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Design and analysis of functionally graded leaf spring structure

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ABSTRACT--- THE AIM OF THE PROJECT IS TO DESIGN A NEW CLASS LEAF SPRING BY USING FUNCTIONALLY GRADED MATERIAL AND FUNCTIONALLY GRADED STRUCTURAL CONCEPT. ANALYSIS IS DONE ON LEAF SPRING OF DIFFERENT MATERIALS HAVING HIGH STRUCTURAL STRENGTH AND DAMPING CAPACITY. WE KNOW THAT EVERY MATERIAL DOES NOT HAVE BOTH THE PROPERTIES. WE CAN ACHIEVE BOTH PROPERTIES IN COMPOSITE MATERIALS BUT WE CAN'T USE IT FOR HEAVY VEHICLES AND ALSO IT IS COSTLY. WE CAN ALSO ACHIEVE THE BOTH PROPERTIES IN CONVENTIONAL MATERIAL LEAF SPRING BY APPLYING THE CONCEPT OF FGM & FGS. IN STATIC ANALYSIS DEFORMATION, STRESS, STRAIN CAN BE FOUND OUT. MODAL ANALYSIS IS DONE TO FIND NATURAL FREQUENCY. WITH OPTIMIZATION IN DESIGN & MATERIAL WE CAN DETERMINE BEST QUALITY OF LEAF SPRING STRUCTURE. THE MODELLING OF THE LEAF SPRING HAS BEEN DONE IN SOLID WORKS. FINITE ANALYSIS OF THE LEAF SPRING IS CARRIED OUT IN ANSYS 14.5 WORK BENCH.

KEYWORDS--- FUNCTIONALLY GRADED MATERIAL, FUNCTIONALLY GRADED STRUCTURE, NATURAL FREQUENCY, STATIC ANALYSIS

I. Introduction

Leaf Spring

Originally it is called as laminated or carriage spring, a leaf spring is a simple form of spring that commonly used for suspension in wheeled vehicles. It is also one of the oldest springing and dating back to medieval times. The advantage of leaf spring compare to helical spring is that the end of the springs may be guided with a definite path. Leaf spring is also called as flat spring made up of flat plates. Leaf springs are designed in two ways. They are multi leaf and mono leaf. The leaf springs may carry loads, brake torque, driving torque etc, in addition to shocks. The multi leaf spring is made up of several steel plates of different lengths attached together. During normal operation, the spring compressed to absorb road shock. The leaf springs bend and slide on each other allowing suspension movement.

II. Construction of Leaf Spring

The leaves are normally given an initial curvature or cambered so that they will tend to straighten under the load. The leaves are placed together by means of band shrunk around them at the centre or by a bolt passing through the centre

Materials for Leaf Springs

The material used for manufacturing leaf springs is usually a plain carbon steel having a carbon 0.90 to 1.0 percent. The leaves are subjected to heat treatment after the forming process. The heat treatment of spring steel products gives greater strength, greater load capacity, greater range of deflection and better fatigue properties.

Working of a Leaf Spring

A leaf spring works on the principle of bending. When a load is applied at the ends bending occurs. Naturally, the structure resists bending. This result in a reaction force which opposes the load applies. Thereby we obtain the spring property of the leaf spring.

Material and Methodology

The material used is directly affects the quantity of storable energy in the leaf spring [1]. In general terms higher alloy content is mandatory to ensure adequate harden ability when the thick leaf sections are used. Plain carbon steel, Chromium vanadium steel are the typical materials that are used in the design of leaf springs. In this work the combination of both Structural Steel and Grey Cast Iron are used to design and analysis of leaf spring.

Properties of the materials

Material	Structural Steel
Young's Modulus	$2*10^5$Mpa
Poisson's Ratio	0.3
Density	7850 kg/m^3
Shear Modulus	$7.6323*10^4$
Tensile Yield Strength	250Mpa
Tensile Ultimate Strength	460Mpa
Compressive Yield Strength	250Mpa

Table-2.1 Mechanical Properties of Structural Steel

Material	Grey Cast Iron
Young's Modulus	138Gpa
Poisson's Ratio	0.28

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Density	7250 Kg/m^3
Thermal Conductivity	57K (w/mc̊)
Specific Heat	460 J/ kg c̊
Thermal Expansion	$10.85*10^{-6}{}_K$

Table-2.2 Mechanical Properties of Grey Cast Iron

The main aim of this work is to design a good leaf spring which is having good structural strength and as well as good damping capacity. This can be achieved by using combination of structural steel and grey cast iron this class of material is called as functionally graded material.

- Preparing the CAD model by using solid works
- Importing the CAD model to ANSYS for meshing and analysis purpose
- Analysis is done for various combination of materials of three leaves(GGG, GGS, GSS, SGS, SSG,SSS)
    - Structural Analysis(deformation, stress, strain)
    - Modal analysis(natural frequency)
- Tabulating and compare the results then select the best material combination leaf spring
- Again analysis is done on different structure of leaf spring

III. Results and Tables

Modeling and Analysis of leaf spring is done on the basis of two concepts those are

- By grading the material
- By varying the structure

According to Functionally Graded Material

TYPE OF FGS	DEFORMATION IN M	STRESS IN PA	STARIN	NATURAL FREQUENCY IN HZ
SGS	0.00027696	2.26e+07	0.0001132	63.534
SSG	0.00031483	2.72e+07	0.0001361	59.719
SSS	0.0002667	2.27e+07	0.00011388	63.977
GSS	0.00031054	1.84e+07	0.0001331	59.91
GGS	0.00032209	1.86e+07	0.00013506	59.555
GGG	0.00038424	2.27e+07	0.00016477	55.331

Table-3.2 deformation analysis

TYPE OF FGS	STRESS IN pa
SGS	2.26E+07
SSG	2.72E+07
SSS	2.27E+07
GSS	1.84E+07
GGS	1.86E+07
GGG	2.27E+07

Table-3.3 von mises stress in pa

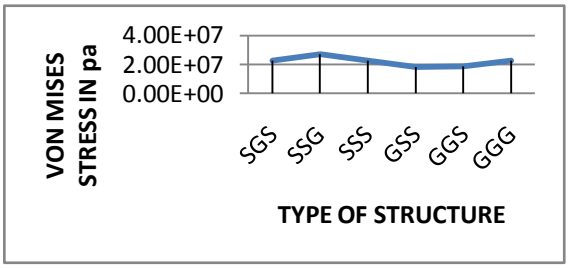

Fig-3.2 von mises stress v/s type of structure

TYPE OF FGM	DEFORMATION in m
SGS	0.00027696
SSG	0.00031483
SSS	0.0002667
GSS	0.00031054
GGS	0.00032209
GGG	0.00038424

TYPE OF FGS	STRAIN
SGS	0.0001132
SSG	0.0001361
SSS	0.00011388
GSS	0.0001331
GGS	0.00013506
GGG	0.00016477

Table-3.4 von mises strain

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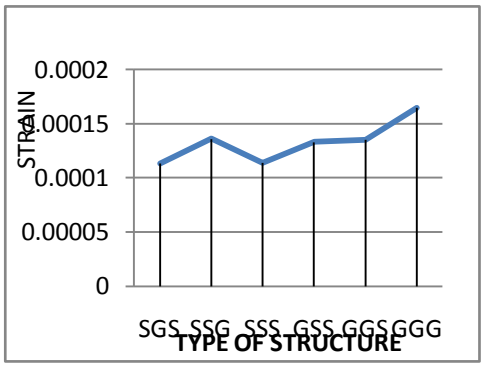

Fig- 3.3 strain v/s type of structure

TYPE OF FGM	NATURAL FREQUENCY in Hz
SGS	63.534
SSG	59.719
SSS	63.977
GSS	59.91
GGS	59.555
GGG	55.331

Table-3.5 mode 1 natural frequency in hz

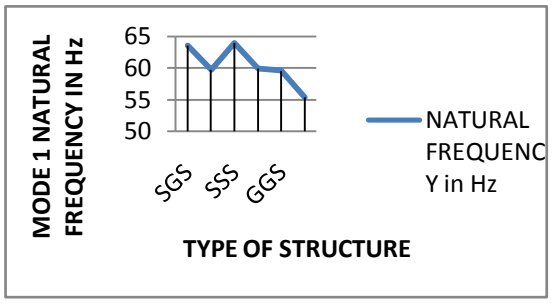

Fig-3.4 natural frequency v/s type of structure

- The above graph s and tables shows deformation is less for the combination of SSS and stress is minimum for GSS and natural frequency is minimum for GSS & GGS. Natural frequency is minimum for GGG combination
- The above analysis is shows that SSS combination has less deformation and GGG combination has high damping capacity
- The intermediate combination GSS & GGS provides moderate structural strength and moderate damping capacity
- The above combination can be improved by FGS concept

- **According to Functionally Graded Structure**

IV. STATIC ANALYSIS

SL NO	DEFORMATION IN m
BASIC	0.00029076
MODEL 1	0.0002667
MODEL 2	0.00026673

Table-3.6 deformation analysis

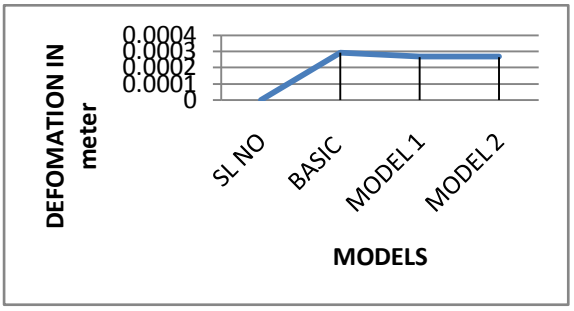

Fig-3.5 deformation v/s models

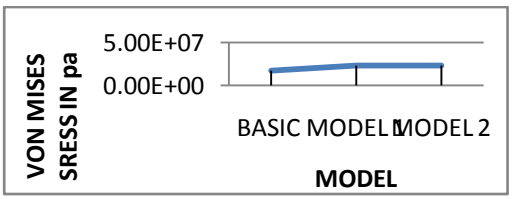

Fig-3.6 von mises stress v/s model

SL NO	STRESS In pa
BASIC	1.76E+07
MODEL 1	2.32E+07
MODEL 2	2.32E+07

Table-3.7 stress analysis

- By observing above graphs and table the model 1 and model 2 have less deformation, stress and strain but model one has very less deformation
- In modal analysis compare to all the analysis model 1 is the best

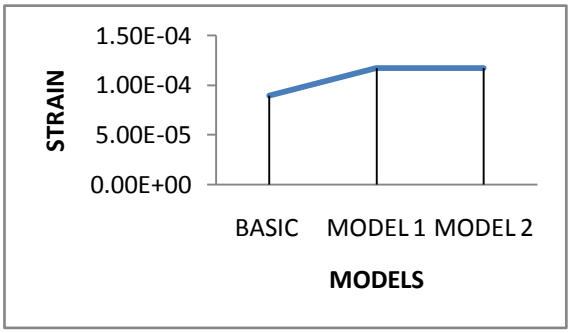

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Fig-3.7 strain v/s models

SL NO	STRAIN
BASIC	8.94E-05
MODEL 1	0.000117
MODEL 2	0.000117

Table-3.8 strain analysis

V. Conclusion

By the combination of Functionally Graded Material and Functionally Graded Structural concept, GSS(grey cast iron, structural steel, structural steel) and GGS(grey cast iron, grey cast iron, structural steel) combined with MODEL 1 is best optimized leaf spring model.

References

[1]. M.Venkateshan , D.Helmen Devraj, "design and analysis of leaf spring in light vehicles", IJMER 2249-6645 Vol.2, Issue.1,pp.213-218, Jan-Feb2012.

[2]. R.S.Khurmi and J.K.Gupta Machine Design chapter 23.

[3]. U. S. Ramakant & K. Sowjanya, "Design and analysis of automotive multi leaf springs using composite material", IJMPERD 2249-6890 Vol. 3,Issue 1,pp.155-162, March 2013,

[4]. Rajendran I., Vijayarangan S., "Design and Analysis of a Composite Leaf Spring"Journal of Institute of Engineers, India ,vol.-8,2-2002

[5]. Dakshraj Kothari,Rajendra Prasad Sahu and Rajesh Satankar Comparison of Performance of Two Leaf Spring Steels Used For Light Passenger Vehicle, VSRD-MAP 2249-8303 Volume2 (1), 9-16, 2012

[6]. Mr. V. Lakshmi Narayana, "Design and Analysis Of Mono Composite Leaf Spring For Suspension in Automobiles" IJERT 2278-0181, Vol. 1 Issue 6, August – 2012

[7]. Shishay Amare Gebremeskel, "Design, Simulation, and Prototyping of Single Composite Leaf Spring for Light Weight Vehicle", Global Journals Inc. (USA) 2249-4596, Volume 12 Issue 7, 21-30, 2012

[8]. Manas Patnaik, NarendraYadav, "Study of a Parabolic Leaf Spring by Finite Element Method & Design of Experiments" , IJMER 2249- 6645, Vol.2, 1920-1922, July-Aug 2012

[9]. Kumar Krishan, Aggarwal M.L, "Computer Aided FEA Comparison of mono steel and mono GRP leaf spring", IJAERS 2249–8974, vol. 1 issue 2, pp. 155-158, jan- march 2012

[10]. Mr. V. K. Aher *, Mr. P. M. Sonawane , Static And Fatigue Analysis Of Multi Leaf Spring Used In The Suspension System Of LCV, (IJERA) 2248-9622 Vol. 2, Issue 4, pp.1786-1791, July-August 2012

[11]. B. Raghu Kumar, R.VijayaPrakash and N. Ramesh, Static analysis of mono leaf spring with different composite materials" JMER , 2141- 2383, Vol. 5(2), pp.32-37, February 2013

[12]. Y. N. V. Santhosh Kumar & M. Vimal Teja,Design and Analysis of Composite Leaf Spring International Journal of Mechanical and Industrial Engineering (IJMIE), ISSN No. 2231 –6477, Vol-2, Issue-1,pp. 97-100, 2012

[13]. Deshmukh.et.al, Design and analysis of fibber reinforced polymer (FRP) leaf spring-A review, International journal of engineering technology and science, Vol.2(4), pp 289-291, 2011.

[14]. William D. Callister Material science and engineering.

[15]. Robert C. Juvinall, Kurt M. Marshek fundamentals of machine component design

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