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Comparative Free Vibrational Analysis of Composite and Steel Leaf Spring.

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Abstract: *The paper deals with behavior composite leaf spring made up of Kevlar for free vibration. The experimental modal analysis is used for investigation. Free vibration method have been applied for measurement of natural frequency and mode shape. A standard steel leaf spring is taken as reference. The composite design is calculated via classical lamination theory and manufacturing was done by using machine lay-up and autoclave. An important aspect for spring is the behavior of spring at different loading conditions. At last numerical analysis of both spring can be done by using ANSYS version 2016 and compared it with experimentation results.*

Key words: **Kevlar, Natural frequency, Mode shape, Classical lamination theory, Machine lay-up.**

INTRODUCTION

Springs are structural components designed for significant deformation when loaded. The spring are generally designed to absorb and store energy and release it slowly during unloading. Function of spring for an automobile is to maintain good controlled stability and improved ride comfort. Therefore, strain energy of material and shape becomes major factor in designing the springs. Key design parameters of spring such as spring rate and failure loads are the function of spring thickness. Springs is reliable and persistent element in automobile which are generally formed by stacking of leaves of steels so that it is thicker at middle portion in order to resist bending and thinner at end to mount on body. It is subjected to tangential load, shear forces and bending forces. Automotive industries looks for improvement in the field of vehicle suspension by the enrollment of composite leaf spring due to least mass, capable of resisting corrosion and having better durability. Therefore industries shown increased interest in replacement of steel spring with composite leaf spring especially of fibers. In order to meet needs of natural resources and energy conservation, automobile manufactures tries to reduce the weight of vehicles. Composite materials has been developed for many applications mainly due to substantial weight saving other advantage are possibility of reducing noise, vibrations and high damping factor, lower maintenance and tooling cost which have favorable impact on manufacturing cost. As mentioned above, one of the most important characteristics of composite leaf spring is their weight, along with that it has high strength to weight ratio(up to 5 times of steel),no interleaf friction, better fatigue strength, corrosion resistance, higher natural frequency. In order to sustain in today's competition in composite, it is essential to control their failure by utilizing their strength in principal direction instead of shear direction. It has been proved that composite leaf spring in an elliptical configuration will eliminate the delamination and matrix quantity which helps to dominate failures. Low density and high elastic strain of Kevlar, S-glass material if provide them with specific strain energy which gives more compliant suspension system that offers more comfortable ride and minimizes damage to road track.

Table No.1.Properties of steel springs

Parameters	Specifications
Material	Steel ($55Si_2Mn_{90}$)
Tensile strength	1962 MPa
Yield strength	1470 MPa
Young's Modulus	210000 MPa
Spring weight	18 kg
Total length	1170 mm
Poisons ratio	0.3

Table No.2 Properties of composite

Parameters	Specification
Material	Kevlar-S glass
Density	1400 Kg/m^3
Tensile modulus	73000 MPa
Shear modulus	2300 MPa
Tensile Strength	1600 MPa
Shear Strength	34 MPa
Thermal Expansion	$-4*10^{-6}\mu m/^oC$
Spring weight	7 kg
Total length	1170 mm

ANALYSIS STRATEGY

Frequency Analysis Based on the Fast Former Transform (FFT) Algorithm is the tool of choice for measurement of vibration. The FFT analyser is recently developed pc based virtual instrument. It uses impulse execution and either frequency domain analysis or time – domain Analysis to entrant the model Parameter from the response measurement in real time. Following impulse are executions of the specimen the measured analog response signal may be digitalized and analysed using the domain techniques or transformed for analysis in the frequency domain using FFT analyser. The peaks in the frequency response spectrum are the location of natural frequency.

EXPERIMENTATION

For carrying out free vibration test, modal hammer is used and for forced vibration, harmonic exciter is used. Further results are stored for free vibration with the help of data processing units.

Free vibration Composite spring

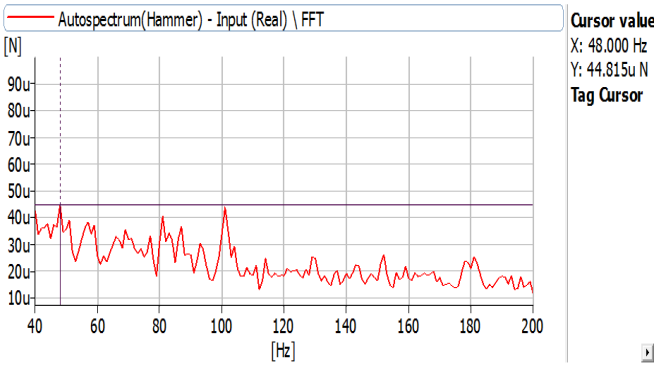

Fig.1. 1st Mode shape for composite leaf spring

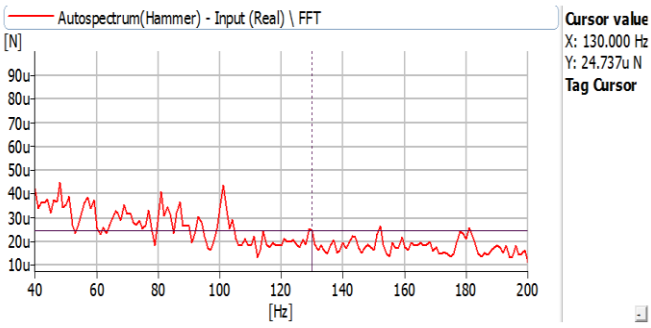

Fig.2. 2nd Mode shape for composite leaf spring

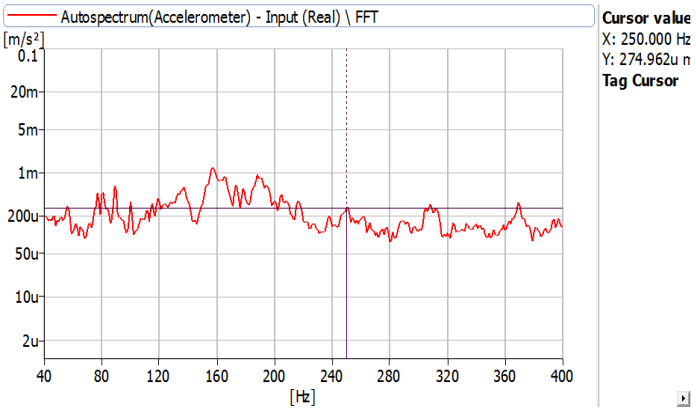

Fig.3. 3rd Mode shape for composite leaf spring

Free vibration steel spring

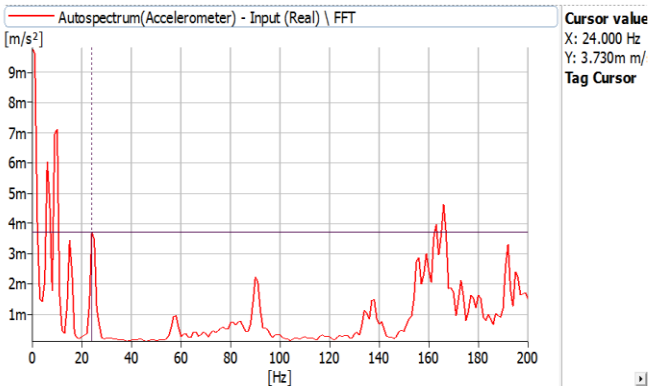

Fig 4. 1St mode shape for steel spring

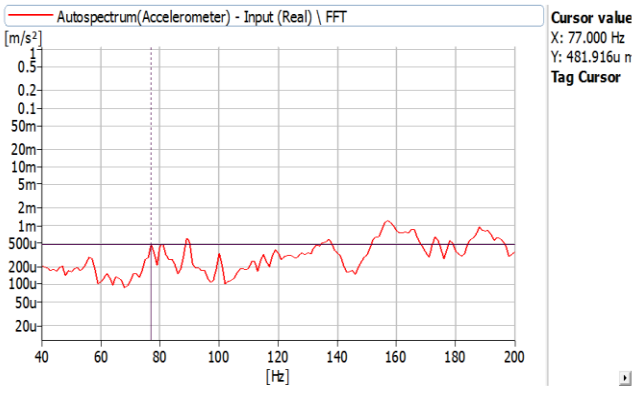

Fig 5. 2ndmode shape for steel spring

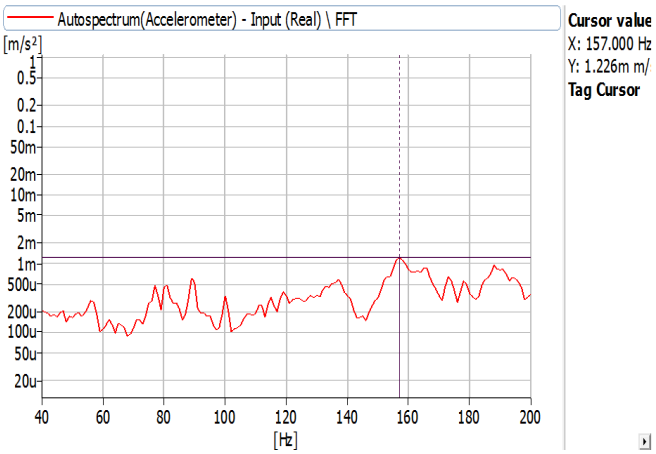

Fig 6. 3rdmode shape for steel spring

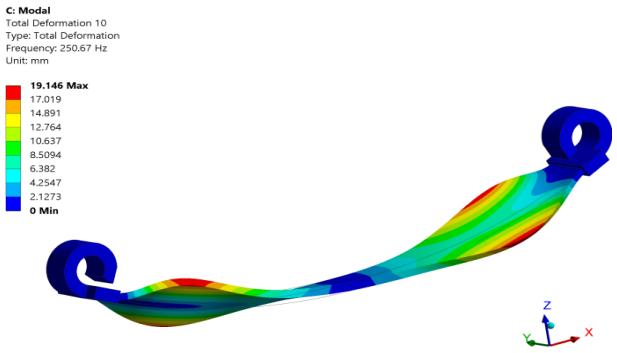

Fig 9. 3rd Mode shape for Composite leaf spring

ANALYTICAL RESULTS

Composite material

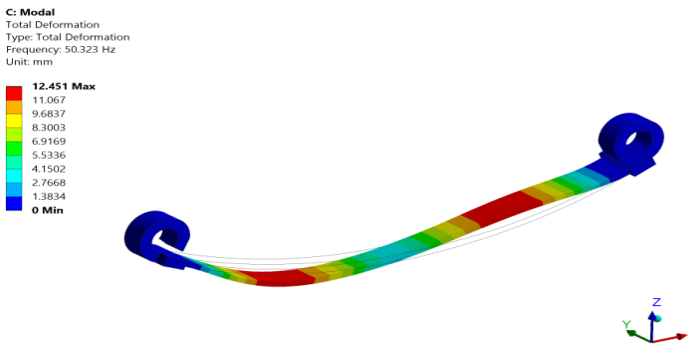

Fig 7.1st Mode shape for Composite leaf spring

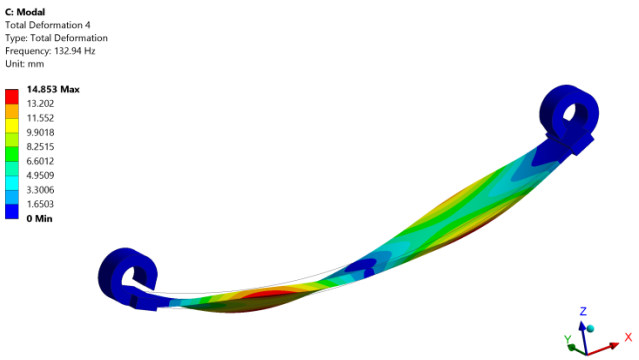

Fig 8.2nd Mode shape for Composite leaf spring

Steel Material

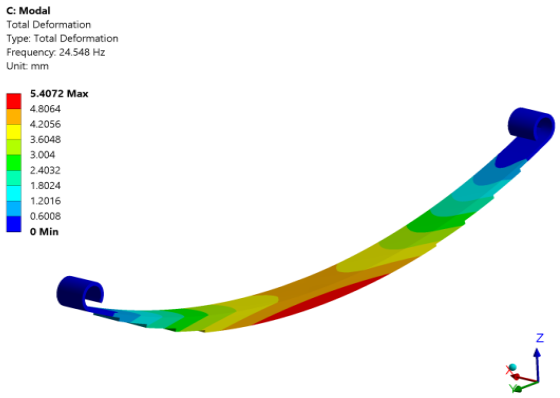

Fig 10.1st Mode shape for steel leaf spring

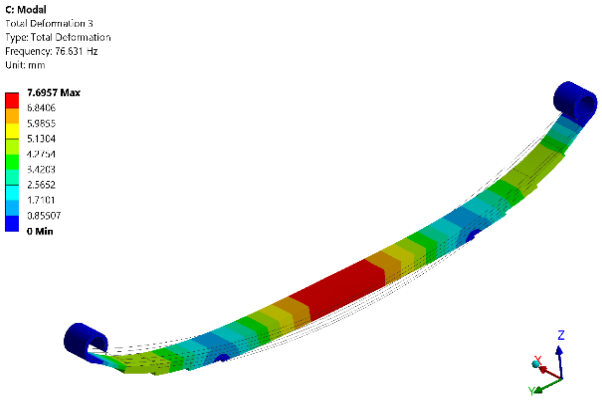

Fig 11.2nd Mode shape for steel spring

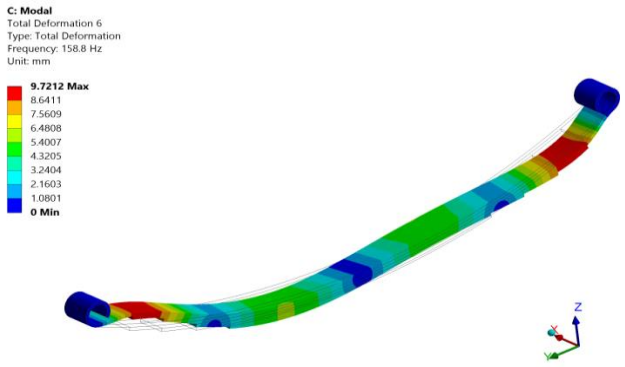

Fig 12. 3rd Mode shape for steel leaf spring

RESULTS AND DISCUSSION

An evaluation of damping properties of leaf spring for vibration of given body was carried out. Table shows results of testing based on resonance frequency and damping parameters. For this purpose original steel body is taken as reference in order to get identified parameter. Composite leaf spring shows higher damping properties than that of steel from mode shape graph.

Sr. No	Mode shape	Steel spring Frequency (Hz)		Composite spring Frequency (Hz)	
		Analytical	Experimental	Analytical	Experimental
1	1	24.54	24	50.32	48
2	2	76.63	77	132.94	130
3	3	158.8	157	250.67	250

CONCLUSION

From the results it can be concluded that results shows good agreement between steel leaf spring and composite leaf spring. Composite leaf spring has better natural frequency which reveals that it has better damping capacity than that of steel spring. Hence there is no doubt to replace conventional by composite.

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