ANALYSIS OF LEAF SPRING WITH VARIABLE THICKNESS FOR COMPOSITE MATERIALS

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Abstract: Fuel efficiency and weight of automobile are the two important parameters to be considered. The most suitable way increase the efficiency of automobile without sacrificing the safety of passengers is by using composite materials. Most of the automobile industries are using composite materials for manufacturing components of an automobile to reduce the weight without compromising quality and reliability. The main objective of this paper is to reduce the weight of the leaf spring by using composite materials such as Epoxy/E-glass and Epoxy carbon. Composite materials are having advantages like high strength, free of corrosion resistance, high specific modulus, high impact energy and reduced weight. Comparing the results between two models like constant thickness leafs of a leaf spring with variable thickness leafs of a leaf spring. Pro-E wildfire 5.0 is the design package used to model the leaf spring and ANSYS 15.0 is the analysis package used to carry out the analysis.
Keywords: leaf spring, composite materials, variable thickness.

I. INTRODUCTION

Vehicle chassis is mounted on the axles with springs in between. This is done to isolate the body of the vehicle from road shocks. The springs used may be of many types like coil spring, leaf spring, torsion bar, plastic spring, air spring and hydraulic spring. Springs are placed between the wheels and the body. When the wheel comes across a bump on the road, it rises and stores the energy. While releasing, due to the elasticity of the spring material, it rebounds there by expanding the stored energy. In this way the spring starts vibrating with gradually decrease in amplitude because of the internal friction between spring materials. Semi elliptic leaf springs are almost universally used for suspension in light and heavy commercial vehicles and these are widely used for rear suspension. The fig.1 shows semi elliptical type leaf spring. The spring consists of a number of leaves called blades and with different lengths. The lengthiest blade has eyes on its ends. This blade is called master leaf. The spring is supported on axle by means of U-bolt. One end is attached to frame by simple pin, while the other end is connected with shackle joint. The shackle joint gives flexible connection when the vehicle comes across a bump. Highly cambered springs provide a soft suspension but they increase the tendency to yaw. Flat springs reduce the tendency of pitching, when breaking or accelerating suddenly. Spring eyes are generally bushed with phosphor or bronze. But for cars and light transport vehicles rubber bushes are commonly used. The spring vibration is reduced by friction between two leaves but it produces the noise[1].

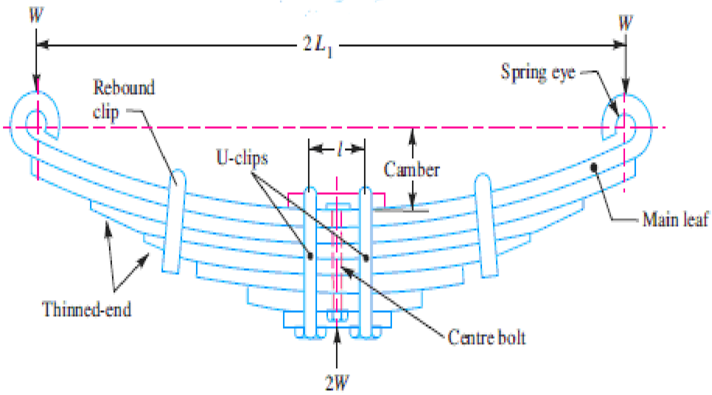

Fig.1 Different types of leaf spring as shown

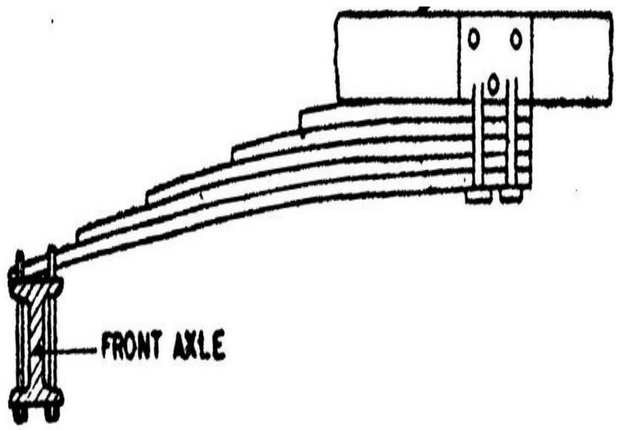

Fig.2: quarter elliptic

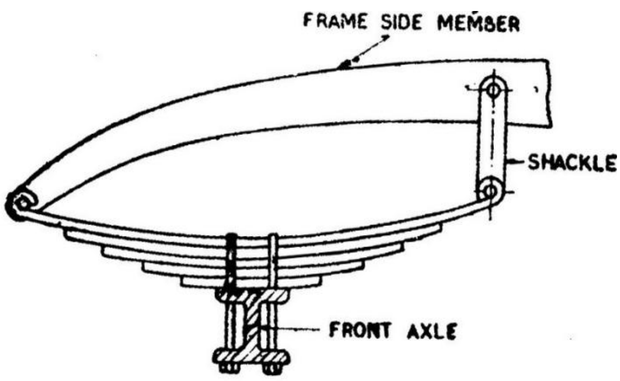

Fig.3 Semi elliptical

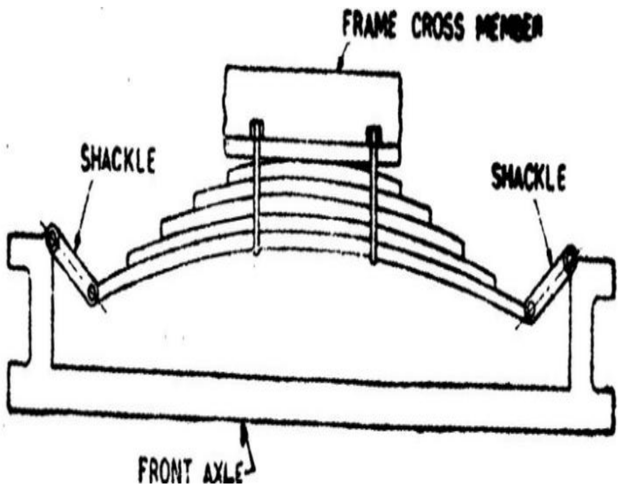

Fig. 4 transverse leaf spring

The semi elliptical springs are simple to fabricate, most of the old cars used elliptical type leaf spring. The last leaves of a spring are first to get failure. It is not because heavy vehicle manufacturers but also by spring manufacturers. The stress actuating in the material is most important element in the structural analysis[2]. Normally the steel industries are using SAE 6150, SAE 5160 and SAE 9254 steels for the manufacturing of leaf spring[3]. In order to decrease the weight of the automobile and without sacrificing vehicle quality and reliability most of the automobile industries are using composite materials. The weight reduction is helpful for reducing the fuel consumption. The advanced composite materials such as Graphite, Carbon, Kevlar and Glass with suitable resins are widely used. The advanced materials are mostly used in leaf spring because their elastic properties increase the strength and reduce the stresses induced during application[4]. The leaf springs mainly of three types: ordinary multi-leaf with constant thickness and stiffness, variable thickness (parabolic or tapered), and variable stiffness. The study of stress distribution inside the leaf spring is very important because it is directly related with fatigue life[5]. Static analysis and model analysis of a leaf spring is essential to know the strength and vibration behavior[6].

Constructional Details:
For constant thickness of leaf spring:
Length of the main leaf = 1200 mm
Camber = 130 mm
Thickness of each leaf = 13 mm

For variable thickness leaf spring:
Thickness of first leaf = 13mm
Thickness of second leaf = 12mm
Thickness of third leaf = 11mm
Thickness of fourth leaf = 10mm
Thickness of fifth leaf = 9mm
Thickness of sixth leaf = 8mm
Thickness of seventh leaf = 7mm

II. COMPOSITE MATERIALS SELECTION

The different composite material likes, Epoxy glass, Epoxy carbon resin are going to analyzed and studied. The various characteristics and properties of composite material are as below:

A. Characteristics of composite material:

- They have high strength, specific modulus and reduced weight.
- Due to reduction in weight, fuel consumption will be reduced.
- The damping capacity is high and hence vibration and noise are low.
- Corrosion resistance is high.
- Torque capacity is greater than steel and aluminum shaft.
- Transmit higher amount of available power due to its lower weight.

III. STATIC ANALYSIS

The material properties considered for leaf spring analysis is given below,

Structural steel:
Poisson's ratio (**ν**) 0.3
Density 7800kg/m^3
Young's modulus 2.07e+11 N/m^2

E-Glass:
Poisson's ratio (ν) 0.3
Density 2000kg/m^3
Young's modulus 5e+10 N/m^2

IV. BOUNDARY CONDITIONS

The fixed support has been taken at the interface of bush and eye and the force applied at the bottom with the magnitude if 2500N.

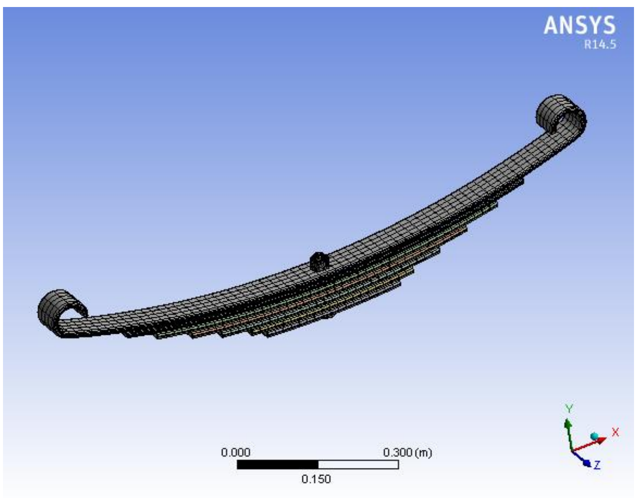

Fig. 5 modeling of leaf spring

V. RESULTS AND DISCUSSIONS

Constant thickness of leaf spring for structural steel:

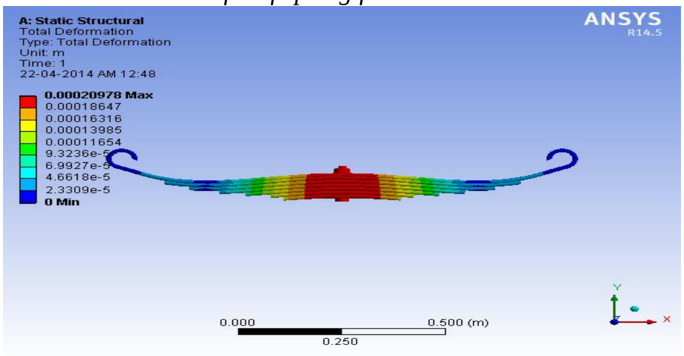

Fig. 6 total deformation

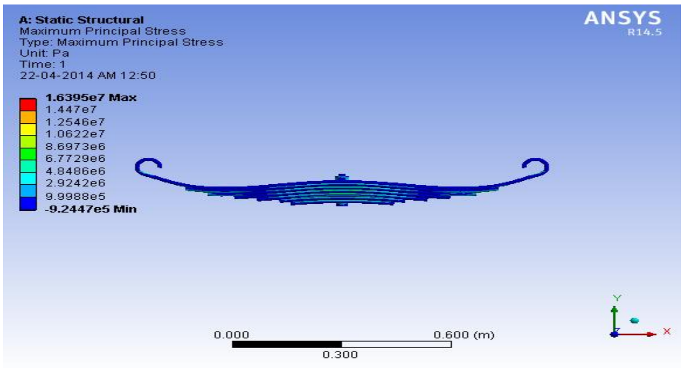

Fig. 7 maximum principle stress

Variable thickness of leaf spring for structural steel:

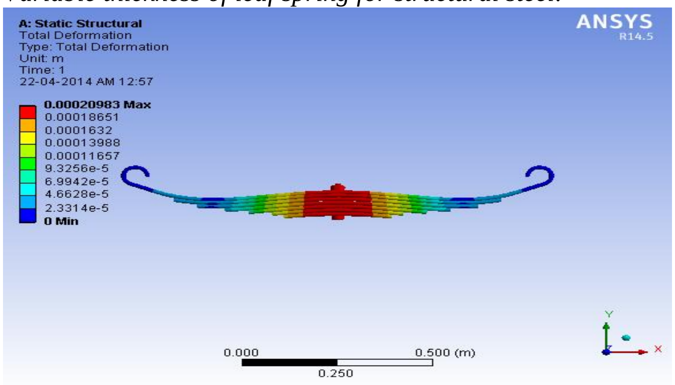

Fig. 8 total deformation

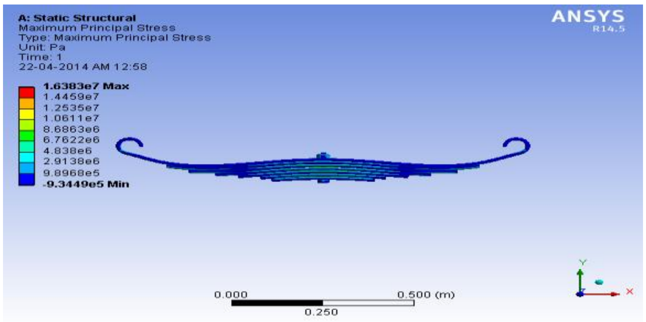

Fig. 9 maximum principle stress

Variable thickness of leaf spring for E-Glass:

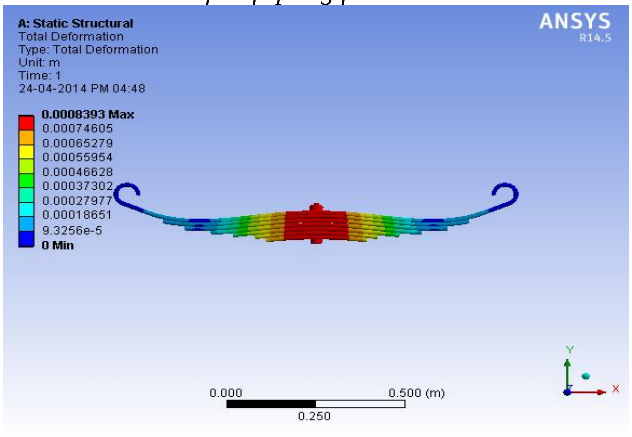

Fig. 10 total deformation

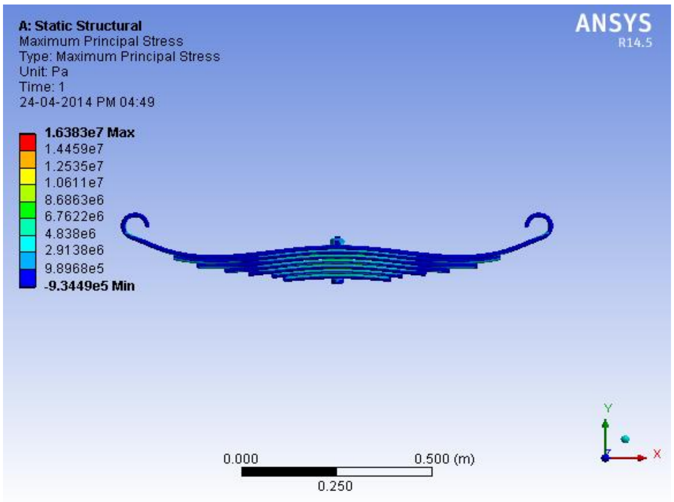

Fig. 11 maximum principle stress

Table. 1:

Type of leaf spring/ property	Structural steel constant thickness leaf spring	Structural steel variable thickness leaf spring	E-Glass variable thickness leaf spring
Total deformation(mm)	0.2097	0.209	0.8
Max principle stress(Pa)	1.639e+7	1.639e+7	1.639e+7
%reduction in weight	-	26	70

VI. CONCLUSION

In order to reduce the weight of the component Epoxy/E-carbon is better compared to variable thickness of steel. In order to the get the minimum deflection variable thickness is better compared both structural steel and E-carbon.

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