Experimental Studies on Stress Analysis of Conventional Leaf Spring by Wrapping Composite Material on It

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Abstract— The oldest vehicle suspension gadgets currently in active use are potentially leaf springs. The key focus of the current scenario was the strengthening of car suppliers. In order to maximise strength, improved material, refining architecture and enhancing production processes can be accomplished primarily. The extra material for leaf spring is included in this dissertation. The new Leaf spring is used, which consists of composite material and increases strength. A vibration study of composite leaf spring with non-linear parameters is the main objective of the research. Composite Leaf Spring is carried out here in contrast to the Steel Leaf Spring, free and force vibration analysis. The nonlinear study of vibration is done. CATIA and ANSYS tools for this purpose were used respectively for three-dimensional modelling and analysis. Compared with experimental Findings, the virtual results.

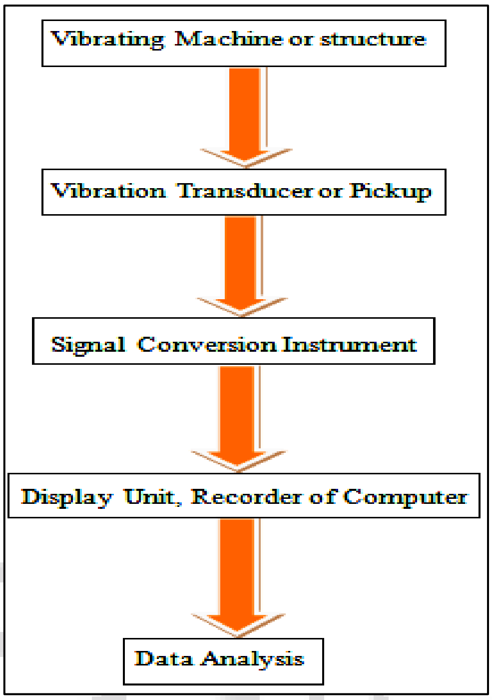
Keywords: ANSYS, Composite, FFT, Layup, Leaf spring, Metal Matrix Composite, Mode Shapes, Von- Misses Stress

I. INTRODUCTION

The method of choice for vibration estimation and diagnosis is the Simple Former Transform (FFT) Algorithm based frequency analysis. A newly designed virtual instrument mounted on a Desktop is the FFT Analyzer. By using impulse execution and either analysis frequency domain or analysis time domain to receive the parameter for the model in real time from the estimation response. After sample impulse execution, the calculate analogue signal response can be digitalized and analysed by domain techniques or Transmuted for analysis in the frequency domain using the F.F.T Analyzer. The typical frequency site is the peaks in the response frequency spectrum. The model parameter may be encoded between one or more places for reference and the measurement location required in the model from a series of Measurements of the frequency response feature (FRF). 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 FFT measurements you can obtain the FRF. With the assistance of PULSE tools, to determine the purpose of frequency includes Mode-Shape determination

II. SCHEME OF VIBRATION CALCULATION



III. APPARATUS REQUIRED

- Model hammer
- Accelerometer
- FFT Analyzer
- Electrodynamics Shaker System for Vibration
- Amplifier power cum Signal Generator
- Table of Vibrations
- Specimen, weight reduction and cost cutting.

A. Impact Hammer

The impact hammer exerts a steady force of interest over a frequency spectrum on the structure. Three interchangeable tips that specify the input pulse width and thus the width of the band are given. Hammer configuration is compensated acceleration due to hammer structure resonance to prevent glitches in the spectrum.

B. The Sensing Equipment

An accelerometer is a sensing feature that identifies acceleration; rate of velocity transfer time is acceleration. It is a vector which has direction and magnitude. A g is the gravity acceleration rate equal to 9.81 m/s2 when calculating accelerometers in units of g. Accelerometers have Established from a water tube having air bubble to show the acceleration trajectory on a circuit board having integrated circuit board Acceleration are capable of measuring the movement, shock, tilt, effect and rotation of an object. The accelerometer used, as shown in Figure

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 capacitance change between a static situation and the 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.

1) The Accelerometer of the Hall Effect:

Changes of magnetic field around the accelerometer are due to voltage changes, which is to be measure. Working magneto resistive accelerometers by calculating differences in resistance due to a force of magnetic .Except that the magneto resistive accelerometer measures resistance instead of calculating voltage, the design and purpose are identical to the Hall effect accelerometer.

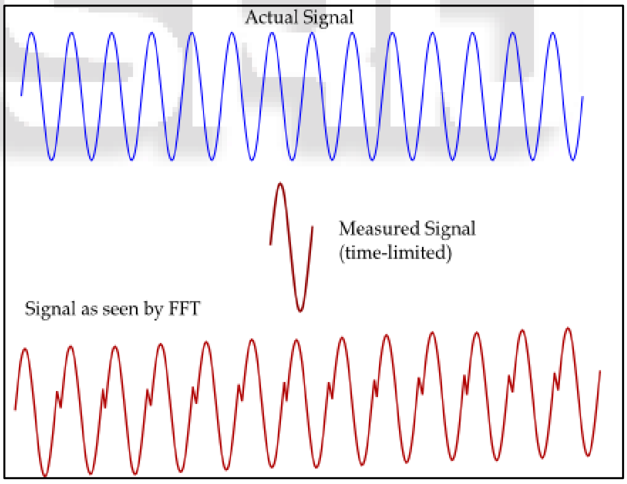
2) Accelerometers based on MEMS:

MEMS (Micro Electro Mech System) relies technology on a range of methods and Technique used to shape dimensional structures of thin, micrometer scale .This approach is now used to create MEMS based accelerometers.

IV. EQUIPMENT FOR DATA PROCUREMENT AND ANALYSIS

Algorithm of Fast Fourier Transform (F.F.T) is for computing the Discrete Fourier Transform (D.F.T) and reverse. A F.T converts time (or space) into frequency and vice versa; F.F.T efficiently measures these transformations or changes by factoring the D.F.T matrix into asperse product (mostly zero) variables. Consequently, F.F.T are widely apply for lots usage in engineering, physics and maths.

In 1965, the principles were popularised, although some F.F.Ts were formerly recognised as early as 1805. The "most significant numerical algorithm of our lifetime" has been described as Fast Fourier Transforms. 'Time' in memory is amount of data represent in the waveform log' before the mathematical FFT method can be implemented. 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, frequency and phases. An Interpretation of the entire portion of the system at any moment in time is the result.



The F.F.T protocol assumes that the received signal are present an infinite duration. This result is based on the presumption that the wave signal acquired in the time record itself and again. If at the beginning and the end of the time record, the amplitude of the original signal is non zero, the FFT 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.

A number of spectral lines will provide the FFT outcome of this presumed feedback and have undesirable errors. The digitised signal must be added to the "time philtre" and is therefore a mat hermetical operation. Windowing is what it is called. The amplitudes at the beginning and at the end are still zero for signals that fall completely into a single time record. These signals are called Self-windowing. No additional windowing needs to be introduced to correctly evaluate them with FFT (sometimes this is called applying a rectangular window). Spikes happening only once and busted digital signals are examples of this sort of signal.

For constant signals though, it is very clear that change the initial wave signs due to the need for windowing, and still apply a specific defect. This philosophy of the F.F.T and can't be avoided. However, by choosing the correct form of this philtre, called the window function, which is dependent on such variables to be calculated (amp, frequency phases), this can be minimised. There are two main types of functions, Hanning and Flattop.

A. *Hanning*

Frequency resolution has fair, the Hanning window has significant portions of the overall amp of the consistent signal. It is also the best option, but not for reliable level measurements, for transient signals and in cases where frequency resolution is precise.

B. *Flattop*

This window has provides less frequency intention but greater amplitude reproduction due to its shape. For amplitude calculate on consistent 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 signal to be calculated (Temporary or continuing) and the purpose of the measurement (frequency resolution or amplitude) must also be considered. Because of the definition of FFT, It takes time to acquire the signal sign and measure the F.F.T, which is not indefinitely less, is another restriction, which means that we will not obtain a actual time representation of the spectrum waves but this delay can be ignored for most monitoring activities The A4400-VA4 Pro has modules for the study, processing of data and vibration 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 vibration signals. The instrument is fitted with an expert device developed by ADASH that detects machinery defects automatically. As seen in Figure 5.5; the Four Channel FFT Analyzer is used.

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 • Analyzer - 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

Table 1: Provides the following technical requirements for the four-channel FFT Analyzer.

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 2: Four Channel FFT Analyzer Technical Specification (A4400-VA4Pro)

C. *Display Unit*

This is mostly in the form of a PC (laptop) since the excitation occurs in the structure of the emitted signals to the portable

PULSE and after transfer; the programme arrives in graphical form. Force against time graphs, frequency against time resonance frequency results, etc., are the key information.

Fig. 1: Display unit

V. ELECTRODYNAMICS VIBRATION SHAKER SYSTEM

A. System Description

For the reason of evaluating the universal physical properties of products and materials, MEV systems are built with indigenous design and manufacturing for dynamic research. In all in digenous materials, we also found mechanical vibrators, transducers, data acquisition systems, centrifuge machines and near-loop electro dynamic techniques, etc. The vibration device series MEV is the result of longstanding experience in the design and manufacture of test systems. It helps the customer in evaluating the product 's protection, reliability, longevity and resonance frequency. A vibration test machine consists of a signal generator, a vibration exciter, and a power amplifier. It consists of the parameters that follow.

1) Table with Vibrations
2) Amplifier power cum Signal Generator

B. Vibrating Table

The MEV SERIES of vibrators are located in the magnetic field and have a rigidly attached drive armature on the spinning frame. As AC current flows, a force is produced in this drive coil by converting an electric current into a mechanical force that drives the platform. The vibrator will operate from either sinus or random input wave shape in the frequency range from 5Hz to 2500 Hz. The aim of a vibration generation device is to establish a selected wave form with the required degree of vibration (i.e. acceleration / velocity / amplitude) and the frequency to quantify the specimen mounted by the vibration exciter. Since there is no wearable rolling part and the frequency of the axial resonance is kept quiet to avoid self-resonance, the Electro Dynamic Vibrator is very stable. The unit force rating and moving element mass are the main features assessing the vibration frequency.

C. Features

- Long term reliability
- Link arm suspension system
- Excellent cross-axial restraint
- Dual suspension system

D. Specifications

- Model: MEV 0020
- PEAK Sine Force: ±20 Kgf (±200N)
- Max. Displacement: 10 mm (pk-pk)
- Frequency Range: 5 Hz to 2500 Hz (Within 0.1 db)
- 1st Major Armature Resonance : >2.5 Kg
- Max. Payload: 2.5 Kg
- Shaker Rotation: ± 90kg degree from vertical
- Drive power: Thru a solid state Power Amplifier cum Signal Generator

Fig. 2: Electrodynamics Vibration Shaker System

VI. POWER AMPLIFIER CUM SIGNAL GENERATOR

Both solid state types that have outstanding reliability are the MPA Series Power Amplifier Cum Signal Generator and are equipped with self protective equipment such as cooling facility inspection, temperature inspection, current supply inspection, and disoperation interlocking equipment to ensure safety activities. Total continuous control and transient state over load are planned for the amplifiers. The amplifiers are of an air-cooling type with a rated performance of up to 15 KVA. (The functions above are depending on the model) The goal of the Power Amplifier Cum Signal Generator is to amplify the output signal of the signal generator enough to drive the exciter to the appropriate vibration level. D.C. supply of electro dynamic vibrators is integrated into the power amplifier to power the magnetic field. The amplifier produces a signal for additional amplification that is fed to the amplifier. It has an integrated sinusoidal waveform generator that provides sine wave output from 1Hz to 10 KHz with adjustable variable frequency in four lapping ranges with fine frequency configuration between ranges.

A. Features

- distortion is low
- power gain is high
- support the Internal field
- frequency bandwidth having Wide range
- Versatile design
- waveform generator in sinusoidal form
- armature voltage and current metering

Fig. 3: Power Amplifier cum Signal Generator

Fig. 4: Electrodynamics Vibration Shaker System with Vibration Table and Power Amplifier cum Signal Generator

VII. Procedure

A. Procedure for Free Vibrations

- The links were made, i.e. the accelerometer, modal hammer, laptop and other power connection.
- 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 vibrations, the above contacts were made.

B. Procedure for Forced Vibrations

- The Electrodynamics Vibration Shaker Device consisting of the Vibration Table And Power Amplifier Cum Signal Generator was used for Forced Vibration.
- Readings have been made for both the Leaf Spring Composite and Leaf Spring Steel.
- The results of analytical project are compared with ANSYS F.E.M kit and empirical values.

VIII. Specifications of Leaf Springs

In this dissertation, the proportions and material constants for a Steel Leaf Spring and Composite Leaf Spring are studied in Table1 and Table2 simultaneously

Parameters	Symbol	Value
Total Effective Length	L	1.17 m
Width	B	0.2 m
Moment of Inertia	I	624 x 10^{-3}m^4
Young's Modulus	E	2 x 10^{11}N/m^2
Mass Density	ρ	7830 kg/m^3

Table 1: Experimental Parameters for Steel Leaf Spring

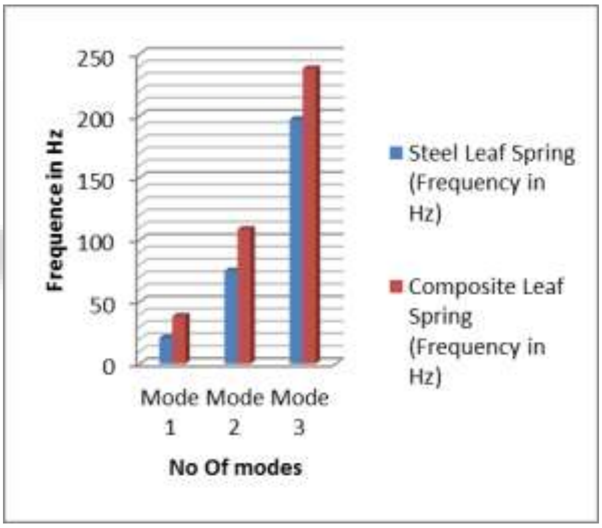
Parameters	Symbol	Value
Total effective Length	L	1.17 m
Width	B	0.022 m
Moment of Inertia	I	918 x 10^{-6}m^4
Young's modulus (Ex)	E	7.3 x 10^{10}N/m^2
Mass Density	ρ	1400 kg/m^3

Table 2: Experimental Parameters for Composite Leaf Spring

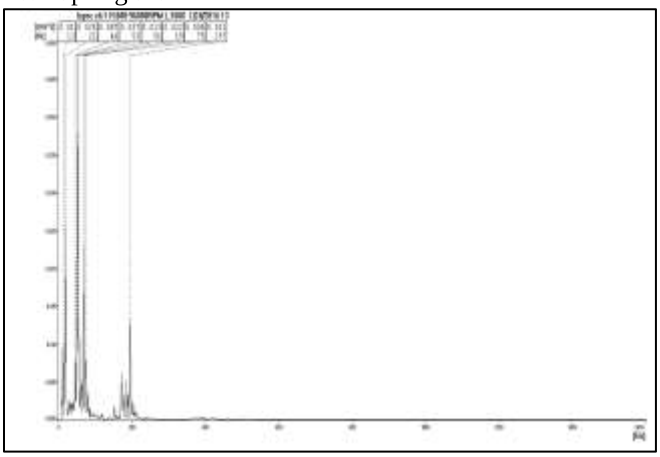
IX. Static Test Result for Free Vibrations:

In this thesis, the Static Test Outcome for Free Vibrations of a Composite Leaf Spring and Steel is analyzed in Table Experimental Static test Results are.

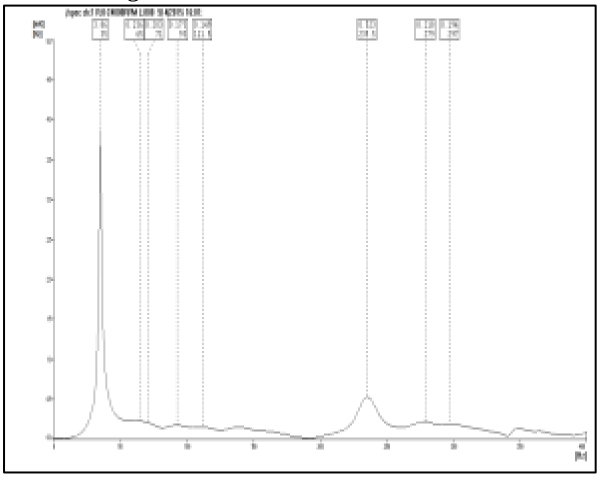
Sr. No.	Steel Leaf Spring (Frequency in Hz)	Composite Leaf Spring (Frequency in Hz)
1st mode	21	38.5
2nd mode	75	108.5
3rd mode	197	238



The schematic results of the static test using the impact hammer for standard steel leaf springs are shown below. As seen in Fig. the free vibration outcomes for Steel Leaf Spring are



For Composite Leaf Spring, the free vibration effects are as shown in Fig.



X. HARMONIC ANALYSIS

A. Harmonic Analysis of Steel Leaf Spring

The Steel leaf Spring harmonic Analysis is obtained as shown in Figure

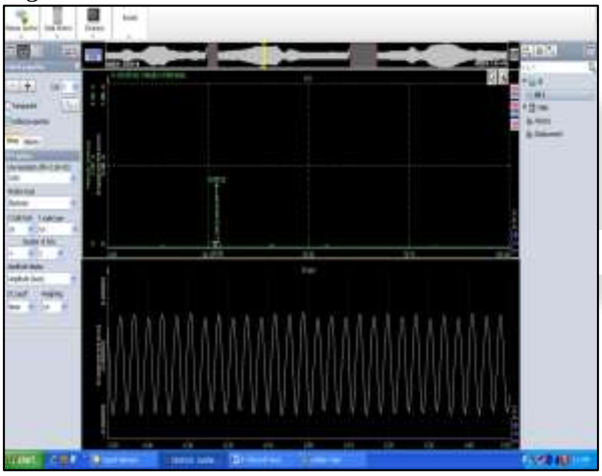


Fig. 5: Steel leaf spring harmonic review

B. Harmonic Analysis of Composite Leaf Spring

The Composite Leaf Spring Harmonic Analysis is obtained as shown in Figure

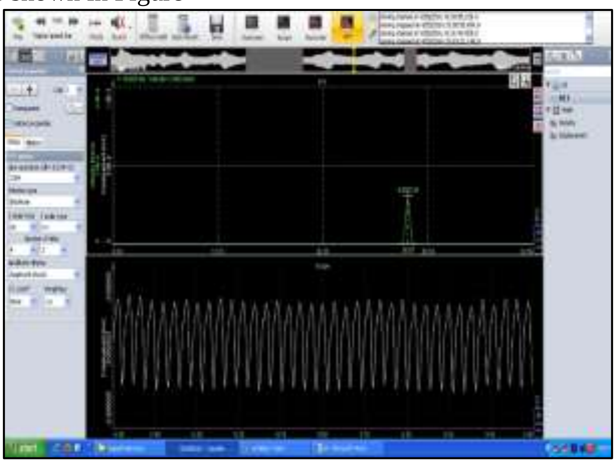


Fig. 6: Composite leaf spring harmonic review

XI. LOAD DEFLECTION CHARACTERISTICS OF LEAF SPRING STEEL AND LEAF SPRING COMPOSITE

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, 100 kg, 200 kg, 300 kg, 400 kg and 500 kg loads are added and deflection is measured experimentally.

A. For Steel Leaf Spring

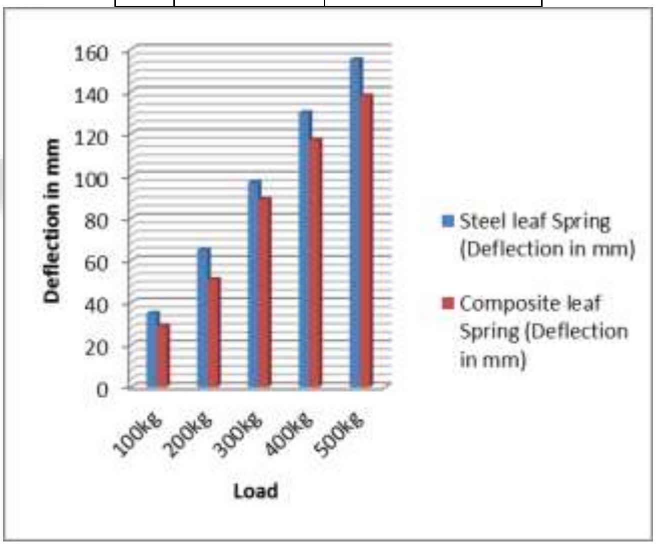
Table display the Steel Leaf Spring experimental test results

Sr.	Load in Kg	Deflection in mm
1	100	35
2	200	65
3	300	97
4	400	130
5	500	155

B. For Composite Leaf Spring

Table display the Composite Leaf Spring experimental test results

Sr.	Load in Kg	Deflection in mm
1	100	29
2	200	51
3	300	89
4	400	117
5	500	138



XII. RESULTS

A. Comparison of Deflection by Experimental Method for Steel Leaf Spring and Composite Leaf Spring

Analysis of deflection for Steel Leaf Spring and Composite Leaf Spring by experimental process

Sr.	Load in Kg	Deflection of steel leaf spring in mm	Deflection of Composite leaf spring in mm
1	100	35	29
2	200	65	51
3	300	97	89
4	400	130	117
5	500	155	138

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