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Vibration Analysis of Canopies Using Elastic Damping Technique

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Abstract: *The sheet metal structures (Canopy) used in DG sets are mostly susceptible to the various static and dynamic loads during their oscillation cycles. Due to this, they encountered resonance conditions at various operating frequencies. Resonance leads to harmonic excitation which further introduces the deformation and stresses leading to the failures of sheet metal structures. Reframing of sheet metal structure with the help of elastic material such as rubber, foam, bitumen, NBR latex etc. changes the stiffness of structure. Thus, stiffness alternation leads to change in dynamic characteristics like natural frequency, mode shapes, and harmonic response. Optimum distributions of damping material in shell structures subject to impact loads by topology optimization. The optimization aims at reducing the residual vibration responses after the application of impact loads. In particular, the dependence of both structural forced vibration and residual vibration on the damping layer distribution is considered by the transient dynamic responses-based optimization approach. Until now, optimum distributions of damping material are always carried out based on frequency domain responses or structural dynamic characteristics. Modal and Harmonic analysis will be simulated using FEA (Ansys Workbench). In experimentation, Impact hammer test and FFT analyzer will be used for the validation purpose. Natural frequencies for sheet metal structure with and without reinforcement will be calculated. Results and conclusions will be drawn by comparing analytical and experimental values. Suitable material will be suggested by analyzing the data along with future scope.*

Keywords: Catia V5, FFT, Model Analysis, Hammer Test, etc.

I. INTRODUCTION

A diesel generator (also known as diesel genset) is the combination of a diesel engine with an electric generator (often an alternator) to generate electrical energy. This is a specific case of engine generator. A diesel compression-ignition engine is usually designed to run on diesel fuel, but some types are adapted for other liquid fuels or natural gas. Diesel generating sets are used in places without connection to a power grid, or as emergency power-supply if the grid fails, as well as for more complex applications such as peak-lopping, grid support and export to the power grid. Proper sizing of diesel generators is critical to avoid low-load or a shortage of power. Sizing is complicated by the characteristics of modern electronics, specifically non-linear loads. In size ranges around 50 MW and above, an open cycle gas turbine is more efficient at full load than an array of diesel engines, and far more compact, with comparable capital costs; but for regular part-loading, even at these power levels, diesel arrays are sometimes preferred to open cycle gas turbines, due to their superior efficiencies.

The packaged combination of a diesel engine, a generator and various ancillary devices (such as base, canopy, sound attenuation, control systems, circuit breakers, jacket water heaters and starting system) is referred to as a "generating set" or a "genset" for short.Set sizes range from 8 to 30 kW (also 8 to 30 kVA single phase) for homes, small shops and offices with the larger industrial generators from 8 kW (11 kVA) up to 2,000 kW (2,500 kVA three phase) used for large office complexes, factories.

A 2,000-kW set can be housed in a 40 ft (12 m) ISO container with fuel tank, controls, power distribution equipment and all other equipment needed to operate as a standalone power station or as a standby backup to grid power. These units, referred to as power modules are gensets on large triple axel trailers weighing 85,000 pounds (38,555 kg) or more. A combination of these modules is used for small power stations and these may use from one to 20 units per power section and these sections can be combined to involve hundreds of power modules. In these larger sizes the power module (engine and generator) is brought to site on trailers separately and are connected together with large cables and a control cable to form a complete synchronized power plant.

A number of options also exist to tailor specific needs, including control panels for AutoStart and mains paralleling, acoustic canopies for fixed or mobile applications, ventilation equipment, fuel supply systems, exhaust systems, etc. Diesel generators are not only for emergency power, but may also have a secondary function of feeding power to utility grids either during peak periods, or periods when there is a shortage of large power generators. In the UK, this program is run by the national grid and is called STOR. Ships often also employ diesel generators, sometimes not only to provide auxiliary power for lights, fans, winches etc., but also indirectly for main propulsion.

With electric propulsion the generators can be placed in a convenient position, to allow more cargo to be carried. Electric drives for ships were developed before World War I. Electric drives were specified in many warships built during World War II because manufacturing capacity for large reduction gears was in short supply, compared to capacity for manufacture of electrical equipment. Such a diesel-electric arrangement is also used in some very large land vehicles such as railroad locomotives.

II. LITERATURE SURVEY

1. Distribution Optimization of Constrained Damping Materials Covering on Typical Panels Under Random Vibration by Shuang Yan Liu, Yi hang Xu, Xiaopeng Shi, Qiong Deng and Yulong Li

This paper studies topology optimization of metallic and composite panels of three different configurations (flat, three-bay and 3*3 grid) covered by the constrained damping materials considering first modal loss factors. The vibration experiments seek to obtain the first modal loss factor and first modal frequency for the aforementioned panels, and corresponding finite element (FE) simulations are completed using commercial software ABAQUSR. According to simulation results, the distribution of constrained damping materials is optimized with evolutionary structural optimization (ESO) method developed using MATLAB.

The results show that the first modal loss factors of optimized panels are reduced slightly if the constrained damping material is removed by 50%. Under the base excitation near each first modal frequency, the maximum root mean square of Von Mises equivalent stress (RMISES) of optimized flat panels and 3_3 grid stiffened panels decrease compared with panels without constrained damping materials. However, the maximum RMISES value of optimized three-bay stiffened panels nearly remains unchanged due to the configuration type of the stiffeners. These results conclude that the three-bay stiffened panel is the best to reduce the maximum RMISES value of at base structure with the same additional mass.

In this paper, metallic and carbon-fiber composite typical panels of three different configurations with constrained damping material treatment were optimized using ESO method with the aim of maximizing the first modal loss factor of panels when constrained damping material is removed by 50%. The stress analysis of optimized metal and composite panels at the first modal frequency during random vibration were conducted. Several conclusions were obtained as follows: (1) The first modal loss factors of optimized metallic and composite panels decrease far less than 50% with the removal ratio of 50%. The results suggest that optimized panels have good performance in suppressing vibration with light weight. (2) The optimized constrained damping materials distribution varies with different panels. The reason is that distinctness of the stiffener configures and material properties of panels lead to significant differences in shear strain distribution of panels.

2. Augmented constrained layer damping in plates through the optimal design of a 0-3 viscoelastic composite layer Ambesh Kumar, Satyajit Panda, Vivek Narsaria and Ashish Kumar.

In this work, a new 0-3 viscoelastic composite (VEC) layer is presented for augmented constrained layer damping of plate vibration. The 0-3 VEC layer comprises a rectangular array of the thin rectangular graphite-wafers embedded within the viscoelastic matrix. The inclusions of graphite wafers in the constrained 0-3 VEC layer confine the motion of the viscoelastic phase for its reasonable in-plane strains along with the enhanced transverse shear strains. This occurrence of coincidental shear and extensional strains within the viscoelastic phase is supposed to cause augmented damping capacity of the constrained layer, and it is investigated by integrating the constrained 0-3 VEC layer over the top surface of a substrate plate.

A finite element (FE) model of the overall plate is developed based on the layer-wise shear deformation theory. Using this FE model, first, a bending analysis of the overall plate is performed to investigate the mechanisms of damping in the use of 0-3 VEC layer. Next, the damping in the overall plate is quantified for different sets of values of the geometrical parameters of the 0-3 VEC layer. These results reveal significant improvement of damping in the plate due to the inclusions of graphite-wafers within the constrained viscoelastic layer. But, the augmentation of damping indicatively depends on the geometrical parameters in the arrangement of the graphite-wafers. So, the 0-3 VEC layer is configured appropriately through an optimization algorithm, and finally, the forced frequency responses of the overall plate are evaluated to demonstrate the augmented attenuation of vibration-amplitude via the inclusions of graphite-wafers within the constrained viscoelastic layer in an optimal manner.

In this work, a new 0-3 viscoelastic composite (VEC) layer is presented for augmented constrained layer damping of structural vibration. The 0-3 VEC layer comprises a rectangular array of thin rectangular graphite- wafers embedded within the viscoelastic matrix. The rectangular graphite-wafers are in the macroscale but evenly spaced with a gap in micro-scale. This 0-3 VEC layer is utilized as a constrained damping layer over the top surface of a simply supported rectangular plate, and its passive damping capacity is investigated by developing an FE model of the overall plate based on the layer-wise shear deformation theory. First, a bending analysis of the overall plate is performed, and the characteristics of the transverse shear and in plane strains within the constrained 0-3 VEC layer are studied_

3. Tuning dynamic vibration absorbers by using ant colony optimization by Felipe Antonio Chegury Viana, Giovanni Iamin Kotinda, Domingos Alves Rade, Valder Steffen Jr.

The present contribution deals with the optimal tuning of two different types of dynamic vibration absorbers (DVA) by using ant colony optimization, namely the vibrating blade DVA and the multi-mode DVA. Dynamic vibration absorbers are mechanical appendages constituted by mass, spring and damping elements, which are coupled to a mechanical system to provide vibration attenuation. The tuning of the dynamic vibration absorber is the procedure that sets the anti-resonance frequency to a given value by adjusting the parameters of the dynamic vibration absorber. Based on this methodology, the optimization problem is defined as the minimization of the objective function that describes the vibration amplitude of the primary structure.

To solve the optimization problem, ant colony optimization was used. In the early nineties, when the Ant Colony algorithm was first proposed, it was used as an alternative approach for the solution of combinatorial optimization problems, such as the traveling salesman problem. However, the extension for operating with continuous variables is recent and this feature is still under development. In the present formulation, the optimization technique was extended to handle continuous design variables. Numerical results are reported, aiming at illustrating the success of using the proposed methodology, as applied to mechanical system design. Noise and vibration suppression techniques allow the construction of more accurate medical instruments, safer buildings, more pleasant environments and more robust products. Physically, the first effect of damping in a structure is the reduction of vibration amplitudes, particularly in the neighborhood of resonance. In this context, passive, active or hybrid vibration control approaches can be used to obtain damping and vibration control.

Actuators, power supplies and control systems characterize the active techniques. the setup of the ACO algorithm used for both case studies. However, it should be added that ACO, as any other nature-inspired optimization method, is sensitive to the setup values. Thus, depending on the application, precision requirements, available calculation resources, etc., these values should be modified. This way, a poor convergence means low level of local search. Two possible solutions for this case can be addressed: (i) to increase the number of ants and/or the maximum number of iterations; and/or (ii) to use a gradient- based technique as a final optimization run in the end of the procedure. None of these alternatives were necessary in any of the case studies_

4. STUDY OF VARIOUS PARAMETERS IN DIESEL-GENERATOR SETS by KOLLI SURYA SREEVATHSANATH.

A diesel generator is the combination of a diesel engine with an electric generator (often an alternator) to generate electrical energy. Diesel generating sets are used in places without connection to the power grid, as emergency power-supply if the grid fails, as well as for more complex applications such as peak-lopping, grid support and export to the power grid. Setsizes range from 8 to 30 kW (also 8 to 30 kVA single phase) for homes, small shops & offices with the larger industrial generators from 8 kW (11 kVA) up to 2,000 kW (2,500 kVA three phase) used for large office complexes, factories. In addition to this there are factors which diesel generators depend on they are Ambient Temperature, Load on the Generator, Altitude of operation of the generator.

Ambient generator refers to the Inlet temperature. Because the generator works with the diesel engine, the heat that the diesel engine emits make ambient temperature more than 40 Celsius. However, temperature should be less than 40 Celsius for operation. In the present work behaviour of 62.5 KVA Diesel Generator is studied in ANSYS V13.0 (A licensed Institute software.) First a schematic approximation of the diesel-generator is drawn in the ANSYS Software and then the Experiments are made to determine the temperature conditions of various surfaces under constant load. These observations are taken for the simulation in the software and the results are displayed.

III. DESIGN AND ANALYSIS

CAD:

Three-dimensional model of Canopy set-up was making in Catia V5 R20 software.

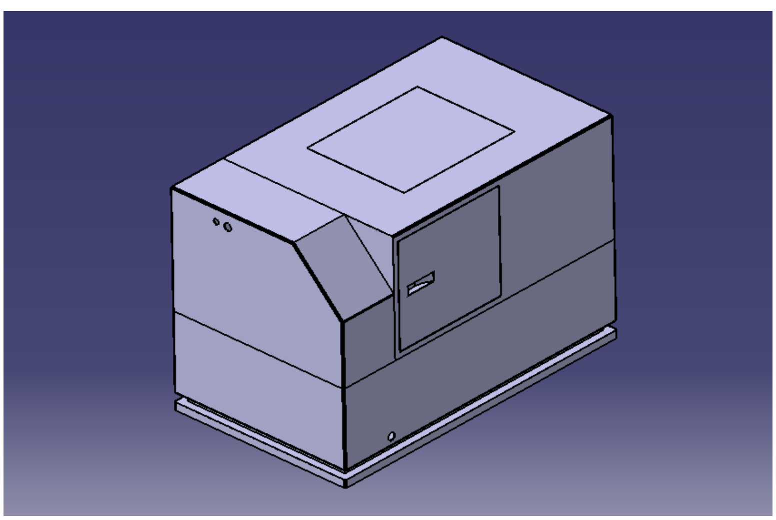

Figure 3: CATIA Model of the Canopy

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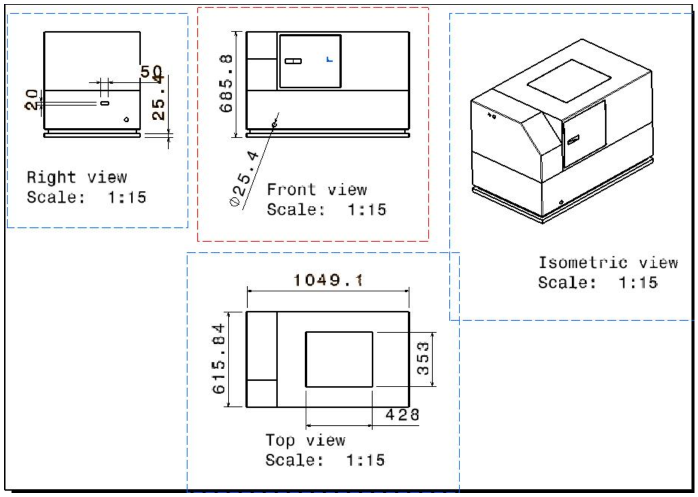

Figure 4: Drafting of Model

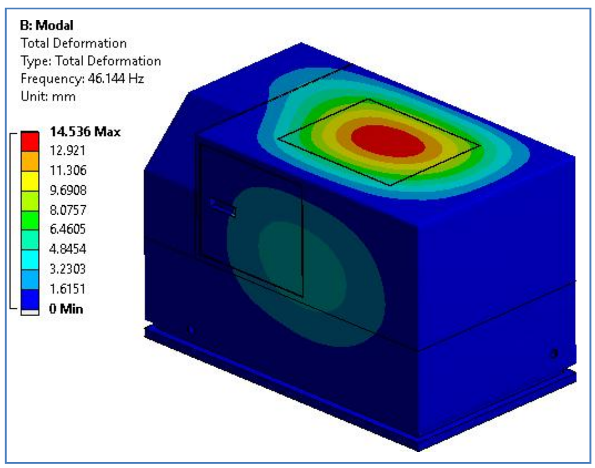

Figure 9: Mode shape 1 and respective frequency

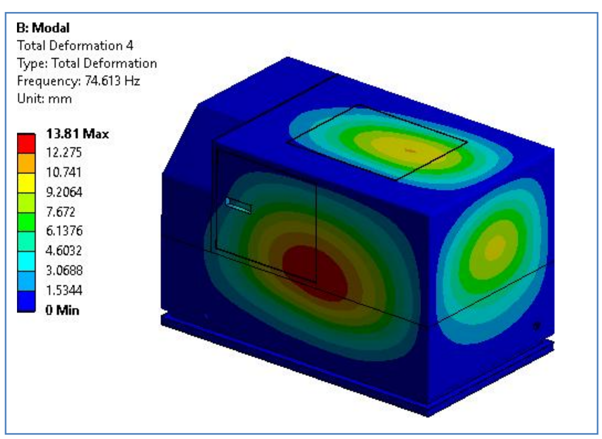

Figure 12: Mode shape 4 and respective frequency

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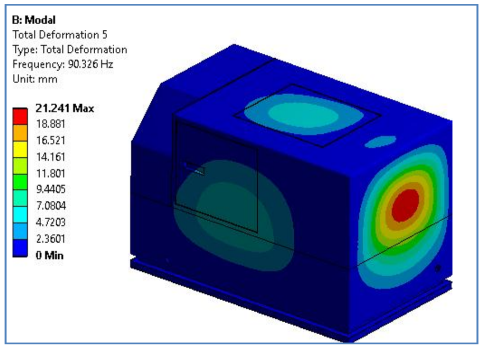


Figure 13: Mode shape 5 and respective frequency

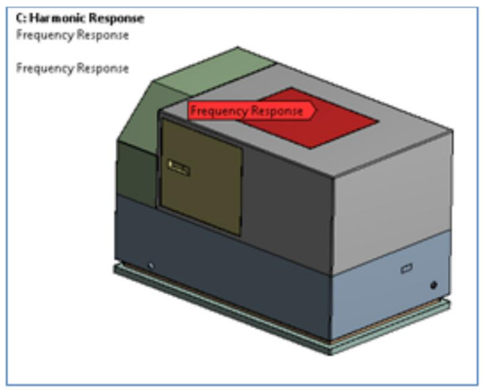


Table 2: Representation of Natural frequency for respective modes

Tabular Data

	Mode	Frequency [Hz]
1	1.	46.144
2	2.	62.209
3	3.	69.126
4	4.	74.613
5	5.	90.326
6	6.	94.619

IV. EXPERIMENTAL ANALYSIS AND SIMULATION

Fast Fourier Transform

FFTs were first discussed by Cooley and Tukey (1965), although Gauss had actually described the critical factorization step as early as 1805 (Bergland 1969, Strang 1993). A discrete Fourier transform can be computed using an FFT by means of the Danielson-Lanczos lemma if the number of points is a power of two. If the number of points is not a power of two, a transform can be performed on sets of points corresponding to the prime factors of which is slightly degraded in speed. An efficient real Fourier transform algorithm or a fast Hartley transform (Bracewell 1999) gives a further increase in speed by approximately a factor of two. Base-4 and base-8 fast Fourier transforms use optimized code, and can be 20-30% faster than base-2 fast Fourier transforms. prime factorization is slow when the factors are large, but discrete Fourier transforms can be made fast for, 3, 4, 5, 7, 8, 11, 13, and 16 using the Winograd transform algorithm.

The experimental validation is done by using FFT (Fast Fourier Transform) analyzer. The FFT spectrum analyzer samples the input signal, computes the magnitude of its sine and cosine components, and displays the spectrum of these measured frequency components. The advantage of this technique is its speed. Because FFT spectrum analyzers measure all frequency components at the same time, the technique offers the possibility of being hundreds of times faster than traditional analog spectrum analyzers.

Fourier analysis of a periodic function refers to the extraction of the series of sines and cosines which when superimposed will reproduce the function. This analysis can be expressed as a Fourier series. The fast Fourier transform is a mathematical method for transforming a function of time into a function of frequency. Sometimes it is described as transforming from the time domain to the frequency domain. It is very useful for analysis of time-dependent phenomena.

Impact Hammer Test

Impact excitation is one of the most common methods used for experimental modal testing. Hammer impacts produce a broad banded excitation signal ideal for modal testing with a minimal amount of equipment and set up. Furthermore, it is versatile, mobile and produces reliable results. Although it has limitations with respect to precise positioning and force level control, overall, its advantages greatly outweigh its disadvantages making it extremely attractive and effective for many modal testing situations.

The use of impulse testing with FFT signal processing methods presents data acquisition conditions which must be considered to ensure that accurate spectral functions are estimated. Problems stem from the availability of only a finite duration sample of the input and output signals. When a structure is lightly damped the response to the hammer impact may be sufficiently long that it is impractical to capture the entire signal. The truncation effect manifests itself in terms of a spectral bias error having the potential to adversely affect the estimated spectra. The signal truncation problem is further compounded in practice by the computational and hardware constraints of the FFT processing equipment.

Typically, the equipment has a limited number of data capture lengths or frequency ranges which are available for an operator to select. Normally a user is more concerned with useable analysis frequencies and less with the data capture length. Therefore, it is conceivable that an inappropriate data capture duration could be used which truncates the vibration signal and introduces errors in the estimated spectra. To suppress the truncation a common practice is to artificially force: it to decay within the data capture window [1,2,3]. This artificial reduction is obtained by multiplying the slowly decaying vibration signal by an exponential function. However, the application of the exponential window must be considered carefully since it may also adversely affect the estimated spectra.

A phenomenon commonly encountered during impact testing is the so called "double hit". The "double hit" applies two impulses to the structure, one initially and one time delayed. Both the temporal and spectral characteristics of the "double hit" input and output are significantly different than a "single hit".

The input force spectrum for the "double hit" no longer has the wide band constant type characteristics of a single hit. The purpose of this paper is to examine the use of impact vibration testing in relation to the constraints imposed by typical FFT' signal processing techniques. The characteristics of the impact testing procedure are examined with analytical time and spectral functions developed for an idealized test: a single degree of-freedom system excited by a half sine impact force. Once an understanding of the fundamental characteristics is developed it is applied to examine the specific situations encountered in structural impact testing. The relationship of the system's parameters with respect to data capture requirements is evaluated.

The effects of exponential windowing are developed to examine the effects on the estimated spectra and modal parameters. Finally, the "double hit" phenomena are examined by combining the results from the single degree-of-freedom system excited by two impulses, one of which is time delayed. The results from these related studies are combined to provide insight into data acquisition guidelines for structural impact testing.

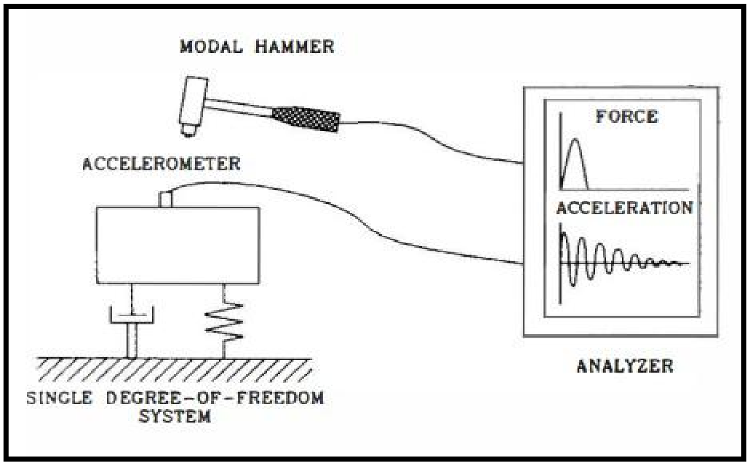
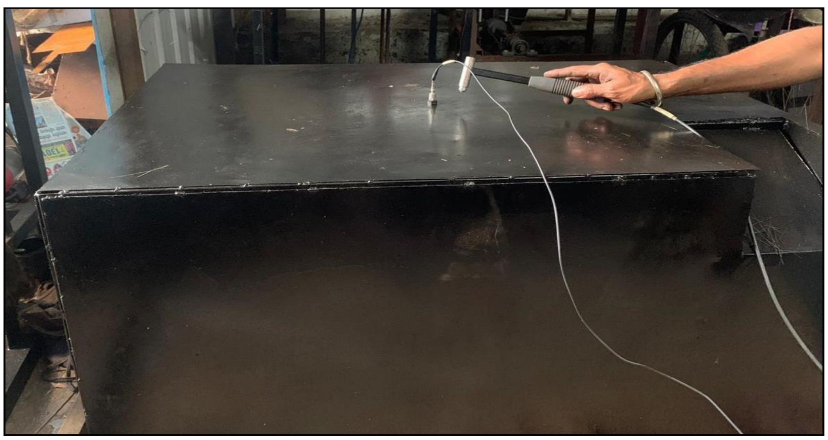
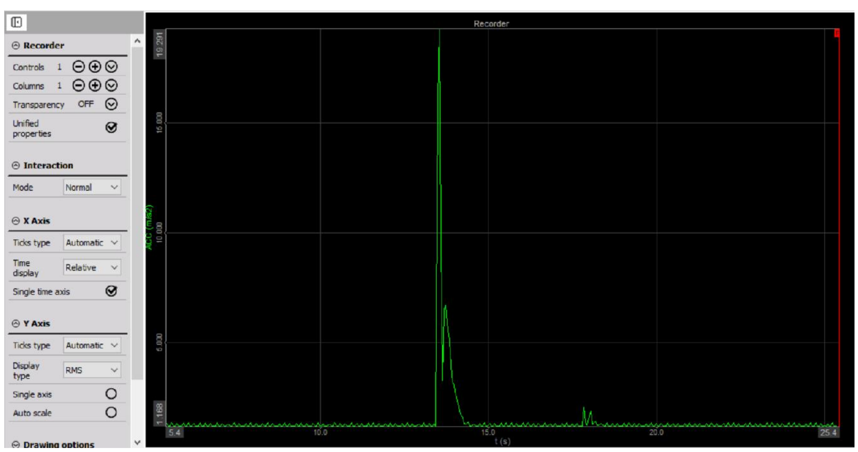


Figure 15: FFT construction





Graph. Maximum acceleration for circular patch

Circular patch – maximum acceleration is observed around 7.92 m/s^2

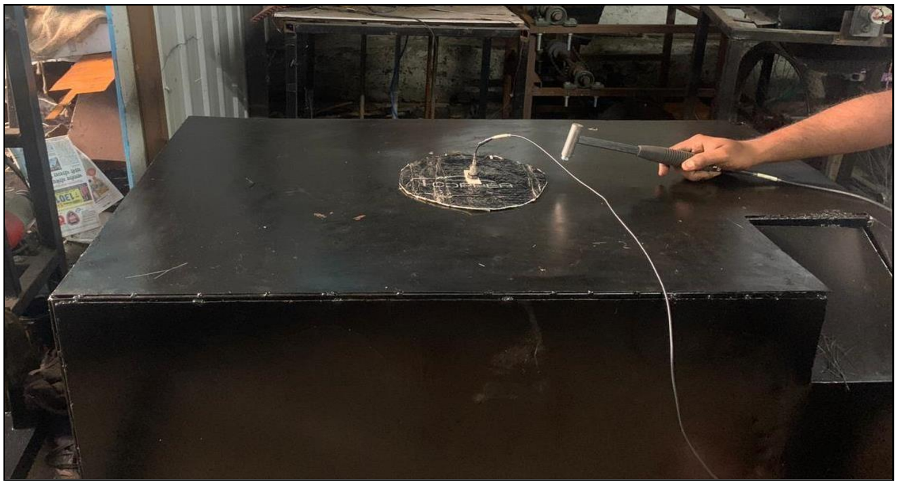
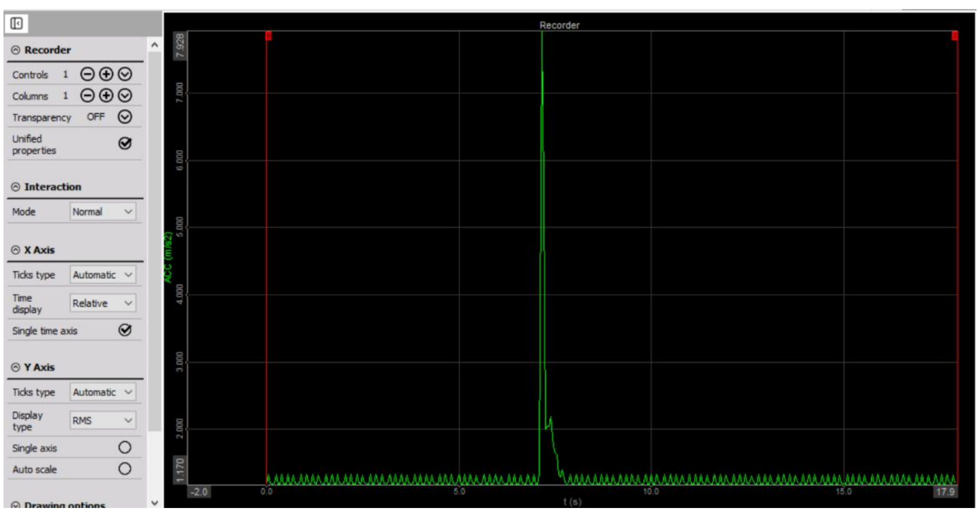


Figure: Experimental setup for circular patch



Graph. Maximum acceleration for circular patch

Circular patch – maximum acceleration is observed around 7.92 m/s^2

V. CONCLUSION AND DISCUSSION

- In present research canopy is designed and modal analysis have been performed to reduce vibration created in engine or generator inside it.
- Modal and harmonic analysis have been performed to determine optimum shape viscoelastic patch namely circular and rectangular shape in which max acceleration is reduced to 48, 63 compared to surface acceleration of 141 m/s^2 amplitude respectively.
- In experimental testing FFT and FEA results are almost in similar range for setup natural frequency.
- In experimental it is observed that maximum acceleration of rectangular, circular and without patch is in 4.87, 7.92 and 19.29 m/s^2 respectively.
- It is observed that rectangular shape viscoelastic patch has better absorbing characteristics than other shape to reduced vibration.

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