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Analysis Of Steel And Composite Leaf Spring

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1. Abstract

A leaf spring is a long, flat, thin and flexible piece of spring steel or composite material that resists bending. The basic principles of leaf spring design and assembly are relatively simple and leaves have been used in various capacities since medieval times. Most heavy duty vehicles today use two sets of leaf springs per solid axle, mounted perpendicularly to the axle and supporting the vehicle's weight. This system requires that each leaf set act as both a spring and a horizontally stable link. In this paper Steel and composite leaf springs are designed in catia and analysis has been done by using Ansys and the results are compared.

Keywords: Leaf spring, axle, catia, Ansys.

2. Introduction.

Kumar Krishna and Agarwal M.L carried out on a multi leaf spring having nine leaves used by a commercial vehicle. The finite element modeling and analysis of a multi leaf spring has been carried out. It includes two full length leaves in which one is with eyed ends and seven graduated length leaves. The material of the leaf spring is SUP9.The FE model of the leaf spring has been generated in CATIA V5 R17 and imported in ANSYS-11 for finite element analysis, which are most popular CAE tools. (1)

Pankaj Saini, Ashish Goel and Dushyant Kumar reducing weight while increasing or maintaining strength of products is getting to be highly important research issue in this modern world. Composite materials are one of the material families which are attracting researchers and being solutions of such issue. In this paper we describe design and analysis of composite leaf spring. The objective is to compare the stresses and weight saving of composite leaf spring with that of steel leaf spring. The design constraint is stiffness. The Automobile Industry has great interest for replacement of steel leaf spring with that of composite leaf spring, since the composite materials has high strength to weight ratio, good corrosion resistance. (2)

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reducing weight of vehicles and increasing or maintaining the strength of their spare parts is considered.(3)

3. Experimental Work.

3.1. Modeling of leaf spring.

Determination of length of leaf spring leaves, consequently the rotation angle and the radius of curvatures of each leaf, these are used in geometric modeling. There is a difference in measurement between the terms "spring arch" and "spring camber". Both are a height measurement and both are referenced from the center mounting surface. Arch is measured to the center of the end mounting eyes.

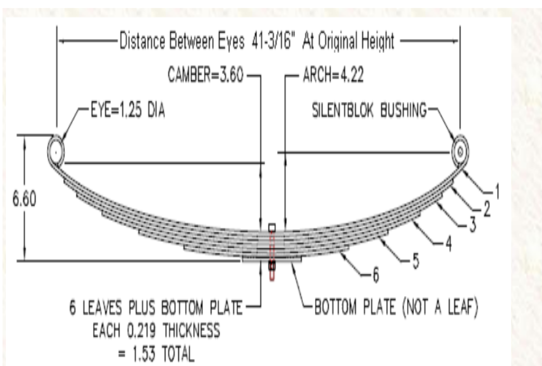


Fig. 3.1. Standard Semi elliptical leaf spring

Distance between eyes = 1100mm

Camber = 96.8mm

Height = 167.64mm

For the leaf spring in original form,

Free Camber = 3.60" (factory specification)

spring eye = 1-1/4" diameter (0.625"-radius).

Leaf thickness = 7/32"

Number of functional leaves = 6

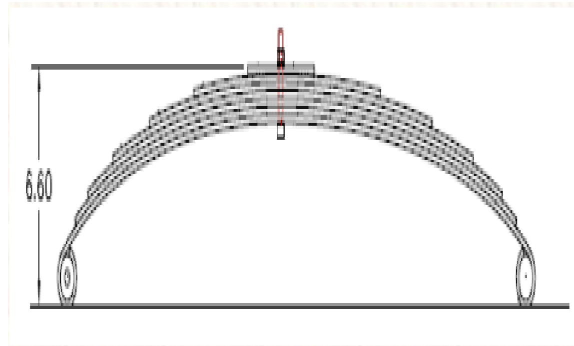


Fig. 3.2. Standard Semi standard height of elliptical leaf spring

0.22 = Thickness of top loop
1.25 = Eye inside diameter
3.60 = Free camber
1.31 = Spring thickness (7/32 x 6 leaves)
0.22 = Bottom plate (short, flat, non-functional)
6.60 = Total spring height, not including center bolt

Fig 3.3 shows final designed model of leaf spring in catia v5 for 55 si 7.

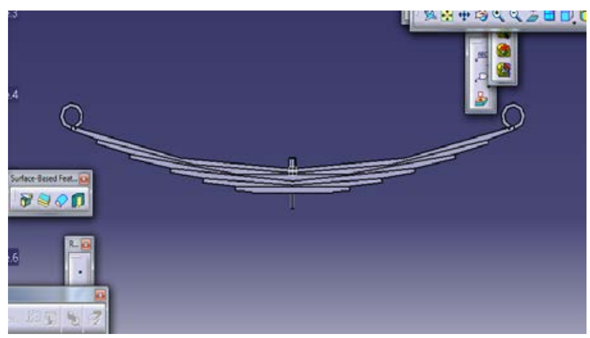


Fig. 3.3. si 7 Leaf Spring Designed in Catia v5

Fig 3.4 shows static structural analysis for (55 si 7) steel leaf spring

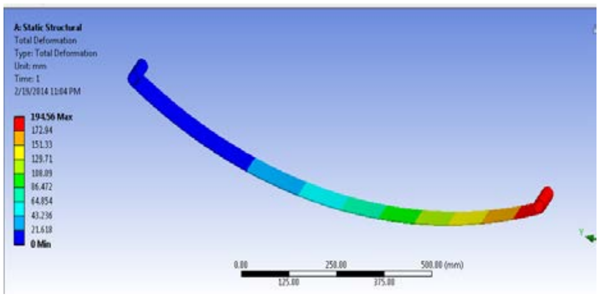


Fig. 3.4 Total deformation 500(N).

3.2. Design parameters of composite leaf spring.

By varying the dimensions and considering the composite material large variation of stress, strain and deformation is obtained when compared with 55 si 7 steel.By considering the modified design values the weight of E-glass/Epoxy leaf spring weight 2.8 Kg and Jute/E-glass/Epoxy leaf spring weighs 2 Kg.

fig 3.5 shows static structural analysis for e-glass/epoxy leaf spring.

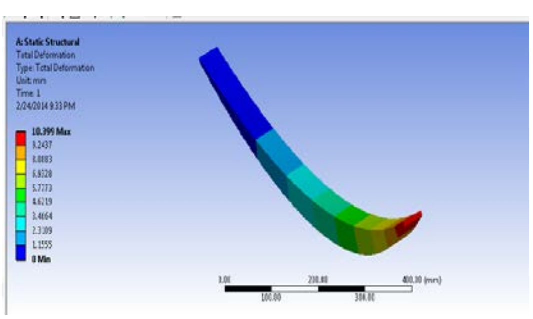


Fig. 3.5 Total deformation 1000(N).

4. Results and Discussion.

A semi-elliptical leaf spring may be considered as two cantilever leaf springs, and a full-elliptical leaf spring.

Let

F= force applied at the end of the leaf spring

b = width of each leaf spring

t = thickness of each leaf

n = number of graduated leaves

l = length of the spring

σb = bending stress

Maximum bending movement, M_{max} =F l

M_{max}

Bending stress , $\sigma b = \frac{Mmax}{Z}$, where

$Z = \frac{nbt^2}{6}$ = $\sigma b = \frac{6F\,l}{nbt^2}$

$\sigma b = \frac{6X\ 500\ X\ 1049.26}{6\ X\ 56\ X\ 6^2}$ = 260.23 N/mm^2

Maximum deflection, $\delta_{max} = \frac{6Fl^3}{Enb\,t^2}$

$\delta_{max} = \frac{6X\ 500\ X\ 1049.26^3}{2.1X\ 10^3\ X\ 6\ X\ 56\ X\ 6^3}$ = 238.75 mm

Strain energy $U = \frac{P^2}{A\ X\ E}$ = 0.0009 MJ

4.1. Comparison of 55 si 7 steels with theoretical and simulation results

Table 4.1: Comparison between Theoretical and Simulation results of 55Si7.

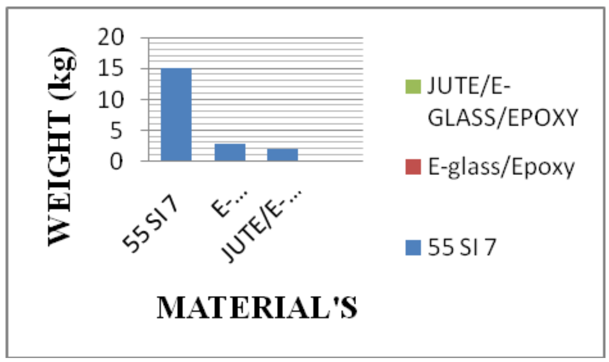
	Total deformation (mm)		Stress (N/mm^2)		Strain energy (MJ)	
LOAD (N)	Theoretical values of steel	Ansys values of steel	Theoretical values of steel	Ansys values of steel	Theoretical values of steel	Ansys values of steel
500	238.75	194.56	260.23	167.05	0.0009	0.0007
1000	477.50	389.12	520.46	334.11	0.0019	0.0015
1500	716.25	583.68	780.699	501.16	0.0028	0.0023
2000	955.00	778.25	1040.93	668.21	0.0036	0.0031
2500	1193.76	972.81	1301.165	835.26	0.0046	0.0039

4.2. Comparison between [a](e-glass/epoxy) leaf spring and [b](jute/e-glass/epoxy).

Table .2: Comparison between E-Glass/Epoxy and Jute/E-Glass/Epoxy results.

	Total Deformation(mm)		Stress (N/mm^2)		Strain energy (MJ)	
LOAD (N)	[A]	[B]	[A]	[B]	[A]	[B]
1000	10.39	11.88	12.822	12.822	0.00053	0.00061
2000	20.78	23.76	25.644	25.645	0.00106	0.00122
3000	31.19	35.65	38.466	38.467	0.00160	0.0018
4000	41.59	47.53	51.287	51.289	0.0021	0.00244

Bar - Chart drawn for the comparison of weight of both steel and composite leaf springs. The bar chart drawn below shows the comparisons in leaf spring weight (Kg) in case of steel and composite material. From this comparison of bar chart it is easily observed that the weight reduction in leaf spring. For steel leaf spring weight is 15kg and for composite leaf springs it is 2 & 2.8 kg.



Graph -1 indicates Weight Vs Material

The conventional steel leaf spring weighs about 15 Kg whereas E-glass/Epoxy leaf spring weighs 2.8 Kg and Jute/E-glass/Epoxy leaf spring weighs 2 Kg. Thus the weight reduction of 37% is achieved while using composite leaf spring and further if we use hybrid composite leaf spring in place of steel leaf, weight reduction of 55% is achieved.

5. Conclusion

The 3-D modeling of both steel and composite leaf spring is done and analyzed A comparative study has been made between composite and steel leaf spring with respect to deflection, strain energy and stresses. From the results,

1. This work provides optimum values for design variables (leaf spring thickness and width) of hybrid composite leaf spring by using Finite Element Analysis.

2. Weight can be reduced by 55% if steel leaf spring is replaced by Jute/E-Glass/Epoxy hybrid composite leaf spring. Weight reduction reduces the fuel consumption of the vehicle.

3. At various loading conditions, hybrid composite leaf spring is found to have less stresses and deflections as compared to conventional steel leaf spring.

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