Study of Analysis of Mono Leaf Spring Composite for Light Commercial Vehicle Using Finite Element Method

Mr. Kumbhar Prafull Mahadeo[1] Prof. Patil Yuvraj R.[2]
[1]Student [2]Professor
[1,2]Department of Mechanical Engineering
[1,2]Dr. J. J. Magdum College of Engineering, Jaysingpur, India

Abstract— Leaf springs probably are the oldest automobile suspension gadgets still in active use. Weight reduction has been the main focus of automobile manufacturers in the present scenario. Weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing processes. In this dissertation work the material of the leaf spring is changed. The new Leaf spring is used which is made of composite material and high weight reduction is achieved. The main objective of research work is to carry out Sensation analysis of composite leaf spring with nonlinear parameters. Here free and forced Sensational Analysis of Composite Leaf Spring is done and compared with Steel Leaf Spring. The nonlinear Sensation analysis is carried out. So, to achieve this, CATIA and ANSYS software's are used for three dimensional modeling and analysis respectively. The simulated results are compared with experimental results. The result shows good Agreement between experimental results and numerical results.

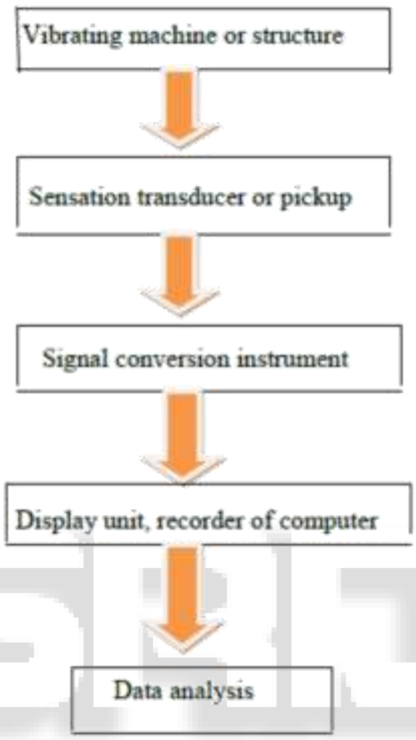
Keywords: ANSYS, Composite, FFT, Layup, Leaf spring, Metal Matrix Composite, Mode Shapes, Von- Misses Stress

I. Introduction

The Quick Former Frequency Transform (F.F.T.) Analysis is the instrument of choice for measuring and medicating sensations. The F.F.T. Analyzer is a newly built virtual instrument mounted on a PC. In reality, it uses pulsation, frequency analysis and time domain analysis to obtain the model parameter from the reaction measurement in real time. The analogue response signal measured can be analyzed using domain techniques or transformed with the F.F.T. Analyzer for analyses in the frequency domain following impulse executions of the sample. The peaks of the F.R.S. are the normal frequency location.

From a series of frequency response function (FRF) measurements, the model parameter can be transmitted one or more benchmarks and place of measurement needed for the model. From either of the FRF measurements, you can find the response frequency and damping value. The execution of the FRF model parameter can be performed on the structure using a number of mathematical curve fitting algorithms. Using multichannel F.F.T. measurements, you can obtain the FRF. The frequency determination with the assistance of PULSE software allows the following determinations to be made.

II. Scheme of Sensations Calculation



III. Necessary Apparatus

- Hammer of model.
- Accelerometer.
- Analyzer of F.F.T.
- Electro dynamic method of sensations shaker
- Amplifier power cum signal generator
- Table of sensations
- Specimen

A. *Modal hammer*

The model hammer exits the system with a steady power over a frequency range of interest. Three exchange tips are provided that determine the width of the input pulse and then the hammer structure's band width is compensated for acceleration to avoid spectrum glitches due to hammer structure resonance.

Fig. 3.1: Modal hammer

B. The Sensing Equipment

An accelerometer is a sensing feature that identifies acceleration; acceleration is the rate of velocity transfer time. It is a vector which has direction and magnitude. Measuring accelerometers in units of G, and G is the gravity acceleration scale equivalent to 9.81 m / s2. Accelerometers have progressed from a basic air bubble water tube that demonstrated the Route of acceleration to an integrated circuit which can be located.

On a board with a circuit Accelerometers are able to measure an object's movements, shocks, tilt, impacts and motion. As seen in Figure 5.3.2, the accelerometer used is

Fig. 3.2: Accelerometer

C. Types of Accelerometers

Various types of accelerometers exist. The sensing aspect and the concepts of its function are what distinguish the forms. With regard to acceleration, capacitive accelerometers detect a difference in electrical capacitance. The Shift in capacitance between a static condition and a dynamic state is felt by the accelerometer. Piezoelectric accelerometers use materials that produce electrical potential from applied stress, such as crystals. This has been referred to as the piezoelectric effect. An electrical charge is generated when force is applied, such as acceleration. Piezoresistive accelerometers (strain gauge accelerometers) act while mechanical stress is introduced by calculating the electrical resistance of a material.

The voltage differences arising from a difference in the magnetic field around the accelerometer are determined by Hall Effect **accelerometers**. Through measuring variations in resistance attributable to a magnetic field, Magneto resistive accelerometers operate. The configuration function is similar to those of a Hall Effect of accelerometer, Except for the fact that the magneto resistive resistance can be measure by accelerometer instead of measuring voltage. MEMS-based accelerometers; the technology of M.E.M.S. is based on a range of methodologies and techniques used to construct thin, micrometer-scale dimensional structures. This approach is now being used to create state of the art M.E.M.S. based accelerometers.

1) Equipment for data procurement and analysis

A (F.F.T.) is an algorithm for computing the Discrete Fourier Transform (D.F.T.) and its reverse. A F.F.T. translates time (or space) to frequency and vice versa; an F.F.T. transforms time (or space) to frequency and vice versa by factoring the D.F.T. matrix into a product of sparse (mostly zero) variables rapidly computes those transformations. Consequently, for more use in architecture, physics, mathematics and F.F.T. are commonly used. In 1965, the basic principles were popularized, although some F.F.T.s was formerly recognized as early as 1805. The most important computational algorithm in our lives "has been described as Fast Fourier Transforms".

A certain amount of data reflecting the waveform needs to be stored in memory as a so-called 'time log' before the mathematical F.F.T. method can be implemented. The length with the lowest frequency to be processed is the minimum duration of this time record. The time that this takes is called the time of collection. And, in one go, the whole waveform is processed and mathematically transformed into a sequence of sinus waves of varying amplitudes, frequencies and phases. An interpretation of the entire portion of the continuum at a certain point in time is the result. The F.F.T. protocol means that for an indefinite time, the obtained signal is constantly present. This suggests that the outcome is based on the premise that the waveform obtained in the time record repeats itself frequently. If at the beginning and the end of the time record, in the initial signal, the amplitude is not zero, the F.F.T. will measure a result at each compilation interval for a waveform with sharp edges. The sample of a simple sine wave signal will demonstrate this effect.

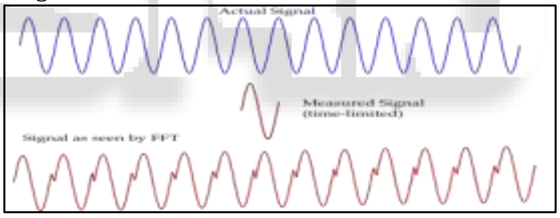


Fig. 3.3: Clear signal of the sinusoidal wave

A number of spectral lines will provide the F.F.T. outcome of this presumed feedback and have undesirable errors. It is important to feed the signal through a filter to avoid such errors, which causes from the start and The Finish Up of each time record, the amplitude will be zero. The digitized signal must be added to this "time philter" and is therefore a mathematical operation. Windowing is what it is called.

For signals that fall entirely into a single time record, the amplitudes are already zero at the beginning and at the end. They call these signs self-windowing. No additional windowing needs to be introduced to correctly evaluate them with F.F.T. (sometimes this is called applying a rectangular window). Spikes happening only once and busted digital signals are examples of this sort of signal, as long as the burst lies entirely within the time record.

However, it is very evident for continuous signals that we adjust the original waveform due to the need for windowing, and still add a certain mistake. This mistake lies in the F.F.T. theory and cannot be stopped altogether. However, this error can be reduced by selecting the correct form of this philter, called the window function, based on the parameter to be determined (amplitudes, frequencies, phases). Here, two major kinds of window functions are common:

– Hanning
– Flattop
– Hanning

While it has reasonable resolution of frequency, the Hanning window suppresses large portions of the continuous signal's total amplitude. For transient signals and in cases where resolution of frequency is significant, it is therefore the best option, but not for precise level measurements.

– Flattop

This window provides less frequency resolution but greater amplitude reproduction due to its shape. For amplitude measurements on continuous signals, it is also the best option. With this data, it is clear that in all situations, there will not be one particular type of window that is a good option. The type of signal to be calculated and the purpose of the measurement must also be considered for the purposes of having a window that provides the good equilibrium.

It takes time to receive the signal and measure the F.F.T., which is not tiny indefinitely, is another constraint due to the concept of F.F.T. This suggests that we cannot obtain a spectrum representation in real time but this delay can be ignored for most monitoring activities.

The A4400-VA4 Pro has modules for the study, processing of data and sensations signal capture. The instrument is improved by complex balance units, run-up and cost-down calculation, lubrication monitoring and testing, and the stethoscope work listening to sensations signals. The tool is fitted with an expert framework developed by Adash, which identifies machinery defects automatically.

As seen in Figure, the Four Channel F.F.T. Analyzer used is

D. Technical Specifications of F.F.T. Analyzer:

Technical specifications of four channels F.F.T. Analyzer is as shown in Table 4.1

Input Channels:	• 4 AC, ICP® power supply on/off • 4 DC for process values • 1 TACHO for external trigger
Input Range:	• AC +/- 12 V peak-peak • DC +/- 24 V
AD Conversion:	• 24 bit, 64 bit internal signal processing No Auto Gain function
Dynamic Range S/N:	Dynamic range S/N: • 120 dB
Frequency Ranges:	• Max. 76 kHz (1 Ch, 196 kHz sampling) • Max. 25 kHz (4 Ch, 64 kHz sampling) • Min. 25 Hz (4 Ch, 64 Hz sampling)
Sampling Mode:	• fully simultaneous for 4 channels
FFT Resolution:	• Min. 100 lines • Max. 25 600 lines
Unit Modes:	• Data-collector - route measurement • Analyser - analytic measurement • Balancer - on-site balancing • Run up / Coast down measurement . Recorder - signal recording
Processor:	• Intel Atom 1.6 GHz
Memory, Route:	• 120 GB, max. 4 GB for one route, number of routes is limited by free memory only
Data Processing	• FFT real time analysis • ENVELOPE analysis • ACMT - low speed bearing analysis • order analysis • user band pass analysis • RPM measurement • DC measurement • Orbit measurement
Signal Recorder:	64 kHz sampling frequency • 4 Ch memory consumption 3 GB/hour • 4 Ch total recording - 35 hours
Trigger:	• Manual, External, Signal level, Time • Use for signal Recording trigger • Speed change, Time interval
Display:	• Color 800 x 600 pixels, LCD
Communication:	• USB
Temperature Range:	• -10°C to +50°C
Power:	• Battery 5 hours operation, AC 230 V
Case :	Aluminum Heavy Duty
Size and Weight:	• 230 x 140 x 60 mm • 2000 g

Table 4. 1: Technical Specification of Four Channel F.F.T. Analyzer (A4400 - VA4Pro)

E. Display unit

This is mostly in the type of a personal computer (lap top) when stimulation happens, in the arrangement of the emitted signals to the handheld PULSE and the graphical program arrives Form after conversion. The data mainly comprises force Vs time graphs, Frequency Vs Time Frequency Resonance Data, etc.

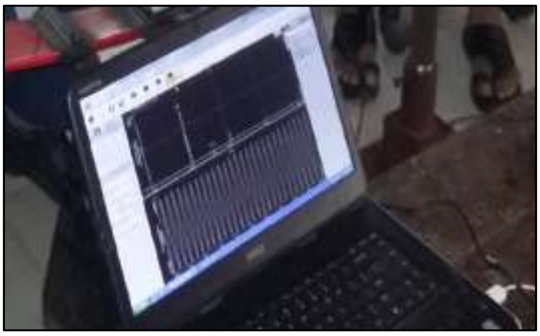


Fig. 4.1: Display unit

F. *Free Sensations Procedure*

- Connections have been developed, such as accelerometer, modal hammer, laptop and other power connections.
- The Leaf Spring's surface has been washed for proper communication with the accelerometer.
- The accelerometer was then connected to the Leaf Springs floor.
- For free sensations, the above links were made for.

G. *Leaf springs details*

In this dissertation, the proportions and material constants for a Leaf Spring (Steel) and Leaf Spring Composite are studied in following Table's respectively.

Parameters	Symbol	Value
Total Effective Length	L	1.17 m
Width	B	0.2 m
Moment of Inertia	I	624 x10-3m4
Young's Modulus	E	2 x 1011N/m2
Mass Density	P	7830 kg/m3

Table 6.1: Experimental Parameters for Steel Leaf Spring

Parameters	Symbol	Value
Total Effective Length	L	1.17 m
Width	B	0.022 m
Moment of Inertia	I	918 x10-6m4
Young's Modulus (Ex)	E	7.3 x 10^{10}N/m2
Mass Density	P	1400 kg/m3

Table 6.2: Experimental Parameters for Composite Leaf Spring

H. *Effect Static Test (for Free Sensations):*

In this dissertation, the static test findings for free motions of a composite and Leaf Spring (Steel) are analyzed in Table 5.6.1.

Sr. No.	Steel Leaf Spring (Frequency in Hz)	Composite Leaf Spring (Frequency in Hz)
1st Mode	21	35
2nd Mode	75	111.5
3rd Mode	197	235.5

Table 7.1. Experimental Static test Results

The Leaf Spring (Steel) free sensations effects are as seen in the figure below.

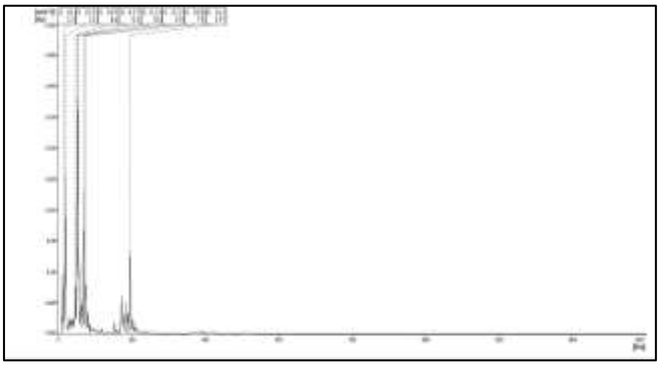


Fig. 7.1: Leaf Spring (Steel)'s Graphical Free Sensations Result.

The Leaf Spring Composite free sensations effects are as seen in the figure below.

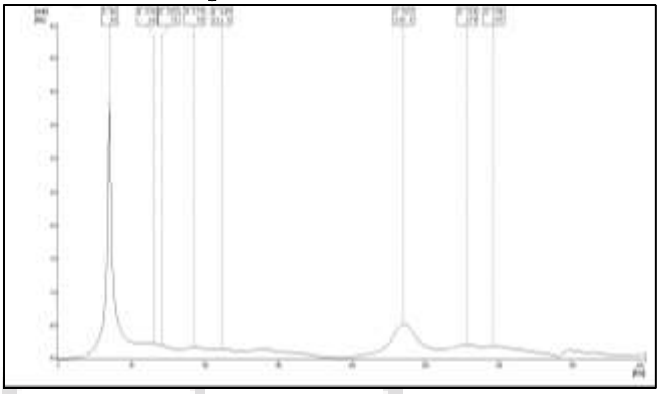


Fig. 7.2: Leaf Spring Composite Graphical Free Sensations Result.

I. *Leaf Spring (Steel) and Leaf Spring Composite Properties of Load Deflection*

The load deflection curve is obtained when the vertical displacement values are obtained experimentally for different concentrated load values. We're thinking multiple leaf springs. On all leaf springs, loads of 0.1, 0.2, 0.3, 0.4 and 0.5 Tons are added and deflection is measured experimentally.

1) *For Leaf Spring (Steel)*

Sr. No.	Load in Kg	Deflection in mm
1	100	35
2	200	65
3	300	97
4	400	130
5	500	155

Table 8.1.1: shows Experimental Test Results for steel Leaf Spring

Fig. 8.1.1: Shows Experimental Setup

Fig. 8.1.2: Shows the Testing Of Component

2) for Leaf Spring Composite

Table 8.1.2 Plays Hybrid Leaf Spring experimental test results

Sr.No.	Load in Kg	Deflection in mm
1	100	22
2	200	46
3	300	75
4	400	102
5	500	129

Table 8.1.2: Experimental Test Results for Composite Leaf Sprig

- Design validation for existing Traditional leaf spring using theoretical approach.
- Detailed stress and modal analysis using FEM of Traditional leaf spring to determine the peak stress counters in the Traditional leaf spring and its mode shapes and natural frequencies.
- Design of mono Leaf Spring Composite for the similar load and its stress and modal analysis using FEM to find out stress distribution and its natural frequencies.
- Experimental validation of stress results obtained by FEM using strain gauge technique for both springs.
- Experimental validation of natural frequencies obtained by FEM using F.F.T. analyzer.
- Determination of minimum thickness for the same load of mono Leaf Spring Composite in order to reduce the material weight and with increased strength using ANSYS only.

IV. Completion

Successive conclusions are drawn from the theoretical, numerical and experimental data.

1) From theoretical, numerical and experimental evidence, successive conclusions are drawn.
2) The normal frequency decreases more quickly for both steel and composite material in the first mode.
3) The normal frequency of the cantilever beam rises rapidly after first mode for both steel and composite material.
4) It is found that the normal frequencies of induced sensations are almost identical to those of free sensations.
5) The theoretical research it not only gives an understanding of geometric nonlinearities, but also a greater understanding of the basic definition of material mechanics.

Since the experimental and numerical effects of Composite and Leaf Spring (Steel) s sensations research are closer to each other. Finally, it is mentioned that numerical analysis of a beam by instead of doing more expensive and time intensive experimental research, ANSYS will be completed.

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