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DESIGN AND ANALYSIS OF COMMERCIAL VEHICLE LEAF SPRING USING AISI1008 CARBON STEEL COMPOSITE MATERIAL

J. J. Jayakanth, M. Jeyaraman, S. Sivaganesan and M. Chandrasekaran
Department of Mechanical Engineering, Vels University, Chennai, India
E-Mail: jj.jayakanth@gmail.com

ABSTRACT

The failure of leaf spring fatigue is to be determined the analysis of life prediction. By using NX Nastran materials various analysis were observed in the selected software with suitable material. In the system of vehicle suspensions Leaf springs are used most in common which are limited to varying cycles stress to millions thus eventually leads to failure of fatigue. High definition value and high elastic limits are presented in spring material possess maximum strength with fatigue effects and shocks. Weight reduction is the main focus in automobile manufactures in direct to preserve natural assets and power of economic in the current scenario. By inducting an advanced material weight reduction can be achieved thus resulted in improved manufacturing process and design optimization, along with better fuel efficiency and affirmed riding qualities. Without reducing the load carrying the capacity and stiffness composite materials were introduced and reduced the weight of leaf spring. The weight ratio of composite material which has elastic strain energy storage capacity is compared to the steel and multi-leaf steel; it also tends to be replaced by composite springs of mono-leaf. The savings of substantial weight which was offered by composite materials are cost effective in terms of counterparts of steel.

Keywords: leaf spring, NX nastran, computer aided engineering, composite material.

1. INTRODUCTION

To store up maximum amount of work energy in the prescribed volume or weight Leaf springs are fitted with locomotives, heavy road vehicles, wagons and carriages without permanent deformation of spring materials [1]. Driving torque, shocks and lateral loads are worked under these designed springs.

In the manufacturing of present automobiles weight reduction is the main focus since it conserves natural resources and economize the energies. By introducing the materials in better manner and designing the optimization in the manufacturing process weight reduction can be acquired [2]. In the account of ten to twenty percent the unstrung weight the suspension leaf spring is the main elements for weight reduction, which emulates the riding qualities of vehicles. In order to design to absorb and to store energy the springs aids it to release it. The major factor of strain energy and the materials are designed in the springs. Therefore to reduce the weight of leaf spring the composite materials are introduced without reducing the load carrying the capacity and the stiffness [10]. The elastic strain energy is more in composite materials the storage capacity is high to strength proportionate to the weight ratio which was differentiated in those steel.

In order to composite the materials for automobiles various papers were devoted in the application. This shows the composite structure for automobiles and its application in order to design the leaf spring composite optimization [3]. In order to hold the full length leaves and graduated length leaves multi leaf springs are utilized in the automotive vehicles which seems to be greater effort is automobile industry. Two eye pins, nine leaves and a center bolt nut is under the research of specimen [4]. To analyze the performance and robustness CAE tools are utilized as the assemblies and components. (FEM) finite element method is a technique of numerical is used. Discrete building blocks which are called as elements are used for FEA multi leaf spring as models, which are described by equations of each element and responds to specific loads [6]. The total response of the design is responded to some equations which were described by those. The input data is assembled by the actual assumptions of the CAE. The benefits like shorten design cycle lower costs have become an important technology of CAE.

2. LAMINATED SEMI-ELLIPTIC LEAF SPRING

The below Figure-1 describes the laminated semi-elliptic leaf spring, the leaf that occurs on the top is noted as master leaf. In order to attach another machine member the eye is attached with spring. The amount which was passing through the eyes in the given bend to the springs of the central line is called as camber. The utmost load and the diverged spring are not projected to contact the machine element since the camber is provided to the attachment. The camber which was revealed in the figure is called as optimistic camber. In order to hold the leaves of the spring central clamp is required, therefore to engage the bolts to claps the bolt holes are required which at some extent leaves the springs weaken [7]. From the master leaf to the graduate leaf rebound clips are used to share the load within it. The nine graduated leaves was left behind at two full length involved by leaf spring, full scale testing machine for jigs, fixtures, and leaf springs are setup for experimental.

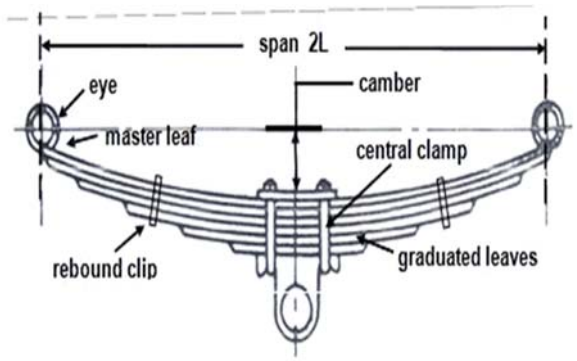


Figure-1. Laminated semi-elliptic leaf spring.

The hydraulic force of 20.6 M pa with a pace rate of 2101 pm is consisted with hydraulic power pack, which was inserted to the actuator of hydraulic to operate in 0.3 Hz frequency through the specified displacement of alternating load [8]. The deflection and bending stress are involved in the process of axial load with leaf spring. By using leaf spring test fig leaf spring model was experimental and verified and for the support laminated spring of the master leaf is hinged. The longitudinal forces are induced and stressed due to the support arising the twist in possible. Therefore the graduate leaves are less stressed in comparing to the stress of master leaf.

The following are the methods to reduce stresses that occur in addition.

a) In comparing with the other leaves master leaf is made stronger.
b) In comparing with additional leaves, master leaf is through thinner which can reduce the stress that bends, proven through the stress equation.
c) In order to amplify the master leaf radius bend than the other leaf the deflection of leaf spring this was under the static loading conditions to measure the vertical static.

3. STRESS ANALYSIS

To estimate and reduce the strength in spring stress calculations were performed which resulted in cracks that were existed before the mid-plane segregation and the accident. To provide the estimation time to reduce the strength spring test data were also utilized. In order to determine the dirt road forces reduction in strength were utilized and forces the large rock strike in absent and adequate to rupture the spring. To learn the subsistence of oblique tensile stresses finite element stress analysis were utilized at the position of breakage. At the vehicle frame the leaf spring was directly protected through the shackled assembly at the end.

Table 1 and 2 shows general specification and design parameters of leaf spring. For the stress that bended through outer fiber is essential for spring fracture at the estimate of 1460 Mpa produced at the old OD crack in the measurements of crack depth. The bending stress estimation for the fracture is calculated in the outer fiber or outer surface is expected in the tensile strength of the spring [11]. While comparing the nominal properties the strength was reduced this was identified through an analyses. The stresses were raised by delimitating the spring thus resulted in unstable fracture at the force of lower levels. The stresses will be doubled by the elimination of the force; the estimation of elastic bending calculations is determined by the longitudinal force as it was necessary to construct the breakage launch assumed by stress. The MPa is 146 in force to reach the estimated 23,000 N for splitting and 10,200 N for the accident spring which was observed in elimination. The result on exemplar spring is yielded by using 48,200 N pull failed in the test result at 52 to 79% of reduction in the strength of the spring. The strength which is likely for the minute break and the splitting are demonstrated the vital reduction [9]. The reduction in the strength is the evidence of the half cracked in the outer side indicates at some occasions which occurs the unstable rupture in plain strain.

Table-1. General specification of leaf spring.

S. No.	Particulars	Dimensions and value
1	Static load acting on the spring (W), N	40000
2	Static deflection of the spring, mm	100
3	Distance between eyes(2L),mm	1524
4	Laden Camber, mm	171
5	Free Camber, mm	271
6	Spring Width, mm	77
7	Number of Leaves	11
8	Thickness	12.5

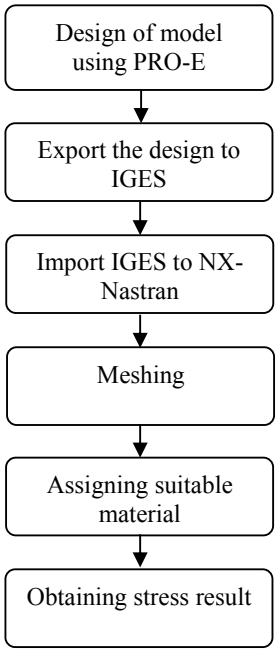
Table-2. Design Parameter of Leaf Spring.

Leaf No.	Full leaf length (mm) 2L	Half leaf length (mm) L	Radius of curvature R
1	1524	762	1307.64
2	1524	762	1315.64
3	1374	687	1323.64
4	1224	612	1331.64
5	1074	537	1339.64
6	924	462	1347.64
7	774	387	1355.64
8	624	312	1363.64
9	474	237	1371.64
10	324	162	1379.64
11	174	87	1387.64

The ID semi of the spring is tough and less in comparing to the OD half, since the presence of intergranular fracture is extensive, the further evidence is embrittlement. When the stable tear and the loading of dynamic are combined to reduce the longitudinal split pace to 0.72 g decisive factor occurs as the final cause.

The delimitation which was segregated in the mid-plane is expected to control the running crack from the external surface. This will intact the rubbing in the mid-plane and leaves the spring weak which resulted in control of the demonstration. By assuming the spring the residual strength for the condition is estimated and cracked in the middle mark.

4. METHODOLOGY



The design of the model is done through PRO-E and the design is being exported to IGES format and it is imported to NX-Nastran for analysis with the composite material AISI1008 carbon steel.Since the leaf spring is fixed with the axis at its center. Only half of it's considered for analysis purpose

5. THREE DIMENSIONAL FINITE ELEMENT ANALYSIS OF LEAF SPRING

The deflection using the 3D finite and the composite leaf spring is set to analyze the static element strength. The software NX Nastran 9.0 version is used to analyze the purpose of finite element in the recent days. The leaf spring which is taken as model has the advantages of loading symmetry in geometry. The eight-noded 3D brick elements are divided into three dimension structure of leaf spring. More number of elements is created to get accuracy in the results, therefore the finite element model is maintained by the ratio of three, which predicts the values and displaced variation of the bending stress. The result of the composite leaf functions proportionately to the under formed shape of the composite leaf spring similar to loading conditions.

5.1 MODELLING OF LEAF SPRING

The Figure 2, 3 shows the model of leaf spring and main components of the leaf spring which is designed using Pro-E.

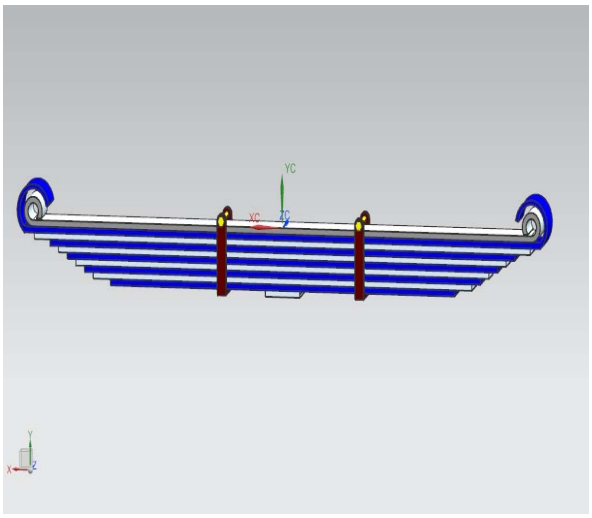


Figure-2. Model for 11 Leaf.

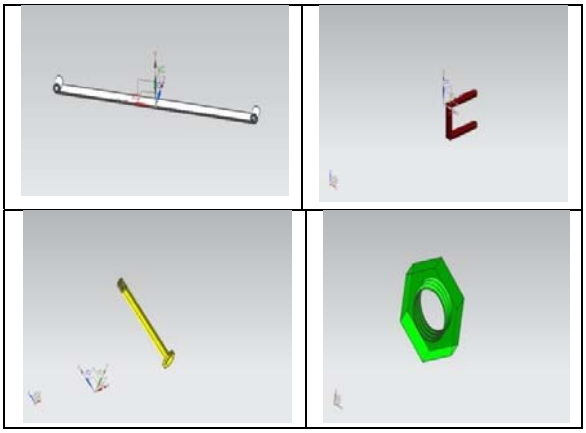


Figure-3. Main components of leaf spring.

5.2 STATIC ANALYSIS OF LEAF SPRING 11-LEAF

Then it is analyzed statically using NX Nastran by composite material AISI1008. Stress and displacement plot for this composite material is shown in Figures 4, 5.

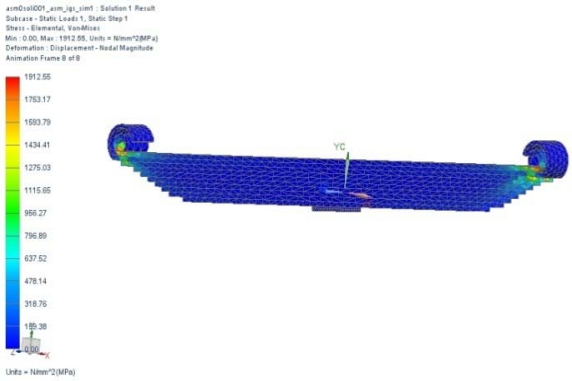


Figure-4. Stress plot for composite material.

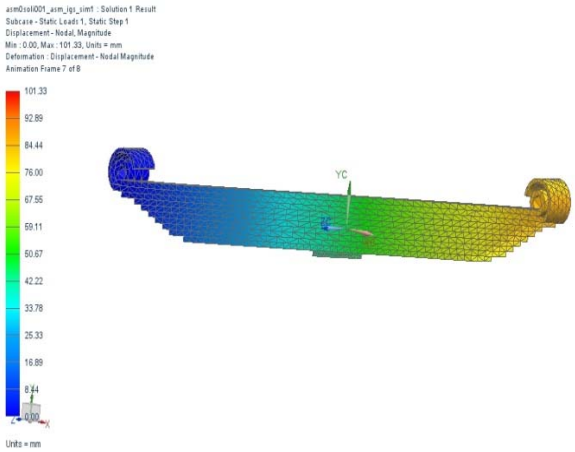


Figure-5. Displacement plot for composite material.

6. RESULT AND COMPARISON

The result of the analysis of composite leaf spring which is compared with steel leaf spring of a commercial vehicle is shown in Table-3. Compared to steel leaf spring the composite leaf spring is less weight and high strength.

Table-3. Properties of leaf spring.

S. No.	Properties	Material stress value in N/mm^2	
		Steel leaf spring	Composite leaf spring
1	Tensile Stress	800-1200	950-1500
2	Yield Stress	600-800	800-1000
3	Elastic Modulus	$2.0x10^5$	$2.1x10^5$
4	Shear Modulus	$0.8x10^5$	$0.9x10^5$

7. CONCLUSION

The conventional steel leaf is heavier than the composite leaf spring and thus the leaf spring is subjected to the design are effective in cost over the steel counterparts specifications. The weight ratio is differentiated to the amalgamated supplies and stretchy twist force, high strength and storage competence with respective to the steel. Hence, it is concluded that effective replacement in the leaf spring is existing in the automobiles leaf spring. AISI 1008 Carbon steel is high in the value of strength and the stresses are bit higher than the mild steel to which the AISI carbon steel is slightly better. In order to lessen the power of spring to the summit the prior cracking in the spring is made extensive and normal dirt road produces adequate forces in rupture. By replacing the steel leaf spring to 40% the weight of the leaf spring is reduced and composite the objective of unstrung mass.

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