Volume-6, Issue-1, January - 2017 • ISSN No 2277 - 8160 IF : 3.62 | IC Value 80.26

Original Research Paper Engineering

Designing and Comparative Analysis of EN-45 Steel Mono Leaf Spring with Composite Material Mono Leaf Spring under Static Loading Condition

Nishant Bhosle
Bachelor of Engineering, UG Student, Department of Mechanical Engineering,Acropolis Institute of Technology and Research, Indore, Madhya Pradesh, India

ABSTRACT *This paper gives a look on how weight of leaf spring is reduced along with bending stresses while maintaining stiffness of leaf spring. CAD model of leaf spring is designed on CRE-O 2.0 and analysis is carried out using ANSYS 14.5. The material used for leaf springs is generally having 0.90 to 1.0% carbon content. For example, conventional spring materials such as 50CrV4, EN45, EN47, etc. are being used since ages because of their tendency to return to their original shape despite of significant deflection. In this paper a mono leaf spring of E-GLASS/EPOXY material is designed and compared with EN45 steel.*

KEYWORDS : EN45 Steel, E-Glass, Creo 2.0, Ansys 14.5, Mono Leaf Spring.

INTRODUCTION

Leaf spring is a main component of an automobile suspension system. They are mainly used to absorb shock loads, sudden jerks and also to support the weight of vehicle. Elasticity is a must condition for a leaf spring as it has to expand when load is applied on it and regain its original shape when load is removed. Leaf springs are sometimes referred to as laminated springs. The centre of this arc-shaped spring is usually attached to the axle of the vehicle it supports and its one end is attached to the chassis while other end will be attached to a short swinging arm known as a shackle. Since leaf spring accounts for the 15-20% of total un-sprung weight of vehicle, it has always been a matter of interest to mitigate its weight while maintaining its stiffness as it was. Reduction in weight and equivalent stress can be efficiently achieved by using composite material such as E-Glass/Epoxy in place of conventionally used EN45 Steel. Main consideration in leaf spring design is stiffness-strength relationship along with weight. Stiffness can be defined as the rigidity of an object i.e. the extent to which it resists deformation in response to the force applied.

Fig.1 Mono leaf spring

Leaf spring CAD Model is designed in CRE-O 2.0 and analysis is carried out theoretically as well as in ANSYS 14.5. Comparative results of equivalent stresses induced and deformation occurred in EN45 Steel leaf spring and E-Glass/Epoxy leaf spring at different loads shows the advantages of using Epoxy material over conventional steel material for manufacturing of leaf spring.

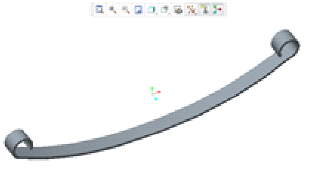


Fig.2 CAD Model of leaf spring

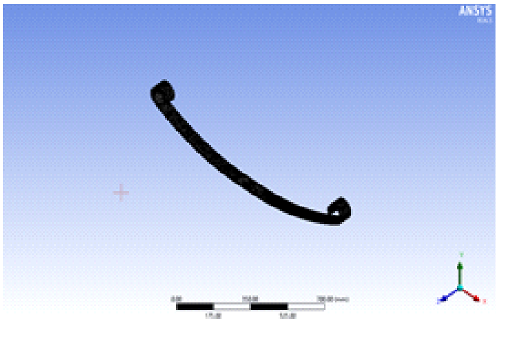


Fig.3 Meshing of leaf spring

PROBLEM DESCRIPTION

Weight of an automobile plays a vital role in deciding its efficiency in actual working condition. Conventionally, leaf springs were made up of heavy spring steel materials such as 50CrV4, EN45, EN47, etc which accounted almost 20% of the total un-sprung weight of vehicle. Therefore, to overcome this bulky and heavy weight drawback of conventionally used materials, an attempt is made to replace these materials with advanced composite materials. Work in this paper is mainly concentrated on using E-Glass/Epoxy composite material. Using E-Glass composite material in place of EN45 Steel will provide a comfortable ride along with improved vehicle efficiency because of reduction in weight.

METHODOLOGY OF RESEARCH

The foremost aim of this research is to develop an efficient and practical methodology for weight and stresses mitigation of Mono Leaf Spring model. The proposed methodology consists of four main stages. In first stage, CAD models of existing EN45 leaf spring and redesigned Epoxy material leaf spring are created on CRE-O 2.0 then these models are analysed at ANSYS 14.5. In second stage, theoretical calculations were done for keeping stiffness same for both the springs. In third stage, comparison of both CAD models was done on the basis of stresses produced in them at the time of loading. At last, results were compared for both the models.

SPECIFICATIONS OF THE CONVENTIONAL LEAF SPRING

Having elastic property is a must condition for leaf spring material. Conventional spring materials such as 50CrV4, EN45, EN47, etc. are being used since ages because of their tendency to return to their original shape. Material used for leaf springs is generally having 0.90 to 1.0% carbon content. Specifically, composition of EN45 Steel is given below:-

Carbon (C)	= 0.43 - 0.60%	Silicon (Si)	= 1.75%
Manganese (Mn)	= 0.50 - 0.90%	Phosphorus (P)	= 0.05%

Volume-6, Issue-1, January - 2017 • ISSN No 2277 - 8160

Sr. No.	Parameters	Values
1.	Span of leaf spring (eye to eye)	1183 mm
2.	Camber at no load condition	130 mm
3.	Number of full length leaves	01
4.	Thickness of leaf	8.25 mm
5.	Width of leaf spring	61.5 mm
6.	Internal diameter of each eye	35.5 mm
7.	**Mass of leaf spring**	**6.48 kg**

Table1. Dimensions of existing leaf spring from TATA SUMO GOLD

1.	Density	7850 kg/m^3
2.	Young's modulus	204000 N/mm^2
3.	Yield strength	350 N/mm^2
4.	Tensile strength	700 N/mm^2
5.	Poisson ratio	0.33

Table2. Mechanical properties of EN45 Steel

SPECIFICATIONS OF COMPOSITE MATERIAL LEAF SPRING

Elasticity is a must condition for a leaf spring as it has to expand when load is applied on it and regain its original shape when load is removed. Conventional leaf spring accounts for the 15-20% of total un-sprung weight of vehicle; it has always been a matter of interest to mitigate its weight while maintaining its stiffness as it was. For this purpose, Epoxy material is used for redesigning of mono leaf spring.

Composition of Epoxy resin is given below:-
Silicon dioxide = 54%; Aluminium oxide = 15%; Calcium oxide = 12%

Sr. No.	Parameters	Values
1.	Span of leaf spring (eye to eye)	1183 mm
2.	Camber at no load condition	130 mm
3.	Number of full length leaves	01
4.	Thickness of leaf	11.065 mm
5.	Width of leaf spring	65 mm
6.	Internal diameter of each eye	35.5 mm
7.	Mass of leaf spring	3.085 kg

Table3. Dimensions of Re-designed leaf spring using composite material

Material Properties

1.	Tensile strength of the material	900 MPa
2.	Compressive strength of the material	450 MPa
3.	Shear modulus (Gxy)	2433 MPa
4.	Shear modulus (Gyz)	1698 MPa
5.	Shear modulus (Gzx)	2433 MPa
6.	Poisson ratio along XY-dirction(μxy)	0.217
7.	Poisson ratio along YZ-dirction(μyz)	0.366
8.	Poisson ratio along ZX-dirction(μzx)	0.217
9.	Mass density of the material (ρ)	2.6e6 kg/mm^3
10.	Flexural modulus of the material	40000
11.	Flexural strength of the material	1200

THEORITICAL CALCULATIONS

Our motive is to reduce the stresses while maintaining its stiffness as it is.

STIFFNESS- It is defined as the rigidity of an object i.e. the extent to which it resists the deformation in response to an applied force. It is denoted by 'K'.

MATHEMATICALLY-
K= Force/Deflection.
Also, $K=(n*8*E*b*t^3)/(3L^3)$
Where,
n= No. of leaves= 1
E= Young's modulus of material (in N/mm^2)
b= Width of leaf (in mm)
t= Thickness of leaf (in mm)
L= Span of leaf (in mm)

1. Stiffness of EN45 Steel leaf spring-
$K=(n*8*E*b*t^3)/(3L^3)$
$=(1*8*204000*61.5*8.25^3)(3*1183^3)$
= 11.34701 N/mm.

2. Stiffness of Composite Material lead spring-
$=(1*8*204000*65*11.065^3)(3*1183^3)$
= 11.34702 N/mm.

Now, Percentage saving in mass of Re-designed leaf spring while keeping its stiffness constant is given by –

% saving in mass of leaf spring
= [Mass of EN45 spring – Mass of composite material spring]*100 / [Mass of EN45 spring]

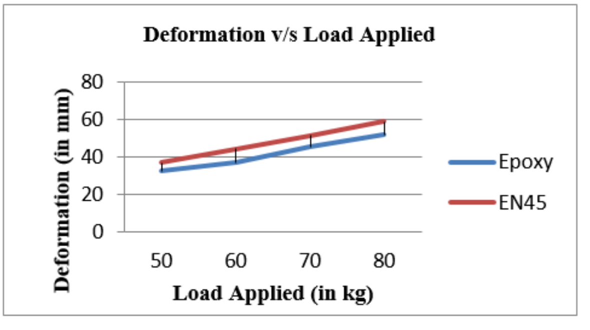
⇨ (6.489 – 3.085)/ (6.489) = 52.46%.

RESULTS AND CONCLUSION

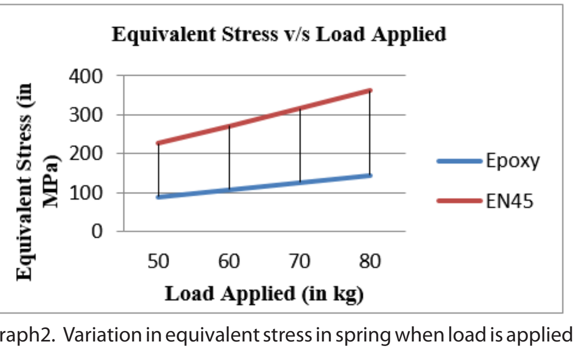
Results- To design composite material leaf spring, a stress analysis was performed under static loading conditions using ANSYS 14.5 software. Calculations show that **60.11%** reduction in equivalent stresses induced and mass reduction of **52.46%** is achieved successfully without compromising on stiffness of leaf spring.

Material		Parameters		
	Load (kg)	Deflection (mm)	Equivalent stress (MPa)	% reduction in stress
Epoxy	50	32.22	90.168	60.11 %
Steel	50	36.674	226	-
Epoxy	60	36.664	108.2	60.11 %
Steel	60	44.008	271.26	-
Epoxy	80	51.552	144.27	60.11 %
Steel	80	58.678	361.68	-
Epoxy	200	128.88	360.67	-

GRAPHS-



Graph1. Variation in deformation of spring when load is applied on it



Graph2. Variation in equivalent stress in spring when load is applied on it

ANSYS ANALYSIS RESULTS-

1. Deformation occurred in springs at various applied loads

1. at 490N

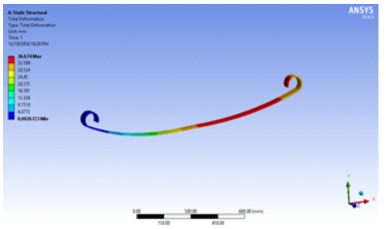


Fig. 4 EN45 Steel

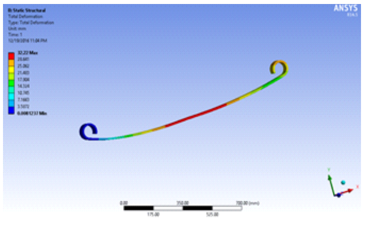


Fig. 5 Composite material

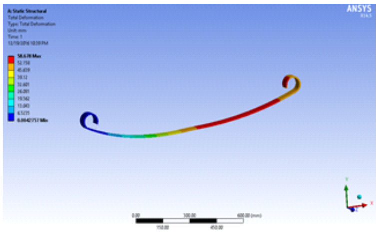


Fig. 6 EN45 Steel

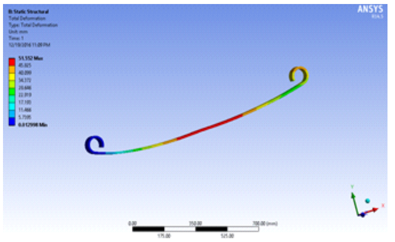


Fig. 7 Composite material

1. Stress induced in springs at various applied loads

1. at 490N

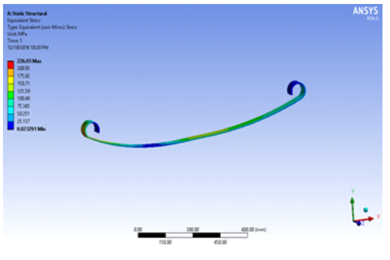


Fig. 6 EN45 Steel

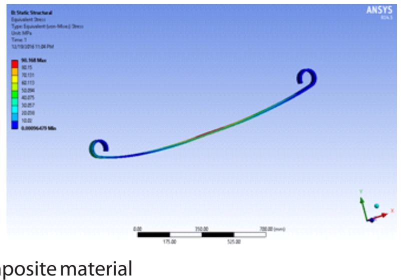


Fig. 7 Composite material

2. at 784N

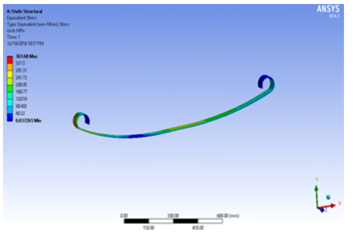


Fig. 8 EN45 Steel

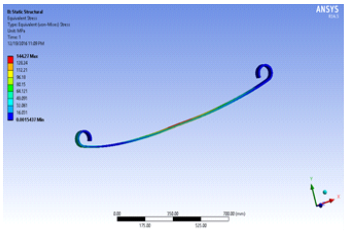


Fig. 9 Composite material

Above ANSYS results are based on two parameters viz. deformation occurred and stress induced in leaf spring when load is applied on it.

Conclusion:-

In my research, calculations show that **60.11%** reduction in equivalent stresses induced and mass reduction of **52.46%** is achieved successfully without compromising on stiffness of leaf spring. Also, Re-designed composite material leaf spring fails above 1960N **(200kg)** load due to exceeding deflection in spring while, in leaf spring made up of conventionally used EN45 Steel failures occurs at just 784N **(80kg)** load due to exceeding value of stress. This shows that Re-designed composite material leaf spring can support **60%** more weight and it weighs **52.46%** less than old EN45 Steel material.

REFERENCES

1. Chetna Wahane, Abhishek Jain, Vivek Khare, "Comparative Analysis of En 45 Steel & Thermoplastic Polyimide Used In Mono Leaf Spring under Static Loading Condition Using ANSYS" International Journal for Scientific Research & Development| Vol. 2, Issue 08, 2014 | ISSN (online): 2321-0613.
2. SushilB.Chopade, Prof.K.M.Narkar, Pratik K Satav "Design and Analysis of E-Glass/Epoxy Composite Mono leaf Spring for Light Vehicle". International Journal of Innovative Research in Science, Engineering and Technology Vol. 4, Issue 1, January 2015 DOI: 10.15680/IJIRSET.2015.0401026 www.ijirset.com 18801
3. Pankaj Saini, Ashish Goel, Dushyant Kumar "Design and analysis of composite leaf spring for light vehicles" International Journal of Innovative Research in Science, Engineering and Technology Vol. 2, Issue 5, May 2013 ISSN: 2319-8753.
4. Mr. Tharigonda Niranjan Babu , Mr P. Bhaskar, Mr. S. Moulali "Design and Analysis of Leaf Spring with Composite materials" international journal of engineering science & research technology ISSN: 2277-9655.
5. M. Patunkar, d. R. Dolas, "modelling and analysis of composite leaf spring. Under the static load condition by using fea" international journal of mechanical & industrial engineering, volume 1 issue 1- 2011.
6. Ajay B.K., Mandar Gophane, P Baskar. "Design and Analysis of Leaf Spring with Different Arrangements of Composite Leaves with Steel Leaves" International Journal of Engineering Trends and Technology (IJETT) – Volume 11 Number 2 - May 2014.
7. Avinash Sharma, Ajeet Bergaley, Satbeer Singh Bhatia "Design and Analysis of Composite Leaf Spring" – A Review. International Journal of Engineering Trends and Technology (IJETT) – Volume 9 Number 3 - Mar 2014.