Design and Material Optimization of Jeep Leaf Spring

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***Abstract*—** The Automobile Industry has shown increase interest for replacement of steel leaf spring with that of composite leaf spring, since the composite material has high strength to weight ratio, good corrosion resistance. The paper describes static and dynamic analysis of steel leaf spring and laminated composite Multi leaf spring. The objective is to compare displacement, frequencies, deflections and weight savings of composite leaf spring with that of steel leaf spring. The dimensions of an existing conventional steel leaf spring of a Light design calculations. Static and Dynamic Analysis of 3-D model of conventional leaf spring is performed using ANSYS 14.5. Same dimensions are used in composite multi leaf spring using Aluminum Alloy unidirectional laminates. Analysis is done by layer stacking method for composites by changing reinforcement angles for 3 layers, 5 layers and 11 layers. The weight of composite leaf spring is compared with that of steel leaf spring. The design constraints are stresses and deflection. A weight reduction of 27.5 % is achieved by using composite leaf spring. in its style sheet.

***Keywords*—**Structural Steel, Kevlar/Epoxy, Aluminium Alloys, Leaf Spring, Static Analysis, Dynamic Analysis FEA.

I. INTRODUCTION

Suspension can be considered as a link between the wheels and the body. It absorbs quick loadings and collects the elastic energy. Design fundamentals are based on the strength and comfort. The strength characteristics are usually determined according to the suspension type and loading. The comfort design fundamentals originate from the fluctuation and vibration point of view. The basic idea for the design is to generate the wanted elasticity and maintain the driving comfort. Suspensions mechanisms also can use different types of springs in the mechanism. The most common are the coil spring, torsion bar, pneumatic, and leaf spring. The choice of spring normally has little effect on suspension performance.

II. OBJECTIVES

In the present scenario, weight reduction has been the main focus of automobile manufactures. The suspension leaf spring is one of the potential items for weight reduction in automobiles as it accounts for ten to twenty percent of the unsprung weight, which is considered to be the mass not supported by the leaf spring. The introduction of composite materials made it possible to reduce the weight of the leaf spring without any reduction on the load carrying capacity and stiffness. Studies were conducted on the application of composite structures for automobile for automobile suspension system.

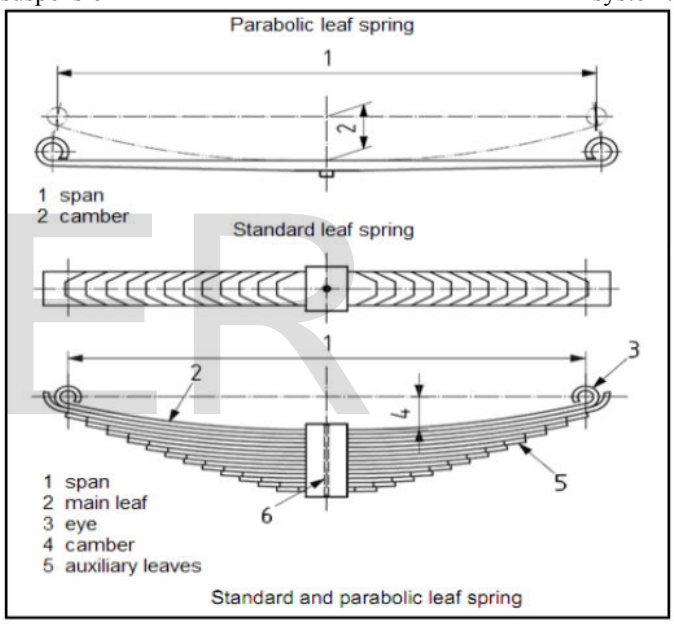


Fig. 1: Parabolic of Leaf Spring

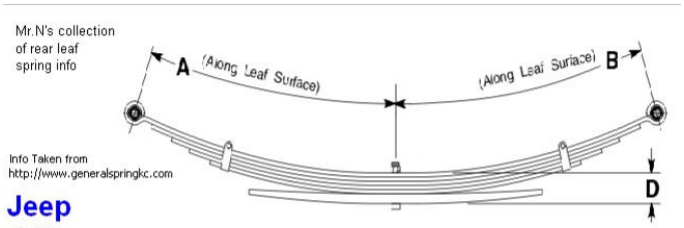
III. DESIGN OF LEAF SPRING

A spring is defined as an elastic machine element, which deflects under the action of the load and returns to its original shape when the load is removed. It can take any shape and form depending upon the application. The important functions and applications of springs are as follows:

- Springs are used to absorb shocks and vibrations, e.g., vehicle suspension springs, railway buffer springs, buffer springs in elevators and vibration mounts for machinery.
- Springs are used to store energy, e.g., springs used in clocks, toys, movie-cameras, circuit breakers and starters.

- Springs are used to apply force and control motion.

A. Specifications Of A Jeep Model:



Jeep

44" 1976 - 1986 Jeep CJ Leaf Springs

Years	Application	# Leaves	Width	Measures (A / B)	Pack Thick. (D)	Spring Capacity
76-86	Jeep CJ Front	4	2	22-1/16 x 22-1/16	1-1/16	640
76-86	Jeep CJ Front	6	2	22-1/16 x 22-1/16	1-1/2	890
76-86	Jeep CJ Front	6/1	2	22-1/16 x 22-1/16	1-11/16	920
76-86	Jeep CJ Rear	4	2-1/2	22-9/16 x 22-9/16	1-1/16	780
76-86	Jeep CJ Rear	5	2-1/2	22-9/16 x 22-9/16	1-1/4	840
76-86	Jeep CJ Rear	6/1	2-1/2	22-9/16 x 22-9/16	1-11/16	900
76-86	Jeep CJ Rear	7/2	2-1/2	22-9/16 x 22-9/16	2-1/8	1200

B. Modelling of Leaf Spring :

CREO PARAMETRIC is a feature based, parametric solid modelling system with many extended design and manufacturing applications which is developed by PARAMETRIC TECHNOLOGY CORPORATION, as a comprehensive CAD/CAE/CAM system, covering many aspects of mechanical design, analysis and manufacturing, CREO PARAMETRIC represent the leading CAD/ CAM/CAE technology. The solid model of the laminated leaf spring component part can be created through the following steps Create the parts of the laminated leaf spring with a coordinate system. Datum Planes are chosen as reference planes for constructing and dimensioning solid models. Commands like, sketch, extrude, line, circle, arc are used for creating the leafs for the spring. Since Pro engineer is feature based design software, it is very simple to create solid parts in it Assemble the created parts. Proper constraints like, mate, align, move, rotate, spin etc., are given while assembling the parts to form the final component for the analysis. The final component is converted into an iges file to export into Ansys for analysis. The iges file is created as solid part.

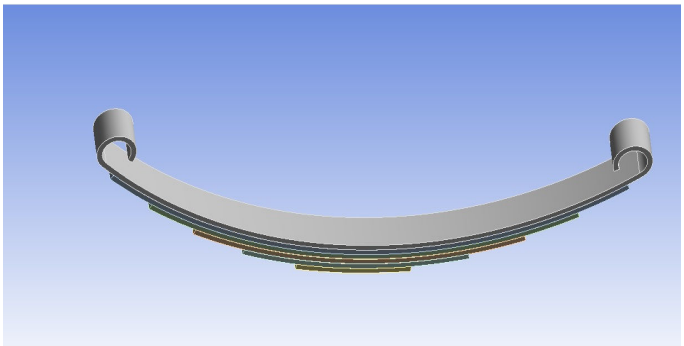


Fig.2. Cad model

C. Material Optimization:

In the present work, a seven-leaf steel spring used in heavy vehicle is replaced with a composite multi leaf spring made of Alumunium alloys and Kevlar/Epoxy. The dimensions and the number of leaves for both steel leaf spring and composite leaf springs are considered to be the same.

Properties	Structural Steel	Aluminium Alloy
Density	7850 kg m^-3	2770 kg m^-3
Compressive Yield Strength	2.5e+008 Pa	2.8e+008 Pa
Tensile Ultimate Strength	4.6e+008 Pa	3.1e+008 Pa
Young's Modulus	2.e+011 Pa	7.1e+010 Pa
Poisson's Ratio	0.3	0.33

Table 1.Material Properties

D. Analysis:

The Stress analysis and Total deformations have been computed for both the design materials on Ansys Workbench.

Stress Concentration Comparison:

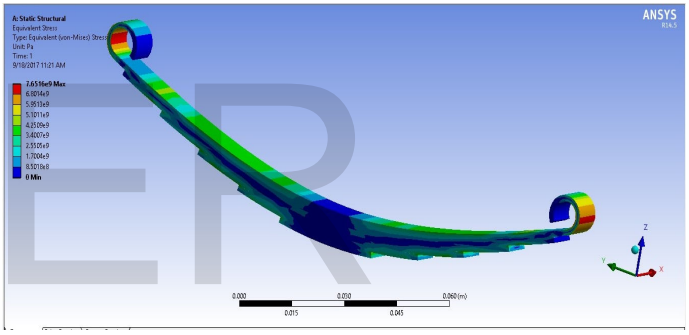


Fig.3.Structural Steel

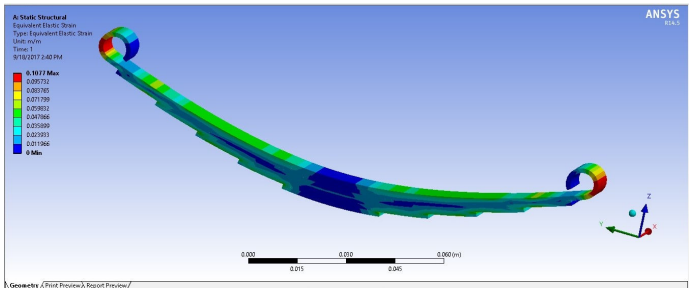


Fig.4.Aluminium Alloy

Total Deformation Comparison

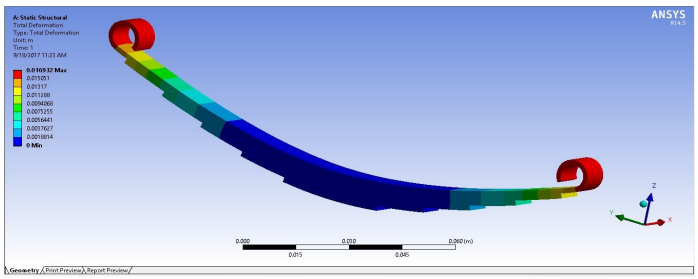


Fig.5. Structural Steel

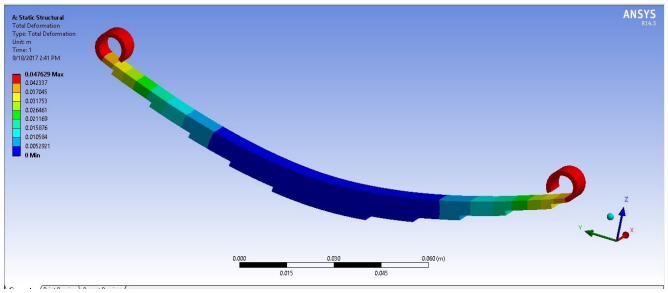


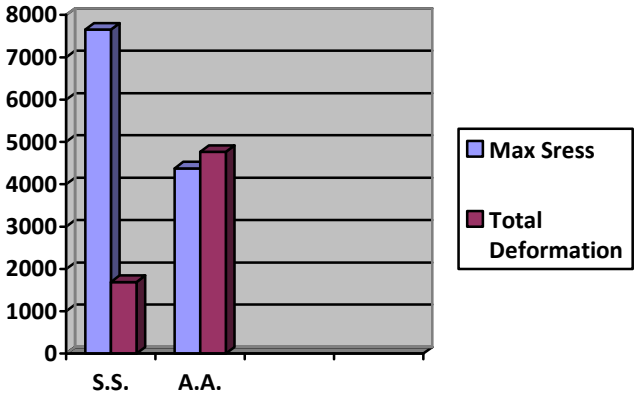
Fig.6.Aluminium Alloy

E. Analytical Values

Structural analysis is the most common application of the finite element engineering structures such as bridges and buildings, but also naval, aeronautical, and mechanical structures such as ship hulls, aircraft bodies, and machine housings, as well as mechanical components such as pistons, machine parts, and tools

In the present scenario, weight reduction has been the main focus of automobile manufactures. The suspension leaf spring is one of the potential items for weight reduction in automobiles as it accounts for ten to twenty percent of the unsprung weight, which is considered to be the mass not supported by the leaf spring. The introduction of composite materials made it possible to reduce the weight of the leaf spring without any reduction on the load carrying capacity and stiffness. Studies were conducted on the application of composite structures for automobile for automobile suspension system.

Objects	Structural Steel	Aluminium Alloy
Density	7850 kg m^-3	2770 kg m^-3
Max Stress	7.6516e+009 Pa	4.3732e+009 Pa
Total Deformation	1.6932e-002 m	4.7629e-002 m



IV. Results & Observation

On the basis of the results of the dynamic analysis and observation of the values it can be concluded that Aluminium Alloy not only reduces the weight of leaf spring but also decreases the stress values in comparison with the regular structural steel leaf springs.

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