Proceedings of **"National Conference on Recent Trends in Science and Advances in Engineering"**
Organized by Fabtech Technical Campus, College of Engineering & Research, Sangola
International Journal of Innovations in Engineering Research and Technology [IJIERT]
ISSN: 2394-3696, Website: www.ijiert.org, June, 2022

AN EXPERIMENTAL APPROACH FOR DYNAMIC ANALYSIS OF STEEL, COMPOSITE LEAF SPRING

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ABSTRACT

Leaf spring is widely used suspension components, especially in commercial vehicles. Most of the vehicles in the Indian market are overdesigned. This is for the type of usage and road conditions or simply to increase factor of safety and prolong product life.

The present paper is the vibration response using the default metal (Steel) leaf springs and then by replacing it with glass fiber springs. A variety of excitation frequencies were used to assess the change in the vibrationresponse. Researches have been made to present experimentation of composite mono leaf spring & steel leaf spring for vibration and compare its results. Experimentation is carried out using FFT (Fast Fourier Transform) analyzer dynamic analysis.

From the study, it is seen there is also significant increase in zeta value of composite spring as compared to steel spring. With increased vibration damping rations offer superior ride comfort.

Keywords - Glass Fiber Reinforced Plastic (GFRP); Static load condition; Ride comfort; Static analysis; Dynamic analysis; Suspension system; Natural frequency.

INTRODUCTION TO DAMPING RATIO, (ZETA):-

Damping ratio expresses that response as a ratio between the actual damping of the automobile system and the critical damping coefficient (C_C).

It is expressed as follows:

$$\zeta = \frac{C}{C_C}$$

where:

- ζ is the ratio of damping (Dimensionless)
- c is the actual coefficient of damping
- c_c is the critical coefficient of damping.

The value of ζ will determine the kind of damping of the system.

$\zeta = \frac{C}{C_C}$, where the equation of motion is

$$m\frac{d^2 x}{dt^2} + c\frac{dx}{dt} + kx = 0$$

and the corresponding critical damping coefficient is

$$C_C = 2\sqrt{km}$$

The damping ratio as the ratio of two coefficients of identical units is dimensionless.

A less damping ratio (ζ) implies a lower decay rate, and so very under damped systems oscillate for long times. So, Engineering system is designed having value of zeta approaches towards the value 1.

Fig.1a Experimental Setup for Dynamic Analysis of Steel Leaf Spring

Fig.1b Experimental Setup for Dynamic Analysis of glass fiber Leaf Spring

Fig.1c Experimental Setup for Dynamic Analysis

Fig. 1a, 1b, 1c shows experimental setup for calculating zeta value (ζ) for steel leaf spring and glass fiber leaf spring. Shackle is mfg. By using M.S. plate. One end of leaf spring is fixed, while other end shackle is provided as shown in fig. Shackle angle kept is 45^0.

The whole arrangement is fixed by side angle with the help of nuts and bolts. The exciter is kept exactly below the center of leaf spring. Tip of exciter is touched to the leaf spring. Accelerometer is attached above the leaf spring and at the center.

The forced excitation is given to the leaf spring with the help of exciter, provided with control panel. The forced excitation is given in the range of 2 Hz from 24 Hz to 36 Hz.

ISSN: 2394-3696, Website: www.ijiert.org, June, 2022

FFT (Fast Fourier Transform) analyzer plots the Displacement time graph. Peak value for particular frequency is noted. Displacement vs. Frequency curves is plotted for calculating zeta value of both composite and steel leaf spring.

7.2 CALCULATION FOR NATURAL FREQUENCY

7.2.1 Calculation for Natural frequency of Composite leaf spring for added mass of 79 gm + mass of accelerometer 55 gm.

Natural frequency, $f_n = \frac{1}{t_p} = \frac{1}{2\pi}\sqrt{\frac{k}{m_{eff}}}$

$f_n = \frac{1}{2\pi}\sqrt{\frac{7741}{0.1534}}$

$f_n = 35.74$ Hz

Where, $m_{eff} = m_{LS} + m_{added} + m_{accl.}$

m_{LS} = mass of Composite leaf spring = 40 gm

m_{added} = Added mass = 79 gm

$m_{accl.}$ = mass of accelerometer = 55 gm

7.2.2 Calculation for Natural frequency of Steel leaf spring for added mass of accelerometer 55 gm.

Natural frequency, $f_n = \frac{1}{t_p} = \frac{1}{2\pi}\sqrt{\frac{k}{m_{eff}}}$

$f_n = \frac{1}{2\pi}\sqrt{\frac{7741}{0.1074}}$

$f_n = 42.71$ Hz

Where $m_{eff} = m_{LS} + m_{accl.}$

m_{LS} = mass of steel leaf spring.

$m_{accl.}$ = mass of accelerometer.

Table 7.1 Obtained Displacement for given Excitation frequency for composite.

Sr. No.	Excitation frequency (Hz)	Displacement (mm)
1	24	0.664
2	26	0.630
3	28	1.56
4	30	3.003
5	32	1.29
6	34	0.604
7	36	0.440

Table 7.2 Obtained Displacement for given Excitation frequency for steel**.**

Sr. No.	Excitation frequency (Hz)	Displacement (mm)
1	24	0.697
2	26	0.700
3	28	1.139
4	30	2.52
5	32	0.837
6	34	0.458
7	36	0.360

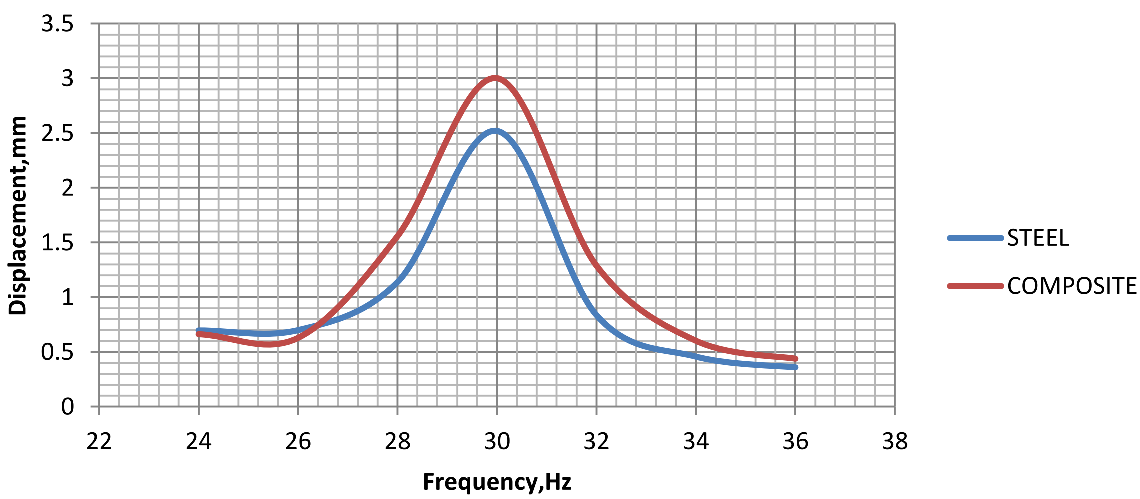

Fig. 7.2 Combined composite and steel leaf Frequency vs. Displacement curves

7.3 Calculation for Zeta

7.3.1 I= 0.9 amp for steel

$$\frac{F_2 - F_1}{F_P} = 2\zeta$$

$$2\zeta = \frac{30.90-28.85}{30}$$

$$\zeta = 0.0341$$

7.3.2 I= 0.9 amp for composite

$$\frac{F_2 - F_1}{F_P} = 2\zeta$$

$$2\zeta = \frac{31.20-28.60}{30}$$

$$\zeta = 0.0433$$

7.4 Calculation for Natural frequency from Zeta

7.4.1 for Steel

$$\frac{F_P}{F_N} = \sqrt{1 - 2\zeta^2}$$

Therefore, $F_N = \frac{F_P}{\sqrt{1-2\zeta^2}}$

$$= \frac{30}{\sqrt{1-2\times 0.034^2}}$$

$$F_N = 30.034 \text{ Hz.}$$

7.4.2 for composite

$$\frac{F_P}{F_N} = \sqrt{1 - 2\zeta^2}$$

Therefore, $F_N = \frac{F_P}{\sqrt{1-2\zeta^2}}$

$$= \frac{30}{\sqrt{1-2\times 0.0433^2}}$$

$F_N =$ 30.056 Hz.

As lower damping ratio means a lower decay rate.

From experiment carried out above shows that there is significant increase in the value of zeta for composite leaf spring as compared to steel leaf spring. So composite leaf spring provides a good riding comfort as compared to steel leaf spring.

CONCLUSIONS

The conclusions drawn from the analysis carried out are as follows:

- A study has been made between glass fiber and steel leaf spring with respect to weight, natural frequency and damping ratio.
- Increase in the value of zeta for glass fiber leaf spring as compared to steel leaf spring. So composite leaf spring provides a good riding comfort as compared to steel leaf spring.

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