IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 10, Issue 4 (Nov. - Dec. 2013), PP 38-41
www.iosrjournals.org

Performance Comparative Analysis of S-Glass Epoxy Composite Leaf Spring with Mild Steel Leaf Spring

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Abstract: *A leaf spring is a simple form of spring, commonly used for the suspension in wheeled vehicles. Leaf Springs are long and narrow plates attached to the frame of a trailer that rest above or below the trailer's axle. There are mono leaf springs, or single-leaf springs, that consist of simply one plate of spring steel. These are usually thick in the middle and taper out toward the end, and they don't typically offer too much strength and suspension for towed vehicles. Drivers looking to tow heavier loads typically use multi leaf springs, which consist of several leaf springs of varying length stacked on top of each other. The shorter the leaf spring, the closer to the bottom it will be, giving it the same semi elliptical shape a single leaf spring gets from being thicker in the middle. Presently leaf spring is made up with forged steel. In this paper, we designed leaf spring for the materials Mild Steel and composite material s-glass epoxy and compared their performance in terms of deflection, stress and vibration. We also checked the strength variations while changing layers. For validating this design, we conducted FEA Structural Analysis on both steel leaf spring and composite leaf spring.. Modal analysis is also done to compare vibration characteristics of steel and composite leaf springs*

Keywords – *semi elliptical, composites, leaf spring,*

I. Introduction

Semi-elliptic leaf springs are almost universally used for suspension in light and heavy commercial vehicles. For cars also, these are widely used in rear suspension. The spring consists of a number of leaves called blades. The blades are varying in length. The blades are us usually given an initial curvature or cambered so that they will tend to straighten under the load. The leaf spring is based upon the theory of a beam of uniform strength. The lengthiest blade has eyes on its ends. This blade is called main or master leaf, the remaining blades are called graduated leaves. All the blades are bound together by means of steel straps. The spring is mounted on the axle of the vehicle. The entire vehicle load is rests on the leaf spring. The front end of the spring is connected to the frame with a simple pin joint, while the rear end of the spring is connected with a shackle. Shackle is the flexible link which connects between leaf spring rear eye and frame. When the vehicle comes across a projection on the road surface, the wheel moves up, this leads to deflecting the spring. This changes the length between the spring eyes. The steel structure leaf springs are definitely heavy mass. In order to reduce the weight an attempt is made in this paper t with S-Glass Epoxy composites ,which is almost 50times less weight than steal spring.

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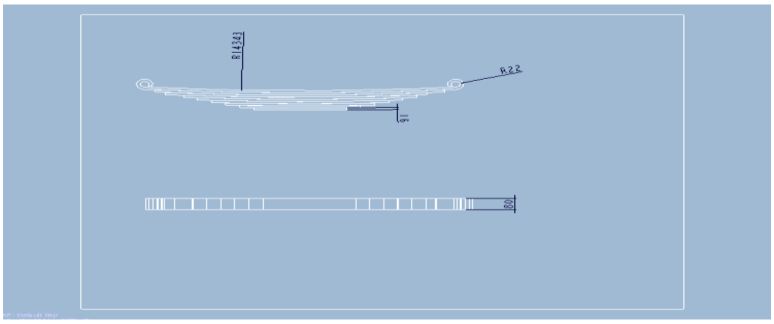
2D DRAWING



1.2 INTRODUCTION TO ANSYS

ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. The software implements equations that govern the behaviour of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results then can be presented in tabulated, or graphical forms. This type of analysis is typically used for the design and optimization of a system far too complex to analyze by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations.

II. Variation Of Exciting Frequency With Vehicle Speed

Speed (Kmph)	Frequency Hz (at WRI=1m)	Frequency Hz (at WRI =2m)	Frequency Hz (at WRI =3m)	Frequency Hz (at WRI=4m)	Frequency Hz (at WRI =5m)
20	5.5500	2.77	1.8518	1.3888	1.11111
40	11.1111	5.54	3.7037	2.7777	2.22222
60	16.6666	8.31	5.5555	4.1664	3.33333
80	22.2222	11.08	7.4074	5.5552	4.44444
100	27.7777	13.85	9.2593	6.9440	5.55555

Modal Calculation for excitation frequency:

Speed v = 100 kmph = 100 x 5/18 m/sec = 500/18 m/sec

WRI L = 1m

Excitation frequency = $2\pi \times (500/18)/1$ rad / sec

= $[2\pi \times (500/18)/1]/2\pi$ Hz = 27.7777 Hz

III. Modelling Of Leaf Spring In Pro/E

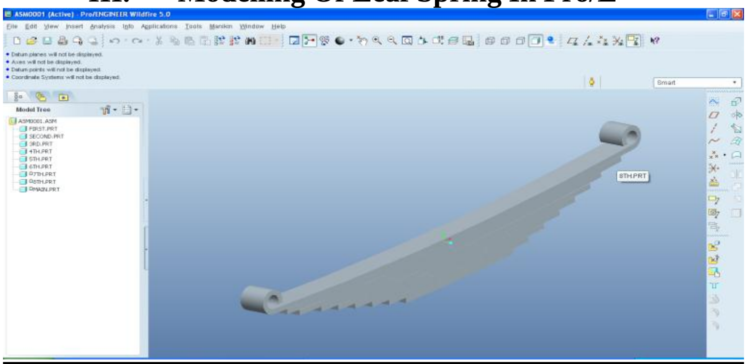


Fig 3.1 leaf spring designed in pro/e software

IV. Specific Capabilities Of Ansys

STRUCTURAL

Structural analysis is probably is the most common application of the finite element method as it implies mechanical structures such as ship hulls, aircraft bodies and mechanical housing as well as mechanical components such as piston, machine parts and tools.

Static analysis

Used to determine displacements, stress...etc. under static loading conditions. ANSYS can compute both linear and non-linear static analyses, non-linearity's can include plasticity stress stiffening, large deflection, large strain, hyper elasticity, contact surfaces and creep

Modal Analysis

A modal analysis is typically used to determine the vibration characteristics (natural frequencies and mode shapes) of a structure or a machine component while it is being designed. It can also serve as a starting point for another, more detailed, dynamic analysis, such as a harmonic response or full transient dynamic analysis.

Modal analyses, while being one of the most basic dynamic analysis types available in ANSYS, can also be more computationally time consuming than a typical static analysis. A reduced solver, utilizing automatically or manually selected master degrees of freedom is used to drastically reduce the problem size and solution time.

V. Analysis Of Leaf Spring

MILD STEEL

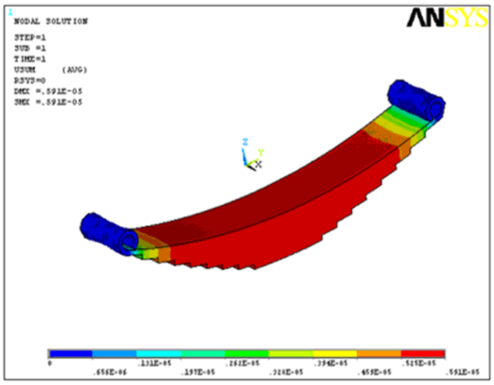
Element Type: Solid 20 node 95

Material Properties: Youngs Modulus (EX) : 205000N/mm^2

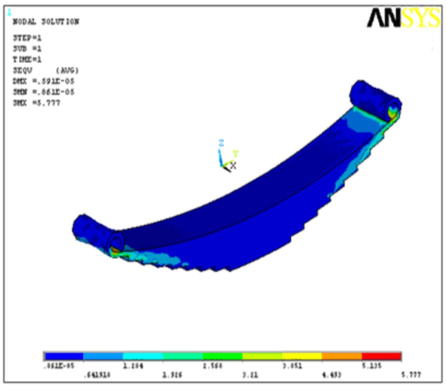
Poissons Ratio (PRXY) : 0.29

Density : 0.000007850 kg/mm^3

Displacement Vector Sum



Von Mises Stress



S – GLASS EPOXY

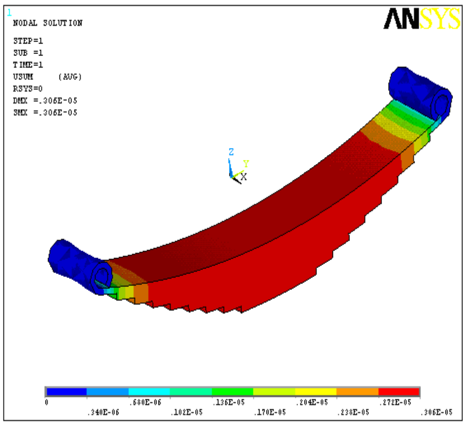
Element Type: Solid 20 node 95

Material Properties: Youngs Modulus (EX) : 88900N/mm^2

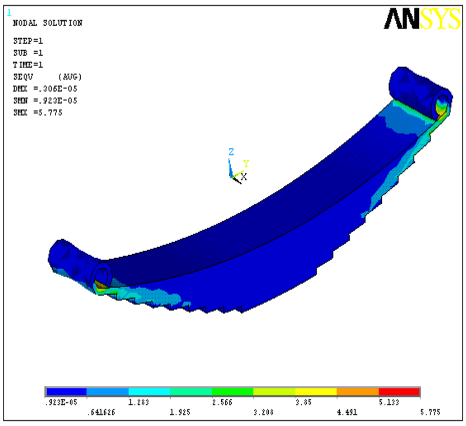
Poissons Ratio (PRXY) : 0.22

Density : 0.000002490 kg/mm^3

Displacement Vector Sum



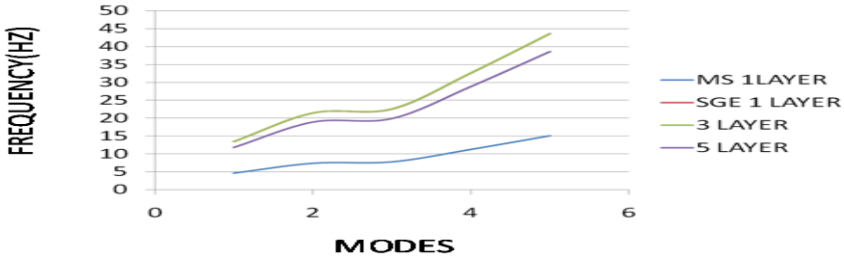
Von Mises Stress



VI. Results And Discussions

		ASSM		LAYERS FOR MAIN LEAF			
		MS	SGE	MS	SGE		
				1	1	3	5
	DISP (mm)	$0.591e^{-05}$	$0.306\ e^{-05}$	7.199	3.737	3.738	4.776
	STRESS (N/mm^2)	5.777	5.775	589.607	591.554	714.941	591.554
MODES	1. Hz mm	7142 6068	20704 12672	4.618 0.425203	13.391 0.888193	13.390 3.738	11.844 0.0888193
	2.Hz mm	12553 5253	36420 10974	7.379 0.589795	21.395 1.232	21.394 1.233	18.923 1.232
	3.Hz mm	14129 3830	40983 8000	7.762 0.455591	22.493 0.951639	22.548 0.950674	19.895 0.95164
	4.Hz mm	22717 6802	65798 14206	11.238 0.468818	32.582 0.979417	32.584 0.979669	28.818 0.979417
	5.Hz mm	33731 5492	97648 11477	15.033 0.42841	43.597 0.895252	43.583 0.897543	38.56 0.895252

6.1 GRAPH



VII. Conclusion

We have done structural and modal analysis on total assembly leaf spring. The results show:

1. The stresses in the composite leaf spring are much lower than that of the steel spring.
2. The strength to weight ratio is higher for composite leaf spring than conventional steel spring with similar design.

We have also done structural and modal analysis on the master leaf for single, 3 layers and 5 layers. From the results we observed, if number of layers are increased for same thickness the vibrations are less.
In this paper we are concluding that using composite S - Glass Epoxy is advantageous. The major disadvantages of composite leaf spring are the matrix material has low chipping resistance when it is subjected to poor road environments which may break some fibers in the lower portion of the spring. This may result in a loss of capability to share flexural stiffness. But this depends on the condition of the road. In normal road condition, this type of problem will not be there. Composite leaf springs made of polymer matrix composites have high strength retention on ageing at severe environments.

It is observed from the present work that the natural frequency increases, but natural frequency decreases with increase of layers. The natural frequencies of various parametric combinations are compared with the excitation frequency for different road irregularities. The values of natural frequencies and excitation frequencies are the same for both the springs as the geometric parameters of the spring are almost same except for number of leaves.

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