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Research Paper

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Dynamic Analysis of Leaf Spring with Structural steel, Albamet, and Fiber Glass

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Abstract**—**Leaf spring is the main part in the suspension system of the vehicle. The ends of the spring may be moved together with a definite path as it swerve to behave as a structural member. The main function of leaf spring is to carry the vertical load but also to distribute the street or floor brought on vibrations. The test was conducted on a leaf spring of three different materials such as structural steel, albamet, and glass fiber.. A finite detail evaluation has been performed to determine safe loads and stresses. The Leaf spring is modeled in CERO PARAMETRIC 2.0 software program and AUTO-CAD 2008 and it was imported in ANSYS. The leaf spring with unique fabric have been analyzed and estimate the Stresses, deformation, strain energy , the cost and weight for the different materials. The outcome of this work is that the weight of the albumet is minimum compared to other materials and the cost is least by using structural steel and the material albamet is the best material for making leaf spring.

Keywords—E glass, Albamet, leaf spring, Vonmises stress, atomized pre alloyed powder

I. INTRODUCTION

Leaf springs catch the vibrations and shocks of automobile vehicles via spring deflections and stored the energy. Semi-elliptic leaf springs are generally adopted in suspension of medium and heavy vehicles, and these are mainly used in the rear suspension. The leaf spring comprises number of leaves called blades. The blades are commonly provide an initial curvature or cambered, hence they may have a tendency to straighten due to weight. The leaf spring is designed according to the idea of a beam of uniform strength. The eyes are provided on the ends of the lengthiest blade and this blade is known as primary or master leaf, and the closing leaf is graduated , and the metal straps which connects the blades.

The complete vehicle load rests at the leaf spring. The pin joint is used to hooked the front end of the spring and the frame, and the rear end of the spring is attached with a shackle. The shackle is the curved link that fastens between the leaf spring rear eye and frame. When the vehicle moves through hump on the road, the wheel lifts up, leading to the deflection of the spring, and these actions occurred between the spring eyes. An end to end distance of the spring is fixed, the spring cannot withstand the variation of length. Hence to stop the variation in length, a shackle is provided at one end, which offers a supple connection. The front eye of the leaf spring is limited in all of the movements, whereas the rear eye is always constrained in X-course. The center of the arc shows the location for the axle, although tie holes are supplied at either separate for attaching to the vehicle frame. In heavy vehicles, a leaf spring may be arranged in several leaves stacked on the pinnacle of each different layers, often with steadily shorter leaves. Where as the inter leaf friction provide a damping motion, it is not well grapple and results insist on the movements of the suspension, and from this motive, a few manufacturers have concentrated on mono-leaf spring.. Naresh [1] shows the design of composite leaf spring by applying stationary load and deriving the stresses and deformation in the leaf spring. The investigation has been carried out by CAD modeling using ANSYS 14.5 workbench. The results obtained is that the numerical and analytical calculations are close values. Hiroyuki Sugiyama et.al. [2] presented the three specific contributions on leaf springs:

i) The development of a new non linear elastic formulation that can be efficiently used to model leaf springs. This permits for making a decreased-order model that includes all significant deformation modes.
ii) To develop a procedure to determine the initial pre-stressed configuration of the leaf spring,
iii) To adopt the proposed methods and to develop a detailed vehicle model based on the nonlinear leaf spring formulation.

The leaf spring version is created by the modeling software programs like CREO and it is imported to the analysis software and applying the boundary conditions and the results are determined by post-processor. This analysis helps to compare the parameters of steel, albamet, and fibre glass and to select the good material for making the leaf spring.

Section I contains the introduction of leaf spring, Section II describes the past research works related to leaf spring, Section, III explains the methodology, Section IV contain the leaf spring design and modeling, section V states the materials, Section VI describes results and discussion, Section VII concludes the research work and future recommendations.

II. RELATED WORK

Nowadays number of literature available in the composite leaf spring which enable higher performances than conventional steel leaf springs. Though an attempt has been made to produce the composite leaf spring with the same cost as that of steel leaf spring. Material properties and layout of composite structures are recommended in many literature. In finite detail analysis, very less information is available in material properties compared to the 2D analysis of leaf spring. At the same time, the literature regarding experimental strain analyses is more.

Rajendran et.al.[3] presented an artificial genetics algorithm for the design and optimization of composite leaf springs. The design parameters of composite and steel leaf springs are optimized by Genetic Algorithm. Optimization by Genetic Algorithm contributes, the reduction in weight of 8% in metallic and composite is 23.4%. J.J. Fuentes et.al (4).examine the premature failure in automobile leaf springs used in buses. The outcome reveals that the failure occurred by fatigue at the central hole region due to high tensile stress. Bhushan B. Deshmukh et.al (5). studied the Fibre Reinforce Polymer leaf spring, and the introduction of this material reduces the weight of the leaf spring without affecting the load-carrying capacity. The composite has high strain energy storage capacity and more strength to weight ratio. B.Ravi Kumar et.al (6) has reviewed the premature fatigue failure of a spring during working. The analysis was carried out by the X-ray diffraction techniques, tensile and hardness testing, Optical and scanning and electron microscopy. The cracks occurred in the cross-section of the spring presumably due to improper quenching. W. Hufenbach et al. (7) introduced a technique to control the spring rate of a leaf spring element. They identifies leaf spring elements with distinct reinforcements shows very good performances among the evaluation and the measured function. K Tenabe et.al. (8) build a prototype by the Carbon fiber reinforced plastics which weighs 2 .kg consisting of the front and rear eyes which minimise the weight of the spring by 76 % compares with steel.

III. METHODOLOGY

The leaf spring was transformed into a model as a solid element known as SOLID187 which is a higher-order 3-D, 10-node detail used to mesh the version. This shows quadratic displacement behavior and is recommended to modeling irregular meshes. The detail was stated through 10 nodes having three degrees of freedom at each node such as translations in x, y, and z directions. The detail has analysed the stiffness, deflection, plasticity, hyperelasticity, creep, pressure, , and large pressure variations.

IV. MODELING AND LEAF SPRING DESIGN

Geometric parameters of Tata ace medium commercial vehicle are given underneath

Weight of vehicle = 1550 kg

Load = 1100 kg

Total load = 1550 + 1100

= 26500 kg

= 25970 N

Load acting on in single leaf = 25970 /4

= 6500 N

Length of spring L_1 = 770 mm

Ineffective period ‘l’ of leaf spring = 85 mm

Effective length of leaf spring = $2L_1$ - l

EL = 1540 – 85 = 1455 mm

Length of master leaf =2 L_1 + (22/7) (d + t) x 2

Where, d = Inside eye diameter

t = thickness of the blade

= 1680 mm

Length of leaf spring leaves

The duration of the go away springs are calculated via the use of the formulation given underneath.

Total number of leafs = 5

EL = (Effective length /(n-1) * 1 + Infective length

= (1455/(5-1)) + 85

= 448.75 mm

Similarly,

Length of 2nd leaf = (EL /n-1) * 2+ Ineffective length

= (1455/(5-1)) *(2) + 85

= 812.5 mm

Length of 3rd leaf = (EL /n-1) * 3+ Ineffective period

= (1455/(5-1))*(3) + 85

= 1176.25 mm

Length of fourth leaf = (EL /n-1) * (4) + Ineffective length

= (1455/(5-1))*(4) + 85

= 1540 mm

Leaf spring model in Creo software

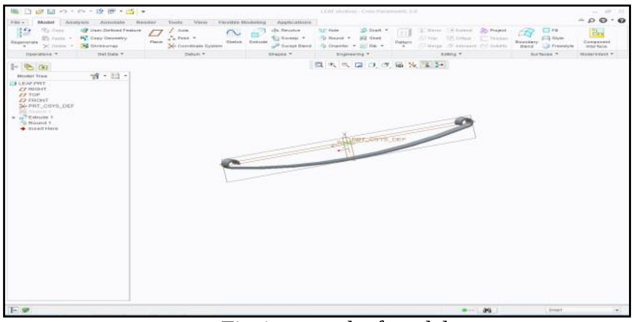

Fig.1 master leaf model

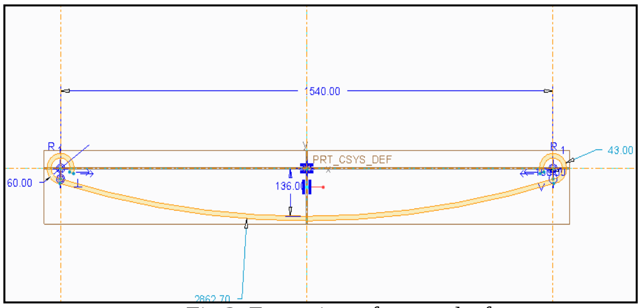

Fig.2 Front view of master leaf

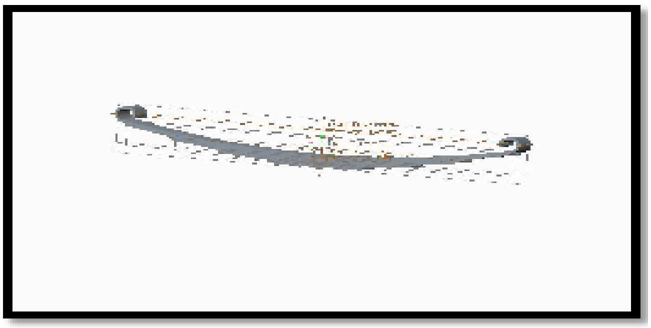

Fig.3 Creo model of leaf spring

V. MATERIAL SELECTION

The materials used for making the leaf spring are carbon steel, chromium-vanadium metallic, chromium-nickel-Molybdenum steel, and silicon-manganese steel (structural steel). The materials selected for study are structural steel, Albamet and glass fiber and identifies which is the best material for leaf spring in vehicles.The first is widely used in the light motor vehicles and the others are composite materials, which are new materials.

5.1 Structural steel

Structural steels exhibits good welding properties with high strength. A variety of structural steels available in the market and some of them are wear-resistant grades, high strength steels, off shore steels, boiler and pressure vessel steels. All of them are usable, but engineers considered which may withstand maximum strength or minimizing its weight.

5.2 E-glass (or fiberglass)

Glass fibre is used for making the fibre glass by arranging the fibre in a random manner and woven into fabric. Fiberglass has strong fabric, and weightless Although energy stored are lower than carbon fiber, less stiff, and the fabric exhibits less brittle at some distance.

5.3 Albamet

Chemical name of albamet is beryllium and aluminum metal which is extracted by a powder metallurgy process. It is manufactured by hot atomized gas impinges on pre-alloyed powder. Each powder particle comprises aluminum and beryllium dendrites combined together to form uniform micro structure. This material has High modulus-to-density ratio, 3.8 times that of aluminum or steel, minimizes flexure and reduces the chance of mechanical failure.

VI. RESULTS AND DISCUSSION

6.1 Deformation analysis

At maximum load (6000N), deformation under various materials is shown

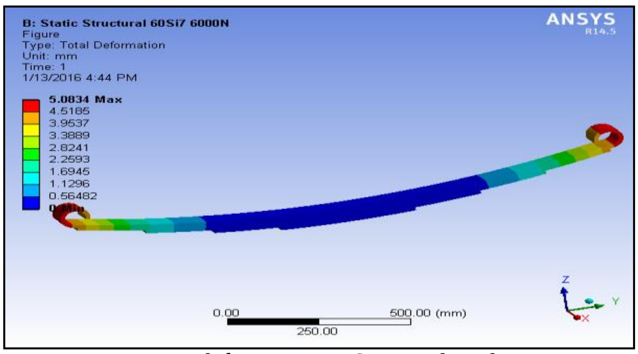

Fig.4 deformation on Structural steel

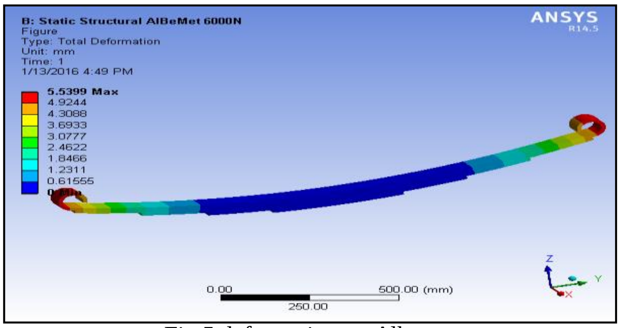

Fig.5 deformation on Albamet

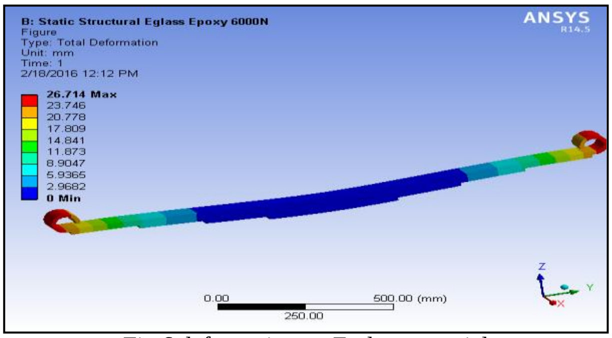

Fig.6 deformation on E-glass material

The maximum deformation under maximum load of three materials are 5.08 mm for structural steel, Albemet is 5.539 mm, and for E-glass is about 26.714 mm, and is acted on the eye end of the spring. The minimum deformation is occurred at the center, where U-bolt is fixed. Albamet shows more deformation and less stiffness, hence we can identified that steel and albamet has high stiffness compare to E-glass.

Table 1 Deformation of different materials

Deformation results under various loads mm		Materials		
		Steel	Albamet	E-glass
2000N	Theoretical	2.261	2.460	11.874
	Ansys	1.6945	1.8466	8.9047
3000N	Theoretcal	3.392	3.691	17.811
	Ansys	2.5417	2.77	13.357
4000N	Theoretical	4.523	4.921	23.748
	Ansys	3.3889	3.6933	17.809
6000N	Theoretical	6.785	7.382	35.622
	Ansys	5.0834	5.5399	26.714

6.2 Stress Analysis

At maximum load(6000N) , von-mises stress under various materials is shown

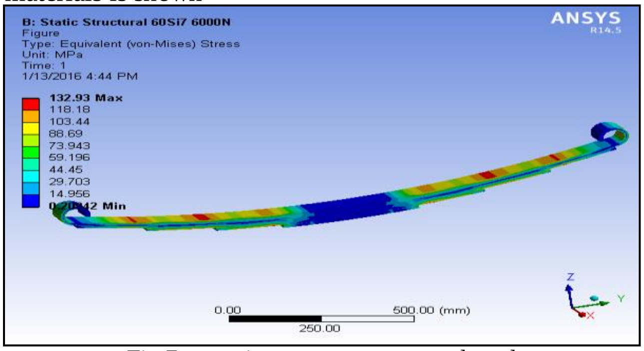

Fig.7 von-mises stress on structural steel

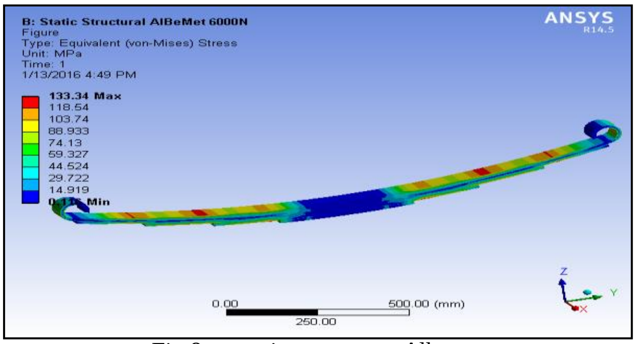

Fig 8 von-mises stress on Albamet

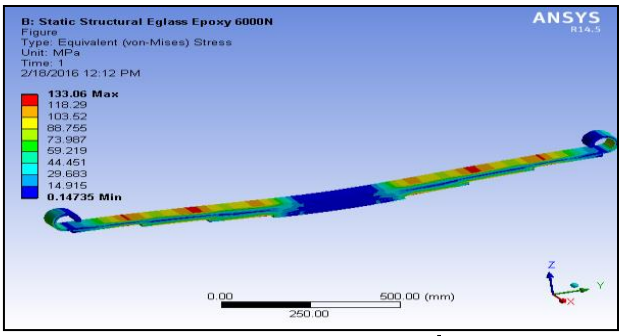

Fig.9 von-mises stress on E-glass

The maximum stress is approximately same for all materials and the value is slightly higher by using albamet and lower by using structural steel. The maximum stress is acted on the region below the pink portion. The pressure performing on the leaf spring is minimal at the middle, because of the U-bolt manual.

Table 2 Maximum bending stress of different materials

Stress induced on Leaf spring under various Loads, MPa		Materials		
		Steel	Albamet	E-glass
2000N	Theoretical	156.21	156.21	156.21
	Ansys	44.31	44.447	44.353
3000N	Theoretical	234.31	234.31	234.31
	Ansys	66.465	66.671	66.529
4000N	Theoretical	312.42	312.42	312.42
	Ansys	88.62	88.894	88.705
6000N	Theoretical	468.63	468.63	468.63
	Ansys	132.93	133.34	133.06

Von mises strain and theoretical bending pressure performing on leaf spring are constant for all cloth leaf spring. Because it does now not rely upon any belongings of the fabric used, it only depends on the geometry of the fabric. The yield stress of structural steel, Albamet, and E-glass is 250Mpa, 180Mpa, and 400Mpa respectively.The ratio of maximum stress to the yield stress of the materials are approximately 0.532 for structural steel, 0.738 for Albamet, and 0.3325 for E-glass material. This outcomes reveals that E-glass fabric has high elasticity to hold more load than other materials.

6.3 Strain energy Analysis

At maximum load(6000N), strain energy under various material is shown

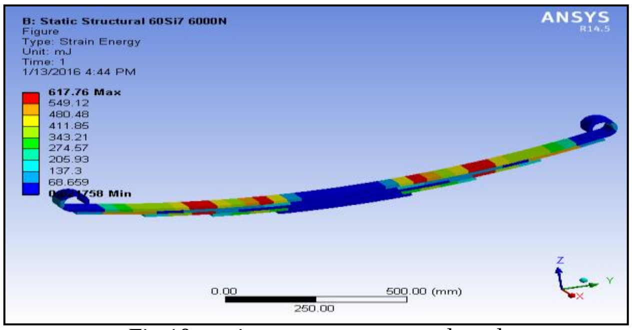

Fig.10 strain energy on structural steel

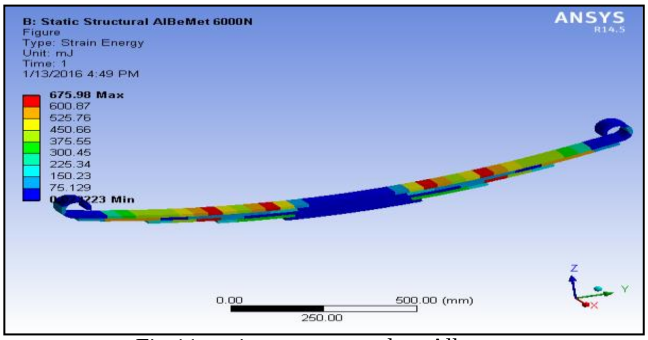

Fig.11 strain energy stored on Albemet

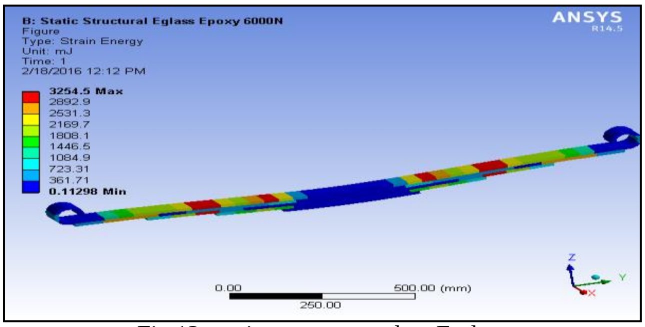

Fig.12 strain energy stored on E-glass

E-glass has less density, and modulus of elasticity as compared to other materials. though it has more energy storing ability. The maximum strain energy stored is 3254.5 MJ for E-Glass, Albamet, is about 675 MJ and for steel is 617.76 MJ.

6.4 Weight & Cost Estimation

The weight of the material depends on the density and quantity of the cloth. The density of structural steel, Albemet and E-glass are 7860 Kg/m3, 2071 kg/m3 and 2600 kg/m3 respectively, and the weights are 41.5, 10.95, and 13.76. Cost of metal, Albemet and E-glass are 250 Rs/kg, 1200 Rs/kg and a thousand Rs/kg respectively. The cost of the structural steel is less and high by using E glass.

Table 3 Weight and Cost of different materials

	Materials		
	Steel	Albemet	E-glass
Weight in kilograms	41.59	10.95	13.759
Cost in Rupees	10397.5	13140	13759

VII. CONCLUSION AND FUTURE SCOPE

This version is analyzed by using ANSYS software and compare the properties which are deformation, stress, strain energy and weight of structural steel, Albamet, E-glass, and cost of leaf spring . The deformation and strain energy is high by using E-glass and weight and strain energy is significantly less in Albamet. By Considering all parameters the outcome reveals that Albemet shows higher performances and it is the better choice for making leaf springs in future.

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