AISI 6150 Steel of leaf spring by mathematical approach. Structural analysis is made for AISI 6150 Steel, Ti-6Al-4V Alloy, S Glass fiber composite. The results show:

1. The stresses in the S Glass fiber composite leaf spring of the design are much lower than the allowable stress.

2. The strength to weight ratio is higher for S Glass fiber composite leaf spring compare to conventional Alloy spring with similar design.
3. Weight of the S Glass fiber composite leaf spring is very less compare to Alloy steel almost more than 3times from AISI 6150 steel and two times from Ti-6Al-4V Alloy for the same design. If the weight is low the mechanical efficiency of the vehicle increases automatically.

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