Experimental Testing and FEA Analysis to Enhance the Strength of Existing Tractor Footrest

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Abstract- *The plan and investigation assumes a significant job for deciding the underlying driver for the issue. When the issue and its underlying driver were very much characterized, the answer for tending to the issue would be clarified. The motor excitation recurrence and the undercarriage regular recurrence were coming nearer and it drives body to resound. The resonance builds vibration levels at the Tractor footrest which was diminishing solace level of the administrator. The vibration decreases procedures like hardening the structure, disconnecting the source from excitation and hosing systems were concentrated to diminish vibration levels at stool. Structure of existing tractor footrest in CATIA software and FEA examination is to be performed utilizing ANSYS software. In present investigation static, modal analysis and harmonic is to be performed on tractor footrest to determine stress, deformation and natural frequency and also to improve the existing design using bead pattern to obtain improved natural frequency. Experimental and FEA analysis results will be compared and conclusion will be drawn.*

Keywords: **ANSYS, Modal analysis, Beading pattern.**

1.INTRODUCTION

A footrest is a household item or a help used to hoist the foot. There are two primary sorts of footrest, which can be approximately classified into those intended for comfort and those intended for work. This kind of stool is utilized to give solace to an individual situated, for instance, in a seat or couch. It permits the situated individual to rest their feet upon it, supporting the legs at a for the most part flat level, therefore offering ascend to the other term footrest. This sort of stool bolsters an individual's feet that don't arrive at the floor when situated. The stool is set under the feet of a sitting individual with the goal that the individual's feet may lay easily on it. A car commonly has a "fake pedal" that goes about as a stool to demoralize "riding the grasp" or "riding the brake". A foot peg is another sort of ottoman for the most part on BMX bikes, bikes, the Ford N-Series tractor, a few kayaks, the Impossible wheel, and other transportation gadgets. Footrests have been known for a long time, and have developed since the beginning. It was put before the chimney, and long enough for the entirety of the relatives to put their feet and warm them up. Footrests where by and large compatible in regular daily existence from the seventeenth through the mid nineteenth century. In early American homes the footrest was truly important, and took valuable space in spite of the fact that the living quarters were confined. Undesirable vibration can cause exhaustion or corrupt the exhibition of the structure. Subsequently, it was attractive to take out or lessen the impacts of vibration. There were higher vibrations on the stool of the Tractor and it was diminishing solace level of the administrator. The objective was set to build characteristic recurrence of gauge tractor model to benchmark as the two tractors have same three-chamber motor which was causing reverberation with body. The acknowledgment rules were created dependent on the contributions from the client rating.

1.1 LITERATURE REVIEW

Vilas Gorakh Umbare et.al [1], In this paper, the creator exhibited the deliberate way to deal with diminish tractor stool vibrations by 20% - 25% through idea plan, virtual examination and exploratory approval. The engine excitation frequency and the undercarriage regular frequency were coming nearer and it drives frame to resound. The resonance expands vibration levels at the Tractor footrest which was decreasing solace level of the administrator. The vibration decreases systems like hardening the structure, detaching the source from excitation and hosing procedures were concentrated to lessen vibration levels at footrest. Vibration levels were brought down in the Tractor stage by 10% than current level. It had expanded solace and consumer loyalty level. The Solution of the advanced cross area grasp lodging was proposed for final usage on new tractors. The outcomes were empowering as vibration levels were brought down in the Tractor stage by 25% - 30% contrasted with the

present tractor. A first step is consider a tangle with a framework design which includes little bulges on the network design on the underside of the tangle. These knocks demonstration to offer a delicate help under light burden, (for example, an administrator's foot laying on the tangle) however will fall to give a firm support under heavier burden, for example, an administrator supporting his weight on the mat.

Kandavel Gowri Shankar et.al [2], In this paper, the creator exhibits the precise methodology in diminishing the guiding wheel vibration through plan for Six Sigma (DFSS). In car frameworks, System-initiated Steering wheel vibration is a noteworthy wellspring of shopper inconvenience. When managing vibration related issues, the plan and examination assumes a significant job for deciding the underlying driver for the issue. The essential driver of the inadmissible Steering wheel vibration was because of reverberation of the control backing and skeleton structure with Engine excitation frequency. Three changes were found to altogether decrease vibration at the controlling wheel Isolating the directing valve from the help Adding critical fore-behind firmness to the control bolster structure. Parting directing sub get together and the hood bolster structure. Disconnecting Steering Assembly from the Control Support, this includes expansion of new isolators between the directing gathering and the control support; in this manner, the vibrations will be assimilated totally by the isolators gave and the controlling get together will just have the outside diversions brought about by higher adequacy modes in chassis.

Michael J. Crosby et.al [3] in this paper it presents a PC recreations of improved taxi ride for both traditional and taxi over motor tractors. Vehicle riding on a street which has the vibrational contribution of the tractor outline. In a few different ways the taxi is like a minimized traveler vehicle. While low pitch frequencies are not alluring for the tractor with its trailer input, the taxi has no tantamount info. In this manner, diminishing the pitch characteristic recurrence of the taxi segregation framework can altogether constrict pitch unsettling influences. In this manner, except for legitimate scorning, nonlinear springs are not commonly required. For exceptionally low recurrence taxi detachment frameworks, the expansion of a traveler in the sleeper and gear must be considered as for static avoidance, nonetheless. As for move dependability, taxi separation frameworks are less basic than vehicle essential suspension. Move firmness necessities for taxis are directed by driver street feel and ride quality contemplations. It is reasoned that taxi confinement framework outer power, loaded to unladen weight, and move soundness contemplations are significantly less tough than for the tractor/trailer. Contrasted with the suspended seat, taxi segregation offers the capability of powerful fore/toward the back just as vertical seclusion, and assurance for the sleeper tenant. The administrator/controls interface issue is not as much as that of the secluded seat. Control linkage issues at the taxi/vehicle interface can be presented by taxi segregation.

Suphattharachai Chomphan et.al [4], in this examination it presents an investigation of the vibration signal sent through four center focuses which are the contacts between driver or rider and the bike body including cruiser left hand, seat, left front stool, and left back footrest. When beginning and quickening the motor, it has been discovered that there was a vibration all through all pieces of the cruiser. The correlation results have been performed by utilizing two parameters of found the middle value of pinnacle and arrived at the midpoint of vitality of the vibrational sign. The outcomes uncover that the left front ottoman has the most noteworthy vibration level in the two parameters, while the seat has the least vibration level. The vibration has been moved from the working motor and all general situations. These focuses are the contacts between driver or rider and the body of the example cruiser body including bike left hand, seat, left front stool, and left back footrest.

S.Shashanka et. al [5], In this paper it presents on capturing vibrations in the footrest of motorcycle, as finished up from the client input examination led over different reviews, regarding the new Royal Enfield thunderbird 500 bike. A modal analysis is made to recognize the degree of vibration along the footrest to distinguish frail focuses and study the conduct of the segment under working conditions. Auxiliary properties are explored with an expect to update the segment and diminish vibration experienced by the rider. The stool geometry is adjusted to limit nodal removal, considering the activity of the footstool as a cantilever bar. So as to test the enhancements affected in the new structure, physical testing is finished by recreating genuine working conditions and estimating vibrations along the focal points on the case utilizing accelerometers. Exploratory examination between the current structure and the changed plan demonstrates that the adjusted structure decreases vibration experienced by the rider and improves by and large drive comfort.

1.2 PROBLEM STATEMENT

Nowadays, to improve the life cycle of existing component its natural frequency must be increased. So, in present

study use of bead pattern in proper location is to be utilised to enhance the frequency of existing tractor foot rest. Experimental and numerical analysis of existing tractor footrest to study the effect of deformation, mode shapes, natural frequencies and harmonic analysis using ANSYS software.

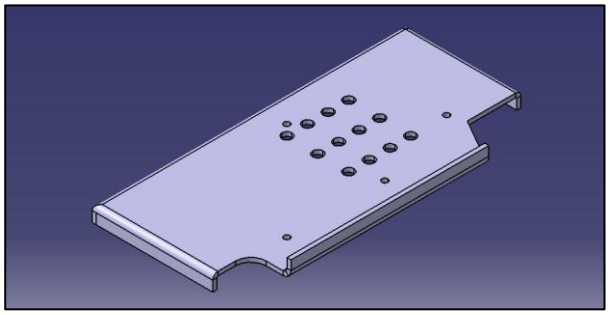
1.3 OBJECTIVES

I. Modelling of existing tractor footrest using CATIA V5 R20 software.
II. To perform static, modal and harmonic analysis to determine deformation, stresses, natural frequency along with mode shape using ANSYS software.
III. To improve the existing design with use of bead pattern and compare with existing design results.
IV. Manufacturing of optimized design and testing using FFT.
V. Validation of FEA and experimental results.

1.4 METHODOLOGY

Step 1:- Initially research paper are studied to find out research gap for project then necessary parameters are studied in detail. After going through these papers, we learnt about tractor footrest.
Step2:- Research gap is studied to understand new objectives for project.
Step 3:- After deciding the components, the 3D Model and drafting will be done with the help of CATIA software.
Step 4:- The modal analysis of the components will be done with the help of ANSYS using FEA.
Step 5:- Experimental manufacturing of component and performing test as per objectives specified.
Step 6:- Comparative analysis between the experimental & analysis result & then the result & conclusion will be drawn.

2. CATIA & DRAFTING MODEL



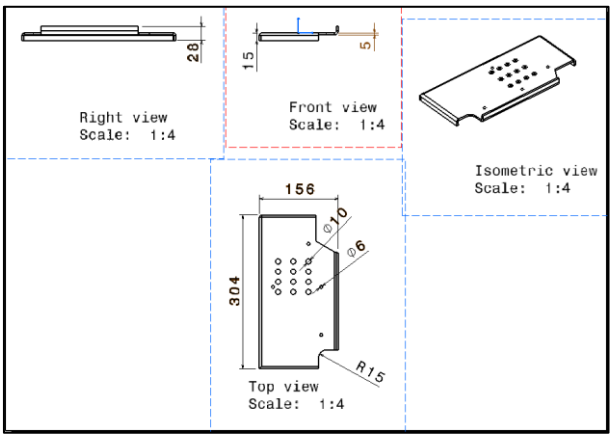


Fig.-1: CATIA and drafting of tractor footrest

2.1 MODAL ANALYSIS OF EXISTING TRACTOR FOOTREST

Table-1: Engineering material properties

Properties of Outline Row 3: Structural Steel

	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	7850	kg m^-3
4	Isotropic Secant Coefficient of Thermal Expansion		
6	Isotropic Elasticity		
7	Derive from	Young's Modulus and Poi...	
8	Young's Modulus	2E+11	Pa
9	Poisson's Ratio	0.3	
10	Bulk Modulus	1.6667E+11	Pa
11	Shear Modulus	7.6923E+10	Pa

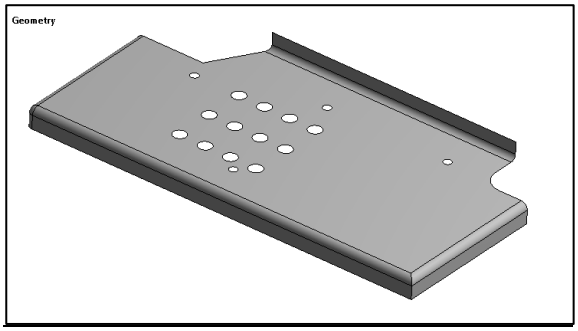
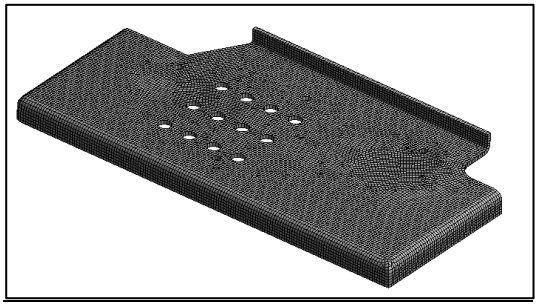


Fig-2: Geometry imported in ANSYS

3. MESH

In ANSYS meshing is performed as similar to discretization process in FEA procedure in which it breaks whole components in small elements and nodes. So, in analysis boundary condition equation are solved at this elements and nodes. ANSYS Meshing may be all-purpose, intelligent, automated high-performance product. It produces the

foremost acceptable mesh for correct, economical metaphysics solutions. A mesh well matched for a selected analysis may be generated with one click for all elements in a very model. Full controls over the options accustomed generate the mesh are accessible for the skilled user who needs to fine-tune it



Statistics	
Nodes	13190
Elements	12881

Fig-4: Details of meshing

3.1 BOUNDARY CONDITION

A boundary condition for the model is that the setting of a well-known value for a displacement or an associated load. For a specific node you'll be able to set either the load or the displacement but not each. The main kinds of loading obtainable in FEA include force, pressure and temperature. These may be applied to points, surfaces, edges, nodes and components or remotely offset from a feature. Fixed support is applied at bolting joint as per existing condition

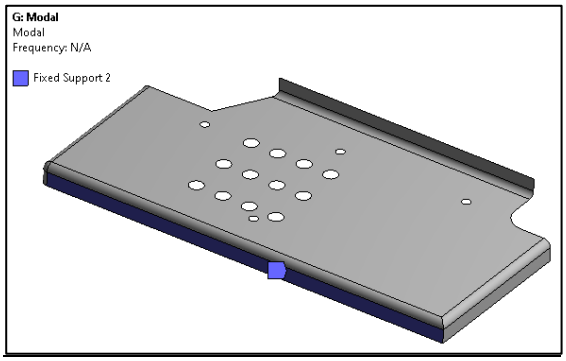


Fig-3: Boundary condition

In boundary condition fixed support is applied face indicated in blue color as per existing boundary conditions.

3.2 TOTAL DEFORMATION

In finite element method the total deformation and directional deformation are general terms irrespective of software being used. Directional deformation may be place because the displacement of the system in a very particular axis or user defined direction. Total deformation is that the vector sum of all directional displacements of the systems.

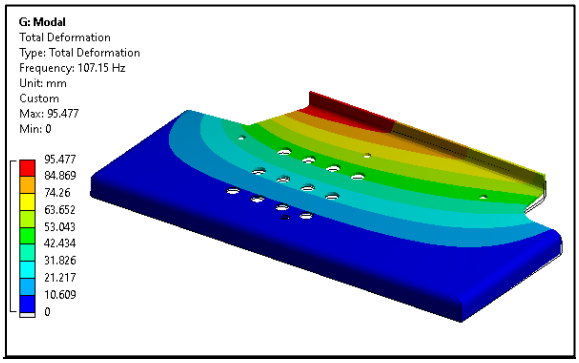


Fig-5: Mode shape 1

Table-2: Tabular data of mode shape frequency

Tabular Data		
	Mode	Frequency [Hz]
1	1.	107.15
2	2.	239.39
3	3.	430.36
4	4.	527.36
5	5.	638.28
6	6.	764.11

4. HARMONIC ANALYSIS FOR EXISTING FOOTREST

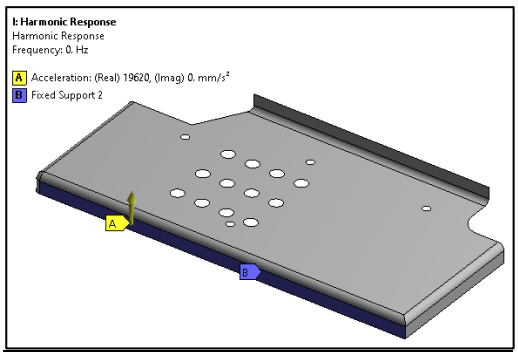


Fig-6: Boundary conditions for harmonic analysis

For harmonic analysis base excitation is provided at fixed support with 2G acceleration and respective frequency response is calculated with frequency.

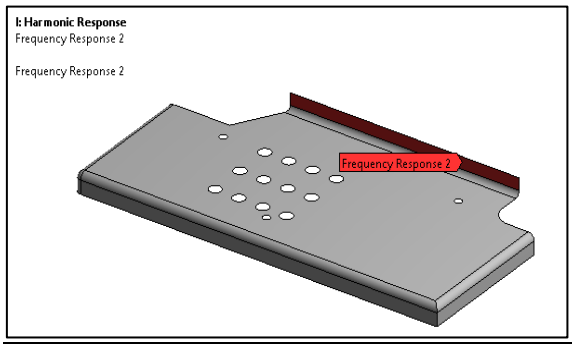


Fig-7: Frequency response surface

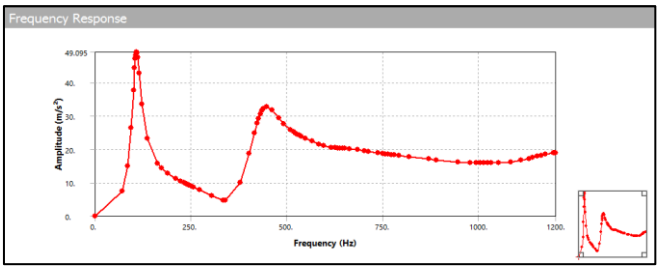


Chart-1: Frequency response result

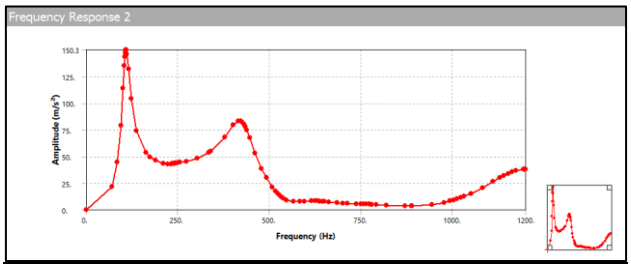


Chart-2: Frequency response result

It is observed from harmonic analysis that frequency response at surface and at edge are 49 m/s^2 and 150 m/s^2 respectively

4.1MODIFIED TRACTOR FOOTREST

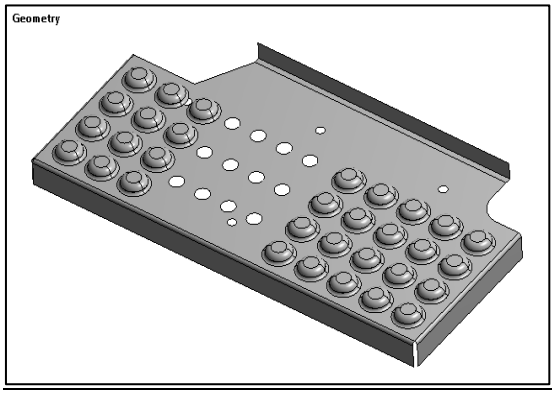


Fig-8: Modified foot rest

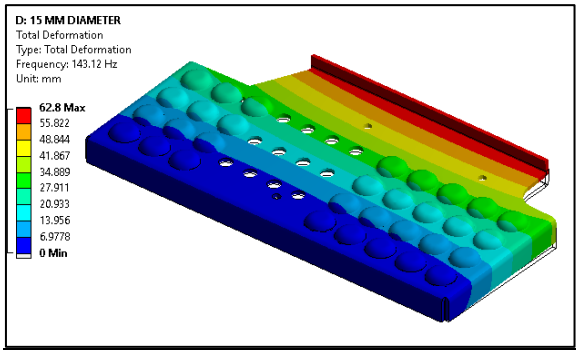


Fig-9: Mode shape 1

Table-3: Tabular data of mode shape frequency

Tabular Data

	Mode	Frequency [Hz]
1	1.	143.12
2	2.	244.19
3	3.	491.15
4	4.	712.36
5	5.	750.34
6	6.	1009.3

It is observed that frequency have been improved compared to existing and modified 10 mm bead pattern design.

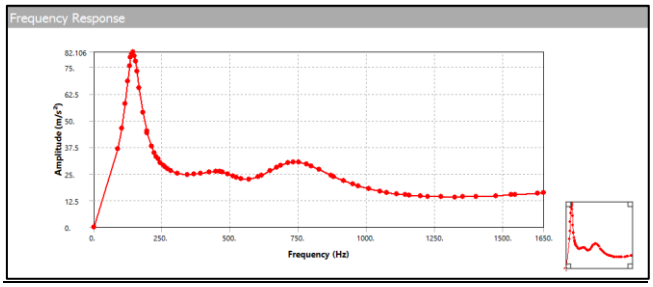


Chart-3: Frequency response result

4.2 STATIC ANALYSIS OF EXISTING FOOTREST

It is observed from static analysis that modified footrest have reduced stress.

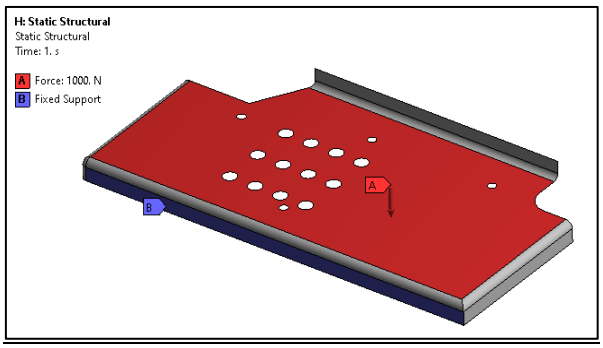


Fig-10: Boundary condition for static analysis

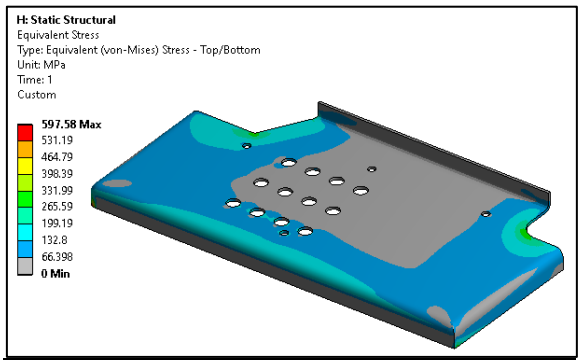


Fig-11: Equivalent stress results for existing design

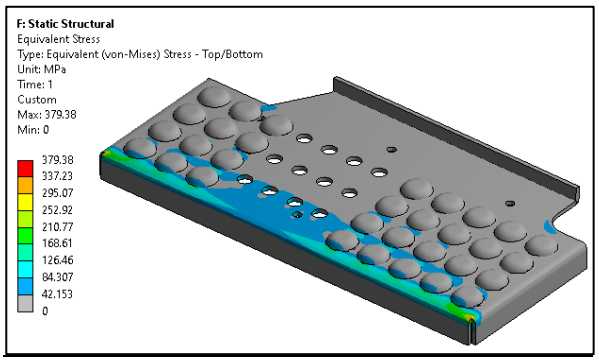


Fig-12: Equivalent stress results for modified footrest

It is observed from static analysis that modified footrest have reduced stress concentration compared to exiting tractor footrest.

5. EXPERIMENTAL TESTING

5.1 Fast Fourier Transform

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.

5.2 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. 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 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 is 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.

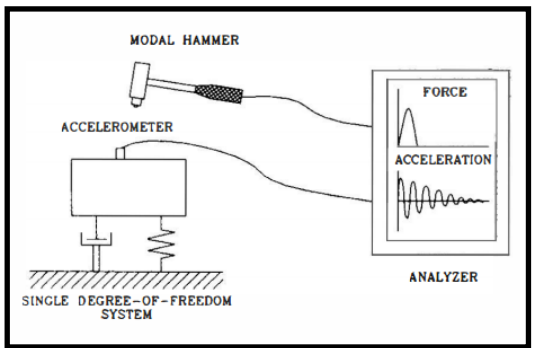


Fig-13: Block diagram of FFT

5.3 EXPERMENTAL PROCEDURE FOR STATIC MODAL ANALYSIS

•Initially fixture is designed according to existing boundary condition as per FEA results.
•FFT consists of impact hammer, accelerometer, data acquisition system in which each supply is applied to DAS and laptop with DEWSOFT software to view FFT plot.
•Accelerometer is mounted at surface as per high deformation observed in FEA results along with initial impact of hammer is placed for certain excitation to determine frequency of respective mode shapes.
•After impact FFT plot are observed on laptop and comparison of FEA and experimental results are analyzed.

Fig-14: Experimental setup

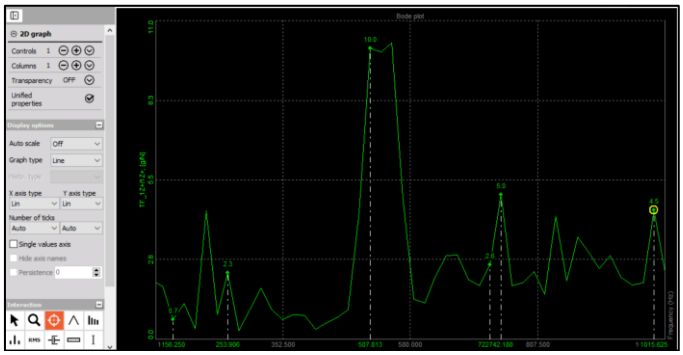


Fig-15: FFT plot for modified tractor foot rest

Table-4: Comparison of FEA and FFT natural frequency

MODE SHAPE (NATURAL FREQUENCY)	FEA	EXPERIMENTAL
1	143.12	156.25
2	244.19	253.90
3	491.15	507.81
4	712.36	722.0
5	750.34	742.18
6	1009.3	1015.62

6. CONCLUSIONS

1. In present investigation static, modal and harmonic analysis is performed to determine stress and deformation with mode shape of respective frequency with existing and modified tractor footrest.
2. It is observed that bead pattern has improved the existing natural frequency along with less deformation and stress concentration reduction.
3. It is observed from experimental and FEA analysis that natural frequency by ANSYS and FFT are nearly identical.

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