Vibration investigation of 2-wheeler speedometer using vibration fixture

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Abstract

In this study, the vibration sustainability of a 2-wheeler Speedometer was investigated using a vibration fixture. The main concern was unwanted vibrations that could cause resonance effects and potentially damage delicate machine components. To ensure the machine's reliability, the Speedometer underwent various vibration tests after manufacturing. The design of the fixture was crucial, as it needed to be sturdy, lightweight, and cost-effective. ANSYS Workbench was utilized for Finite Element Analysis (FEA) of the Speedometer fixture, focusing on determining its natural frequency. Modal and harmonic analyses were performed using ANSYS Workbench, and based on the FEA results, modifications were made to the Speedometer fixture. If the observed natural frequency range fell within the operating frequency, the fixture would be deemed safe and validated. To experimentally validate the FEA results, an FFT analyser and an impact hammer were employed.

Keywords: 2-wheeler Speedometer, FEA, Modal and harmonic analysis, FFT analyser & impact hammer.

1. Introduction

Fixtures are made to test a component's endurance and guarantee that it will fail from fatigue. Materials with a good strength to weight ratio are used to make the fixtures. The fixtures are designed to be sufficiently rigid to endure the shocks and random vibrations caused by erratic driving conditions. The limitations of the fittings are that they must be lightweight and protect the component from road shocks and vibrations.

Trucks, buses, and two-wheelers can be employed for a number of tasks in a variety of working environments. When it comes to long-haul services, for instance, a competitive market forces businesses to continually work on increasing the operational capacity of their vehicle fleets. The various parts of the vehicle are put under a lot of stress as a result. The number of electrical and electromechanical components used in two-wheelers, trucks, and buses is growing as technology advances. They therefore progressively contribute to ensuring a vehicle's correct functionality. The interface between the test object and the vibration apparatus is a vibration test fixture. However, because vibrations during accelerated testing are substantially worse than vibrations during actual operation of the component, the test fixture needs to be stiffer and more rigid than the matching part used for mounting on the vehicle. A significant issue with the operation of automotive machinery is vibration. Vibrations are taken into account while constructing a machine because unwanted vibrations might have a resonance effect that can harm delicate machine parts. After a machine or machine component is manufactured, it is put through a number of vibration testing. Fixtures then transmit energy to test samples. The design of the fixture must be straightforward, lightweight, and most significantly, inexpensive. The use of contemporary analysis tools and computer-aided design software has simplified fixture design. Designing a vibration fixture is a crucial part of doing vibration testing, but it can be difficult for many engineers. The material selection is crucial when it comes to the design of fixtures. Examples of typical materials are steel, aluminium, and magnesium.

Fig.1 Electrodynamic shaker (cylindrical white piece on the right) and associated slip table (left)

Electronics are used almost everywhere in dynamic mechanical systems and modern machines to control and monitor operation. Vibrations are produced within the system due to the machine parts' dynamic nature. Long-term use of these vibrations wears out mechanical components and interferes with the sound operation of electronic components. If the generated frequencies coincide with the natural frequencies of any component, resonance may result, which could cause long-term damage to the system. Therefore, vibration testing of the electronic parts used in a mechanical system is crucial to ensure appropriate operation.

2.Vibration Fixture Design Materials

Magnesium – Magnesium has various advantages for vibration fixture designs. For instance, when it comes to weight to stiffness ratio, magnesium continues to be the greatest option. Additionally, compared to other materials, magnesium has increased damping. AZ31B Magnesium Alloy is one of the greatest kinds of magnesium for these designs.

Aluminium – For small to medium-sized fixtures, aluminium alloy is an excellent material choice because it is less expensive than alternatives like magnesium. Aluminium alloys 6061 and 7075 are two trusted types of alloys for the creation of mild vibration fixtures.

Steel – Steel weighs the most of the aforementioned metals, but because of its high strength to cost ratio, it is also the least economical. Due to its dynamic reactivity, steel is not a good material for higher frequency testing. When resonance is discovered, steel, for instance, will "ring"; this "ringing noise" is brought on by low damping. To make this ringing event (dynamic reaction) return to zero, many software programmes really employ a decay filter.

3. Literature Review

M. YUVARAJ et al. [1] Recently, Organizations in the manufacturing industry have shown a stronger interest in automation. In other words, new industries are developed as technology develops. Processes are undoubtedly streamlined through industrial automation in terms of production, dependability, and speed. In this thesis, CATIA software is used to model a welding fixture for a two-steering wheeler's handle. The position of circular components during welding is determined by estimating forces and analysing the results. The arrangement of curved surfaces is very unlikely to be accurate when welding a circular rod over another circular rod in mass production. In this case, the issue is resolved by a new fixture design, and without the use of any robots, both the angle and the linear movements are maintained with an accuracy of 0.1 mm. Effort is required to maintain consistent high quality, minimise cost, and maximise productivity in welding engineering, which does not require automation.

A. Krishnamoorthy et al. [2] In this study, we discuss how altering the isolation pad's design and material can improve its performance over an existing one. A spring isolator is a part of the existing design, and two new design models are created using the "Spring Isolator" model. The new variety has a parabolic-shaped helical spring attached to it, while the other type has a spherical ball-shaped helical spring linked to it. Solidworks was used to create the design models. In ANSYS Workbench, static and dynamic analyses have been carried out. A material called a vibration isolator is put at the bottom of heavy or tiny mechanical equipment in the mechanical industry to lessen vibration of the machine under dynamic conditions. In more recent years, there is a spring isolator in the existing design, and two new design models are produced from the "Spring Isolator" model.

Rushikesh D. Bhosale et al. [3] The purpose of this paper base frame is a crucial component of the generator canopy. The engine will not mount properly if it is not accurately machined with a sufficient tolerance, and the canopy will be rejected. The jigs and fittings ensure that the parts will be accurately assembled, allowing the primary generator parts, such as the engine and alternator, to install correctly on the base frame. As is common knowledge, jigs and fixtures being inexpensive means of achieving mass manufacturing. The distance between the engine and alternator mounting channels is fixed, although the engine and alternator bending tolerance is only 1mm. Jigs and fittings need to be created with consideration for the operation's kind and the machine tool that will carry it out. They are constructed from steel that has undergone a heat treatment process to make it corrosion- and wear-resistant.

Shailesh S.Pachbhai et al. [4] Consider this paper. Different industries need different types of fixtures depending on their use. This can be done by placing fixturing components like locators and clamps in the best possible places. Component fixture setup is done manually. It takes longer to load and unload the cargo because of this. Therefore, it is necessary to create systems that can aid in increasing production and saving time. Fixtures speed up operations, boost output, and enable high operational quality. To maintain machining precision in machining fixtures, it is crucial to reduce workpiece deformation brought on by clamping and cutting forces. The many methods for clamping operations used in various applications The method has improved the fixture design's efficiency and dependability, and the fixture design's outcomes are now more logical. This method can help shorten the cycle time needed to load and unload a part. Significant improvement is guaranteed if contemporary CAD and CAE tools are employed in system design.

Siddesha K et al. [5] This article's primary goal is to study the component, which comprises identifying stresses, strains, and deformation caused by the clamping load in a welding fixture both before and after welding. The analysis also considers the temperature distribution of the component during welding. A welding fixture's numerous design elements are also covered in this essay. It is necessary to estimate stresses in areas near the weld in order to prevent brittle fractures and fatigue. Analyses were carried out using the finite element method. The fixture was constructed using Solidworks modelling software, and the components were analysed using the finite element approach using ANSYS software (FEM).

H Radhwan et al. [6] Focus your research on this paper's analysis of how the task of producing the part was handled. Currently, they handle each component manually during assembly. The method is being improved by creating a semi-automatic jig to replace the manual handling currently used. Investigating the data gathered and analysing the design of a jig and fixture to make work handling easier are the goals of this project. This project's process for conducting research includes data collection, idea generation and interpretation, design concept, and documentation. Software called Unigraphics NX7.5 is being used to design the jig and fittings. The data that can be investigated include cost analysis, time study analysis, design ergonomic analysis, and Finite Element Analysis (FEA) utilising CATIA software. When this project is finished, the research will be able to explain jigs and fixtures, design using Unigraphics NX7.5 software, and then perform analysis for the chosen product part using FEA and other pertinent analyses.

K.V.Vidyanandan et al. [7] look over this article EV acceptability rises as the drive range per recharge does. EV batteries must have the following qualities: a long cycle life, high energy density, a high-power density, safety, and a low cost. In order to make batteries lighter, smaller, and able to store enough energy to allow EVs to compete with conventional autos, new cell chemistries are being explored. The most common EV batteries on the market right now are lithium-ion ones. Although there are many lithium-ion cell chemistries, cathode material and lithium-ion passage between electrodes are what differentiate them. The limitations of Li-ion batteries, potential safety issues, and developing battery technologies that will be necessary to meet future demands are all covered in this paper.

Sudipta Basua et al. [8] review this article EV acceptability rises in tandem with the drive range per recharge. The high energy density, power density, cycle life, safety, and affordability of EV batteries has made them a highly desirable product. Electric vehicles must develop smaller, lighter, and more energy-dense batteries in order to compete with conventional cars. The most widely used EV batteries available right now are lithium-ion ones. During charge/discharge processes, lithium ions move between the electrodes, and a variety of cell chemistries are referred to as lithium-ion cells depending on the cathode material. This paper discusses the drawbacks of Li-ion batteries as well as potential safety concerns and emerging battery technologies that will be required to meet future demand.

4.Problem Statement

The equipment that is available for testing the speedometer against vibration and shock examples from real life does have some restrictions. They only have a small space for mountings. These vibration-related parts cannot be mounted directly on the corresponding machine. Therefore, we must create fixtures that can both retain the component and be put on the testing device.

5.Objective

1. Using the CatiaV5 R21 software to create the vibration test fixture for a 2-wheeler speedometer whose natural frequency is higher than the maximum test frequency.
2. Static, modal and harmonic analysis of 2-wheeler Speedometer vibration Fixture by using ANSYS Workbench.
3. Experimental validation of fixture by using FFT Analyser & impact hammer test.

6.Methodology

Find out Literature Survey, Gathered Research Papers

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Learned about a 2-wheeler speedometer vibration fixture.

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Describe Literature review, Identify need of project.

↓

Finalising concept 3D Model and Drafting.

↓

Material selection design and Modification.

↓

Finite element analysis and Harmonic analysis of the speedometer vibration fixture.

↓

Perform the experimental testing of a speedometer vibration fixture using FFT Analyzer.

This methodology outlines the steps taken to improve the vibration performance of a 2-wheeler speedometer vibration fixture. It involved conducting a literature survey and gathering research papers, reviewing the literature to identify areas for improvement, finalising a concept and creating a 3D model, selecting appropriate materials and modifying the design, and conducting finite element and harmonic analysis to compare the performance of the original and modified fixtures. The design is then finalised by creating a 3D model and conducting finite element analysis and harmonic analysis to validate the design's strength and stability. This methodology provides a structured approach for improving the vibration behaviour of the fixture.

Experimental testing is performed using an FFT analyser to measure the effectiveness of the fixture in reducing vibrations. The results are analysed, and any necessary modifications are made to the design. The project aims to provide an efficient solution to the problem of speedometer vibration in 2-wheelers, ultimately improving the accuracy of the speedometer and providing a better riding experience.

7. Geometry of Fixture:

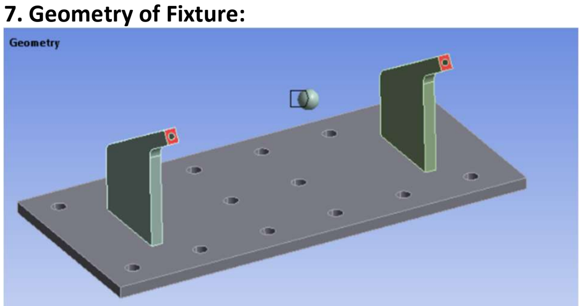


Fig.2 CAD model of 2-wheeler Speedometer vibration Fixture – CATIA

8. Requirements and specifications for Fixture design:

2-wheeler Speedometer vibration Fixture was design according to following norms, i.e., Table 1:

Automotive Industry Standards (AIS) include vibration testing, which is a process used to evaluate a product's ability to withstand vibrations that occur during shipping or use. This type of testing can be done on various types of products, including electronic devices, vehicles, and machinery.

During vibration testing, a product is subjected to controlled vibration levels and frequencies to simulate real-world conditions. The test is typically conducted in a laboratory environment using specialised equipment that can generate precise and repeatable vibration levels.

The results of the vibration test are analysed to determine if the product can withstand the vibration levels and frequencies it is likely to encounter during use or transport. If the product passes the test, it is considered suitable for use or shipping. If it fails, modifications may be made to improve its ability to withstand vibrations.

In summary, vibration testing is an essential process to ensure that products are durable and reliable. By subjecting products to controlled vibration levels and frequencies, manufacturers can determine their ability to withstand real-world conditions and make necessary improvements to ensure product safety and reliability.

AIS-156/DF

ANNEX 8A	
VIBRATION TEST (See 6.2.1.)	
Table 1	
Frequency and acceleration (gross mass of tested-device less than 12 kg)	
Frequency [Hz]	**Acceleration [m/s²]**
7 - 18	10
18 - approximately 50 (1)	gradually increased from 10 to 80
50 - 200	80
Table 2	
Frequency and acceleration (gross mass of tested-device of 12 kg or more)	
Frequency [Hz]	**Acceleration [m/s²]**
7 - 18	10
18 - approximately 25 1)	gradually increased from 10 to 20
25 - 200	20

Table 1. AIS 156, Annex 8A Vibration test

9. Material Used:

Aluminium alloy 6061 is an excellent material choice for small to medium-sized vibration fixtures due to its affordability and trusted performance. It may not have the weight to stiffness ratio of magnesium, but it still provides sufficient stiffness for many applications. Additionally, it has good damping properties, which can help reduce resonance and ringing effects. Overall, Aluminum alloy 6061 is a reliable and cost-effective material option for mild vibration fixtures.

	Properties of Aluminium alloy		
	A	B	C
	Property	Value	Unit
1	Density	270	Kg m^-3
2	Isotropic secant coefficient of thermal expansion		
3	Isotropic elasticity		
4	Derive from	Young's modulus and Poisson's ratio	
5	Young's modulus	7.1E+10	Pa
6	Poisson's ratio	0.33	
7	Bulk modulus	6.9608E+10	Pa
8	Shear modulus	2.6692E+10	Pa

Table 2: Properties of Al alloy [9]

10. Finite Element Analysis

It is possible to simulate and examine the structural behaviour of a 2-wheeler speedometer fixture using finite element analysis (FEA). The fixture can be modelled as a complex system of interconnected parts and components, each with its own material properties and structural behaviour.

Using FEA software, the fixture can be divided into smaller finite elements, and the behaviour of each element can be approximated using mathematical equations. These equations can be combined into a larger system of equations, which can then be numerically solved to determine how the fixture will behave overall under various loading scenarios.

The stresses and strains in the fixture can be analysed using FEA to pinpoint the locations with the highest levels of stress. By changing the material qualities or the shape of particular components, it is possible to adjust the design of the fixture to minimise stress levels and enhance overall performance.

In summary, FEA can be a valuable tool in the design and analysis of a 2-wheeler speedometer fixture, by allowing engineers to simulate and optimise its structural behaviour under various loading conditions

10.Original Geometry:

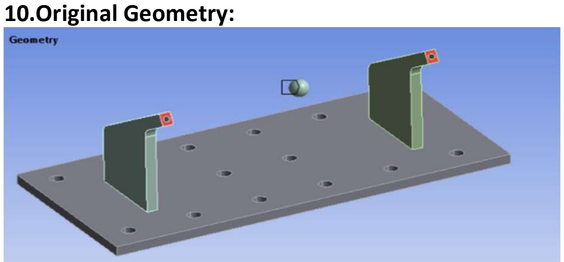


Fig.3 Geometry of 2-wheeler Speedometer vibration Fixture

10.1. Mesh

ANSYS, A high-performance, adaptable, intelligent, automated product is coming together. For accurate, efficient Multiphysics solutions, it produces the best mesh conceivable. A mesh that is most suited for specific research can be built for any part of a model with a single mouse click. Full control over the options used to generate the mesh is offered to the expert user who wants to customise it. Your mesh generation delay is automatically shortened by making use of parallel processing's strength.

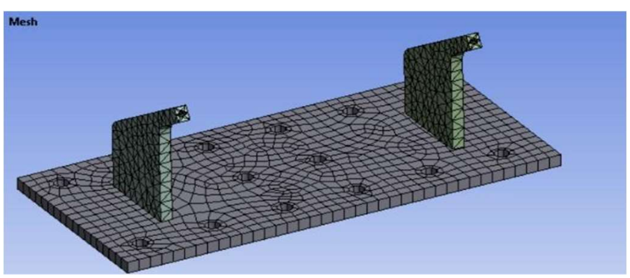


Fig.4 Meshing of 2-wheeler Speedometer vibration Fixture

Statistics	
Nodes	9296
Elements	2471

Final 2-wheeler Speedometer vibration Fixture mesh model, i.e., Fig.4, it contains 9296 nodes and 2471 elements.

10.2. Boundary Condition

When designing a 2-wheeler speedometer fixture, boundary conditions are a crucial component of the finite element analysis (FEA). For the purpose of simulating the fixture's real operating conditions, boundary conditions in FEA specify the limits and loads that must be imposed to the fixture as shown in Fig.5.

Finite element analysis (FEA) is used to design a 2-wheeler speedometer fixture, and boundary conditions are a key component of this process. Boundary conditions are used in finite element analysis (FEA) to specify the loads and constraints that must be applied to the fixture in order to accurately simulate the fixture's real operating conditions. For example, a fixed-point constraint can be used to model the mounting points of the fixture on the dashboard, while a force load can be used to simulate the force exerted by the speedometer cable on the fixture.

The selection of boundary conditions can significantly affect both the overall design of the fixture and the accuracy of the FEA results. It is important to choose boundary conditions that accurately represent the real-world operating conditions of the fixture, and to validate the results of the FEA with experimental testing.

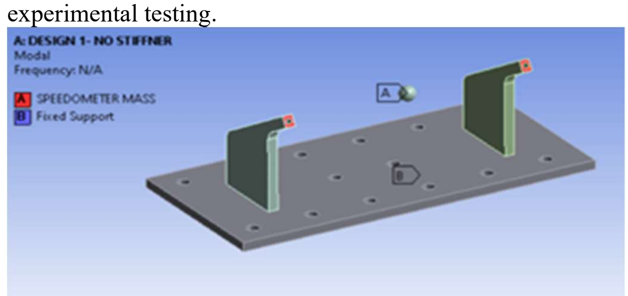


Fig. 5: Boundary condition for modal analysis of 2-wheeler Speedometer vibration Fixture

10.3. Modal Analysis of 2-Wheeler Speedometer Vibration Fixture:

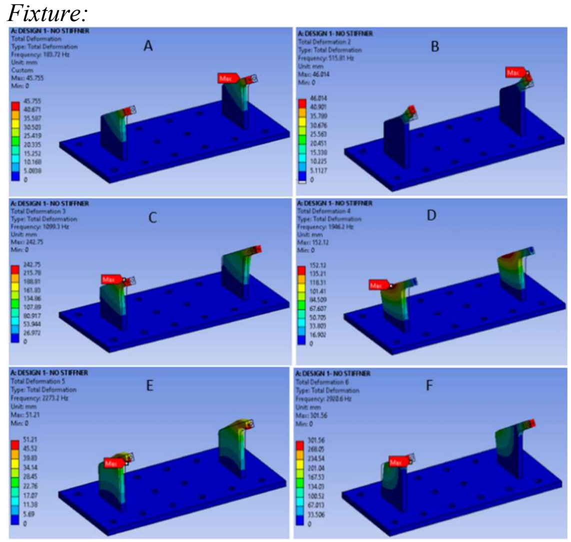


Fig.6. Modal Analysis of 2-Wheeler Speedometer Vibration Fixture

Natural frequency of A (Fig.6) for random direction is 183.72 Hz. These are the frequency modes for ensuring the fundamental frequencies of 2-wheeler Speedometer vibration Fixture. These frequencies are essential to be analysed to find out the frequency range of the product.

Figure	Mode Shape	Frequency (Hz)
A	1	183.72
B	2	515.81
C	3	1099.3
D	4	1946.2
E	5	2273.2
F	6	2920.6

Table 3. Modal Analysis Result

10.4. Harmonic response analysis of 2-Wheeler Speedometer Vibration fixture:

We may infer from the findings of the modal analysis that the 2-wheeler Speedometer vibration Fixture won't experience resonance while it is operating. In order to evaluate the specific response effects of the vibration fixture utilised in 2-wheeler speedometers, a harmonic response analysis based on modal analysis is also required. Based on modal analysis, harmonic response analysis of the finite element model was carried out using SPSS (square-root method).

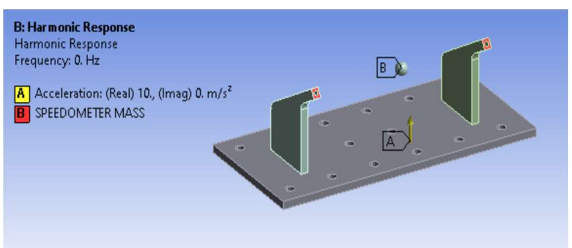
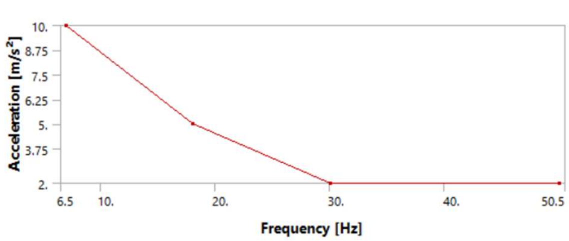


Fig.7. Boundary condition of 2-Wheeler Speedometer Vibration Fixture

Tabular Data

	Frequency [Hz]	Acceleration [m/s²]
1	7.	10.
2	18.	5.
3	30.	2.
4	50.	2.



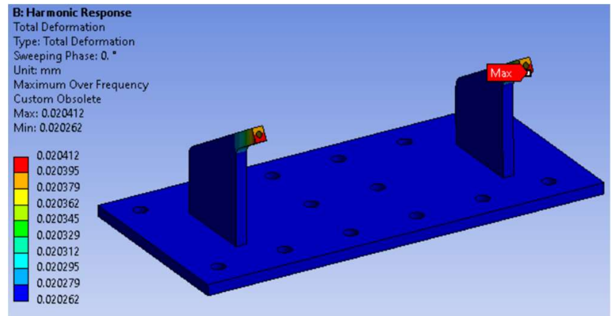


Fig.8. Harmonic response displacement diagram of 2-wheeler Speedometer vibration Fixture

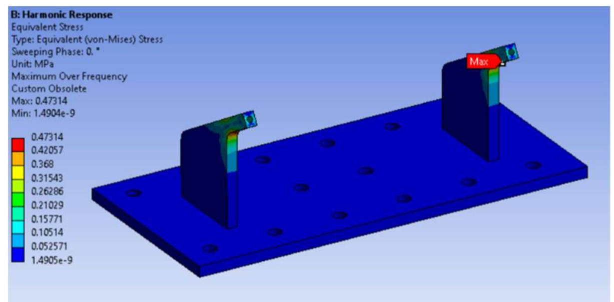


Fig.9. Harmonic response stress diagram of 2-wheeler Speedometer vibration Fixture

The 2-wheeler Speedometer vibration Fixture's highest stresses were 0.47314 MPa (Fig.9) and its maximum displacements were 0.0204 mm (Fig.8), respectively. The 2-wheeler Speedometer vibration Fixture had relatively minor strains and displacements as a result of machine vibration, which had no effect on the Fixture's stability or strength.

is because if the fundamental frequency of the fixture is lower than that of the specimen, it can result in resonance between the fixture and specimen. Resonance can cause the fixture to vibrate excessively, leading to structural failure or damage to the test specimen. As per AIS 156 fundamental frequency of operating is 200 Hz and fundamental frequency of fixture is below 200 Hz. Hence, fixture design is unsafe.

11. Modified Geometry:

The fundamental frequency of the fixture that is currently in use, which is 200 Hz, is lower than the fundamental frequency of the fixture that needs to be checked in this instance. Therefore, the fixture design is not safe as it could result in resonance during the testing process. To ensure the safety of the fixture and the accuracy of the test results, it is necessary to modify the fixture geometry so that its fundamental frequency should be greater than the fundamental frequency of the test specimen.

The modification could involve changing the shape of the fixture to increase its stiffness and raise its fundamental frequency. We are adding the stiffener into our existing geometry. Alternatively, this modification to the fixture to reduce its vibration amplitudes and avoid resonance.

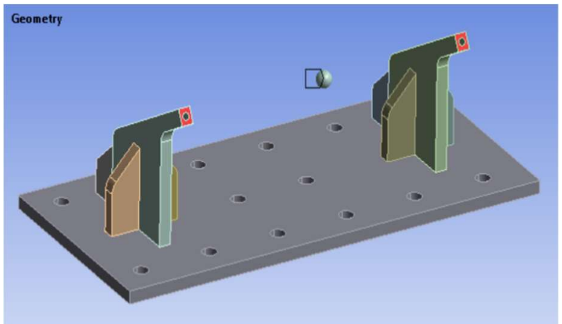


Fig.10: Modified Geometry design of 2-wheeler speedometer vibration fixtures

11.1. Mesh:

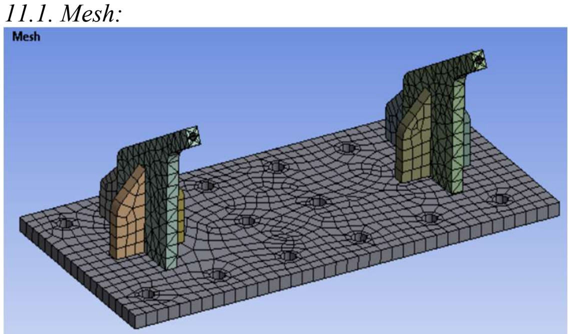


Fig.11: Meshing of 2-wheeler Speedometer vibration Fixture with stiffer.

Statistics	
Nodes	10033
Elements	2347

Final 2-wheeler Speedometer vibration. Fixture mesh model, i.e., Fig.11, it contains 10033 nodes and 2347 elements.

11.2. Boundary condition

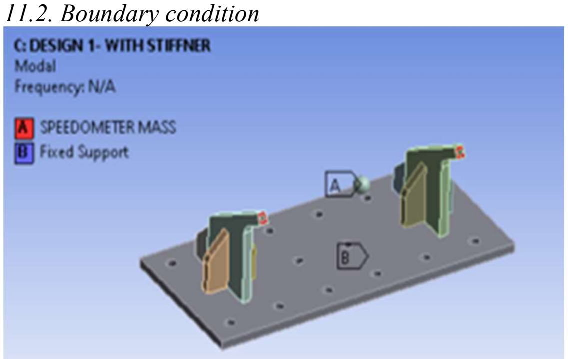


Fig.12: Boundary condition of 2-wheeler Speedometer vibration Fixture with stiffer.

11.3. Modal Analysis of 2-Wheeler Speedometer Vibration fixture with Stiffener:

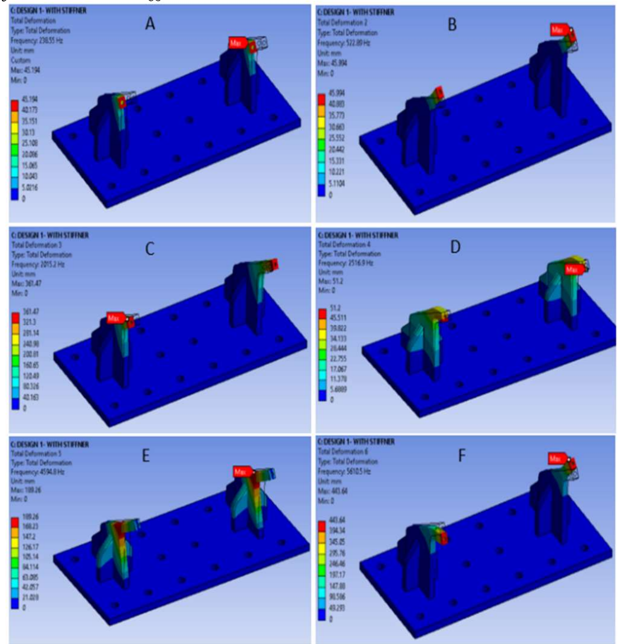


Fig.13: Modal Analysis results of 2-Wheeler Speedometer Vibration fixture with Stiffener

Natural frequency of model A (Fig.13) for random direction is 238.55 Hz.

Figure	Mode Shape	Frequency (Hz)
A	1	238.55
B	2	522.89
C	3	2015.2
D	4	2516.9
E	5	4594.8
F	6	5610.5

Table 4. Modal Analysis Result

11.4. HARMONIC RESPONSE ANALYSIS OF 2-WHEELER SPEEDOMETER VIBRATION FIXTURES:

We may infer from the findings of the modal analysis that the 2-wheeler Speedometer vibration Fixture won't experience resonance while it is operating. It is necessary to look at the specific response of the 2-wheeler Speedometer vibration Fixture before conducting the harmonic response analysis based on the modal analysis. Based on modal analysis, harmonic response analysis of the finite element model was carried out using SPSS (square-root method).

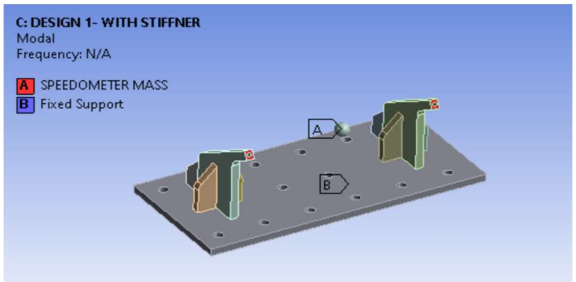
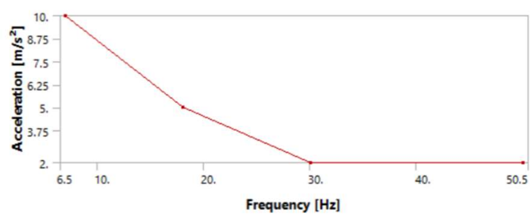


Fig.14. Boundary condition of 2-Wheeler Speedometer Vibration Fixture

Tabular Data

	Frequency [Hz]	Acceleration [m/s²]
1	7.	10.
2	18.	5.
3	30.	2.
4	50.	2.



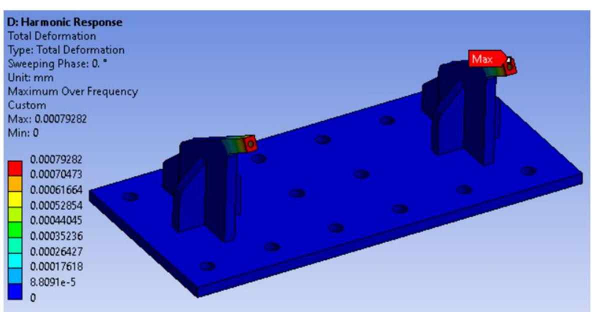


Fig.15 Harmonic response displacement diagram of 2-wheeler Speedometer vibration Fixture with stiffeners

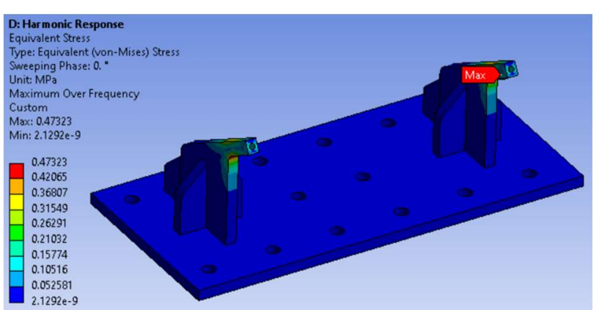


Fig.16 Harmonic response stress diagram of 2-wheeler Speedometer vibration Fixture with stiffeners

The stiffeners on the 2-wheeler speedometer vibration fixturing system allowed for maximum displacements of 0.00079 mm (Fig.15) and maximum stresses of 0.47323 MPa (Fig.16), respectively. The stresses and displacements experienced by the stiffeners in the 2-wheeler Speedometer vibration Fixture under the influence of machine vibration were extremely low, therefore they had no effect on the fixture's stability and strength.

11.5. Result of Modified geometry

As per AIS 156 fundamental frequency of operating is 200 Hz and fundamental frequency of fixture is above 200 Hz. Hence, fixture design is safe.

12. FEA Results comparison

Mode Shape No	Original Fixture Natural Frequency (Hz)	Modified Fixture Natural Frequency (Hz)
1	183.72	238.55
2	515.81	522.89
3	1099.3	2015.2
4	1946.2	2516.9
5	2273.2	4594.8
6	2920.6	5610.5

Table 5. Natural Frequencies Comparison (Hz)

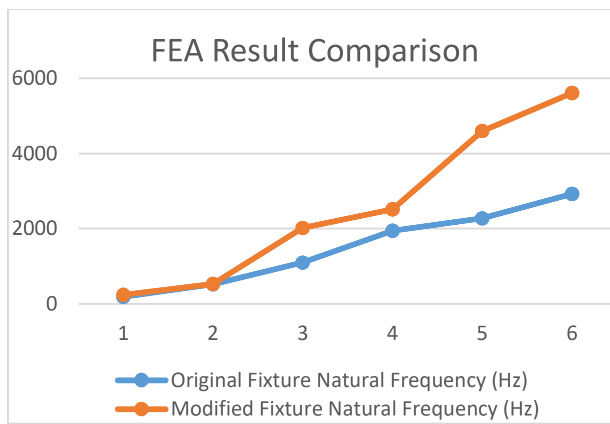


Fig.17. Graph between Natural Frequencies Comparison (Hz)

Based on the table 5 and Fig.17, we can see that the modified fixture has higher natural frequencies compared to the original fixture for all six mode shapes. This suggests that the modifications made to the fixture have increased its stiffness, resulting in a higher natural frequency.

Having a fixture with higher natural frequencies can be advantageous in many engineering applications, including meeting the requirements of the AIS 156 standard. The higher natural frequencies suggest that the fixture has increased stiffness and vibration resistance, which can help ensure that the vehicle or component being tested is less likely to experience excessive vibration or resonance under certain loads and frequencies.

13. Experimental Testing

An essential phase in the design and development process is the validation of FEA (Finite Element Analysis) results through experimentation. The manufacturing of fixtures should be based on modified geometry. This process ensures that the FEA model is accurate and reliable, which is essential for making informed decisions regarding the product or system being analysed.

13.1. Fast Fourier Transform

A mathematical technique for quickly calculating a function's discrete Fourier transform, particularly for powers of two, is the Fast Fourier Transform (FFT). It can also be used for prime factorization with certain algorithms. The FFT spectrum analyser offers a faster alternative to traditional analogue spectrum analysers by measuring all frequency components simultaneously. Fourier analysis of periodic functions involves extracting the series of sines and cosines that reproduce the function, expressed as a Fourier series. The FFT is useful for analysing time-dependent phenomena by transforming from the time domain to the frequency domain.

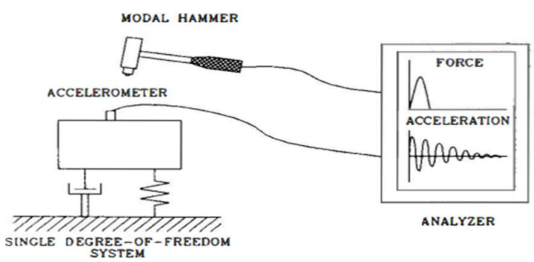


Fig.18 FFT construction

13.2. Impact Hammer Test

Impact excitation is a common method for experimental modal testing due to its versatility and reliability. However, it presents challenges for accurate spectral function estimation due to truncation and hardware constraints. Exponential windowing can be used to suppress truncation, but must be applied carefully. Double hits, which apply two impulses to a structure, pose further challenges as they differ from single hits in both temporal and spectral characteristics. Analytical functions for an idealised test are developed to understand these challenges and provide data acquisition guidelines for impact testing.

Fig.19. Experimental setup

13.3. Experimental Procedure

- According to the results of the FEA (Table 5), the fixture is initially created using the current boundary conditions.
- Impact hammer, accelerometer, data acquisition system, laptop with DEWSOFT programme to view FFT graphics, and data acquisition system are the components of the FFT.
- In order to evaluate the frequency of the corresponding mode forms, an accelerometer is installed at the edge in accordance with high deformation seen in the FEA findings.
- After the impact, a laptop is used to view the FFT plot (Fig.20), and the comparison of the experimental and FEA data is done.

13.4. Experimental Result:

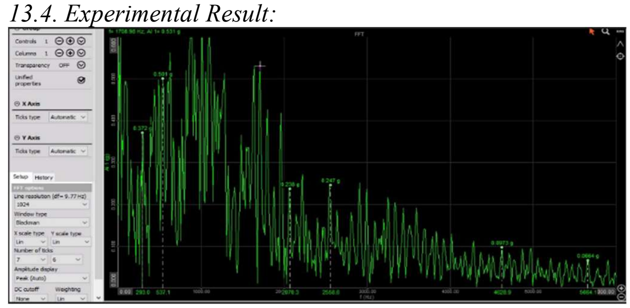


Fig.20. Experimental result: FFT plot

Mode Shape	Frequency (Hz)
1	293
2	537.1
3	2070.3
4	2558.6
5	4628.9
6	5664.1

Table 6. Experimental results

14. Result and Discussion

Mode Shape	FEA (Hz)	Experimental (Hz)
1	238.55	293
2	522.89	537.1
3	2015.2	2070.3
4	2516.9	2558.6
5	4594.8	4628.9
6	5610.5	5664.1

Table 7. Result comparison: FEA vs Experimental (Hz)

The finite element analysis (FEA) model's ability to forecast the dynamic behaviour of the structural system is demonstrated by the comparative study of mode shapes and frequencies between the FEA and experimental results, which shows overall good agreement.

The findings demonstrate the FEA model's capability to precisely capture the dynamic response of the system for Modes 2 and 5, with near alignment between experimental and FEA frequencies for these modes. The accuracy of the FEA models in forecasting mode shapes and frequency is supported by this agreement.

The variances between the FEA and experimental frequencies are just marginally different for various modes (Mode 1, Mode 3, and Mode 6). They could be attributable to variables like measurement mistakes, boundary conditions, material qualities, or modelling assumptions. However, the general patterns imply that the FEA model offers a respectable approximation of the dynamic behaviour of the system for these modes.

The results highlight FEA's usefulness and practical application as a technique for structural analysis. A greater knowledge of the structural response is made possible by the FEA model's capacity to precisely forecast mode shapes and frequencies, which helps with design decisions and optimizations.

It is crucial to keep in mind that further FEA model improvement, including more accurate system characteristic representations and enhanced measurement methods in experimental testing, may result in even tighter agreement between FEA and experimental data. The accuracy and dependability of FEA as a predictive tool for dynamic analysis will improve with continued study and development in this area.

The comparison research (Table 7) shows that the FEA model offers useful and trustworthy insights into the dynamic behaviour of the structural system, empowering engineers to make knowledgeable design decisions and improve structural performance.

15. Conclusion

- By comparing and validating the results obtained from Finite Element Analysis (FEA) with the experimental measurements, we have confirmed the accuracy of the FEA model in representing the physical system.
- According to AIS 156, the fundamental frequency of an operating fixture is 200 Hz, and the fundamental frequency of a modified fixture is higher; as a result, the fixture design is secure.
- A modal analysis of the stiffeners-added 2-wheeler speedometer vibration fixture revealed that the working vibration frequency was entirely avoided by the ditch device's natural frequency.
- Using SPSS, harmonic response analysis of the finite element model was carried out based on the modal analysis. The stiffeners-equipped 2-wheeler speedometer vibration Fixture was known to encounter relatively little stress and displacement during the vibration condition, indicating that the fixture's strength and stability were unaffected.

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