International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 5, Issue 9, September 2016)

# Theoretical & Experimental Analysis of Bike Handle Bar

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***Abstract*: All machines, vehicles and buildings are subjected to forces which causes vibration. Many noise and vibration problems that occur are due to resonance phenomena where the operational forces excite one or more modes of vibration. Modes of vibration that lie within the frequency range of the operational forces always represent potential problems. Mode shapes are the dominant motion of a structure at every of its natural or resonant frequencies. Modes are an inherent property of a structure and do not depend upon the forces that act on it. In this paper, optimization and modal analysis of the handle bar of Pulsar 150 is done. Handle bar has been modelled using CATIAV5, meshing will be done in HYPERMESH12.0, and ANSYS will be used for post processing. Boundary forces will be calculated. Static analysis will be done based on which further optimization will be carried out. Re-analysis (modal analysis) will be done on the handle bar by considering glass fibre composite material.**

***Keywords* - Finite Element Analysis, Glass fibre, Handle bar, modal analysis.**

## I. INTRODUCTION

A handle bar is a tubular component of a two wheeler's steering mechanism. Handle bar provide mounting for brake, lights, horn and rear view mirrors additionally they could support part of riders weight.

Handlebars are created from hollow metal tube, typically from aluminium alloys, mild steel, chrome plated steel and Stainless steel however additionally of carbon fibre and Ti, shaped to the required contour. Holes may be drilled for the internal routing of control cables for brake, clutch, and throttle. Risers hold the handlebars above their mounting position on the higher triple tree or at the high end of fork, and may be integrated into the bar itself or separate things. Bar-end weights are typically added to either end of the bar to damp vibration by moving the bars' resonant frequency away from that derived by the engine. Electrical heating elements could be added below the handle bar grips to provide comfort to the user in cold atmospheric conditions.

Why modal analysis: Modal frequency response analysis is although a different approaches to decisively find the frequency response of a structure. Modal analysis is an economical dynamics. The dynamic behaviour of a structure in a provided frequency range can be modelled as a set of individual modes of frequency. The important modal parameters are: natural frequency or resonance frequency, and mode shape. The modal parameters of all the modes, within the frequency range of interest, represent a complete dynamic description of the component. By using the modal parameters for the element, the model can later be used to come up with possible solutions of a particular component issues.

That's the reason why modal analysis on handle bar makes a very important investigation for getting out the mode shapes and frequency.

At present traditionally used material for handle bars are low carbon or mild steel. Though steel have advantages over its simple accessibility, cheap, easy to machine, it has its disadvantages over its weight. So an effort must be taken to design a handle bar with alternate materials which has low density and good structural strength.

The main objective of this paper is to check different materials i.e. Aluminium, glass fibre on handle bar and to search out its natural frequency.

Motivation behind choose Topic, This project will serve as reference to researchers who will be working on this subject. There has been tremendous efforts being put by researchers to find alternative to conventional material used. Handle bar with a composite material is a new concept which can be accepted and adopted in today's market.

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## II. Literature Survey

S. V. Jaswandkar, et. al (2014) studied Road load acceleration data is obtained and applied to a handle bar assembly to check for its stresses and deformation through linear static analysis. The purpose of this research was to evaluate strength of a handle bar by changing the material i.e. AlSi132, C35

Harale Shivraj. N, et. al (2012) studied Frequency response analysis is done based on road load data obtained. The analysis of handle bar emphasis more on the behavior of handle bar for vibrations. Efforts are done to increase the strength of handle bar.

Rajratna M. Kharat, et. al (2015) focuses on the effect of vibrations on health of the rider if these vibrations go beyond permissible limit. In order to make this study successful vibration signals were measured while driving with different speeds and different road surfaces

Harshada G. Deshmukh, et al, (2014) in their study two wheeler rider systems is considered as a 4 DOF spring mass damper system. An anthropomorphic data is used for modelling of human body. A Mass and stiffness value of individual component is carried out. The aim of this study was to validate effect of vibration on health of rider by considering vibration of whole body of the vehicle

Jaimon Dennis Quadros, et al (2013) mentioned that People in the age group of 30 to 45 years have pains in their body due to irregular road conditions and improper design of vehicle. It is found that 13.33% of people have musculoskeletal pain problems. So an attempt is made to find suitable safe speed to ride. It was found that for HeroHonda Splendor, idealized operating speed is 49.66KMPH.

Patil Pruthviraj Devidas , et al, (2013) Handle bar for torsional loading is analyzed to find out safe value of torsional loading. Also torsion buckling analysis is carried out for different loads.

Amol h. parihar, et al, (2012) Handle bar vibrations are studied through mathematical modeling and experimental analysis found to be in line with the numerical study

Alexandre Callensa, et al, (2012) Fatigue analysis of welded aluminium-alloy bicycle frame is done. The objective is to optimize the design prior to the standard testing by calculating the fatigue reliability of the bicycle frame

H. A. Khade, et al, (2014) Buckling analysis on handle bar shows that by increasing the thickness of handle bar decreases the buckling stresses and total deformation

## III. Problem Statement

Vibration analysis is usually done to make sure that potentially catastrophic structural natural frequencies or resonance modes don’t seem to be excited by the frequencies present in the applied load. Sometimes this is not possible and designers then got to estimate the maximum response at resonance caused by the loading.

## IV. Objectives

The main objective of the study is to optimize and find natural frequency of handle bar. This optimized model will have better performance.

To achieve this objective following steps must be taken:

- To study various research papers to study the work done on handle bar.
- To draw CAD model in CatiaV5
- Study boundary conditions and loadings acting on the handle bar.
- Carryout analysis.
- Optimization
- Conclusion

## V. CAD Model & Analysis on Handle Bar

The conventional model used in Pulsar 150 is used. Dimensions are taken through reverse engg i.e. through hand calculations. CAD model then is made by the commands in CATIA of Pad, pocket, fillet, and geometrical selections in part design module.

The CAD data of the handle bar structure is imported and the surfaces were created and meshed. Since all the dimensions of handle bar are measurable (3D), the best element for meshing is the tetra-hedral. Meshing is done by considering quality criteria for 3D mesh i.e. tet collapse.

Meshing details are:

Number of nodes: 4759

Number of elements: 14266

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Fig 1: Image of Pulsar150 handle bar

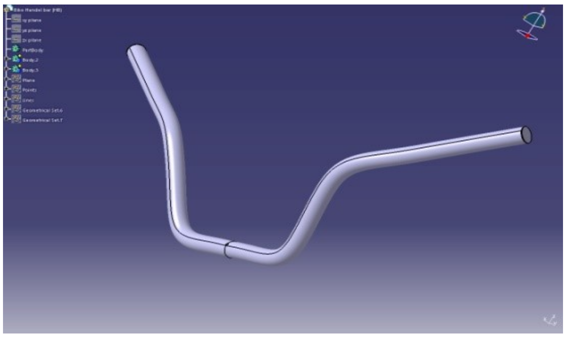
Fig 2: CAD model of handle bar in CATIAV5

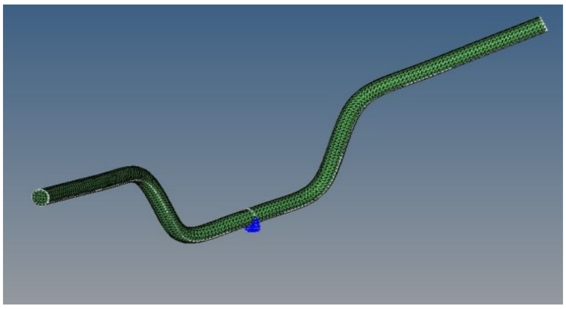
Fig 3: Meshed model of handle bar in Hyper mesh

Boundary condition:
In Static Condition the rider sitting position is such that it makes an angle of 30 degree with the horizontal imaginary line from the handle bar gripper parallel to the ground as shown in below picture.


Fig:4 Sitting posture

Therefore the weight (force) of the rider will be taken into account for the static loading,

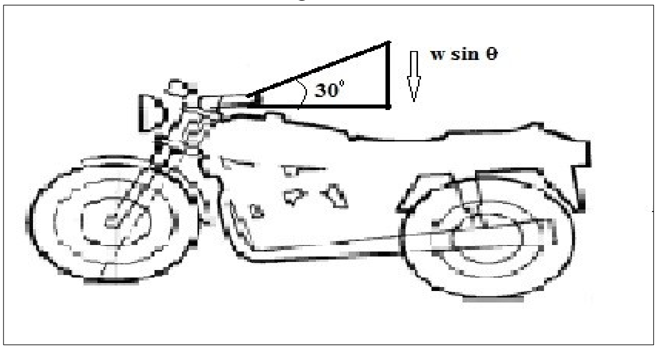

Fig:5 Vertical force on Handle bar

Vertical force on handle bar

VF = W sin ɵ ............ (1)

Put Value ɵ in Equation (1)

VF = 70 sin(30)

VF = 70 x 0.5

VF = 35 x g

VF = 343.5 N ............ (2)

Braking force calculation:
Under heavy breaking the front portion of the vehicle experiences heavy load due to the weight transfer. Directly the forces are transferred from the front fork suspension to the handle bar of the vehicle .Hence the force on the forks from the wheel is calculated.
Rake angle- Rake can be described as an angle at which the headstock of the motorcycle is inclined when compared against a vertical line drawn perpendicular to the ground

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Under breaking the rake angle causes some of the braking force to be reacted to the front forks. Therefore the spring compression and dive are increased over that due to weight transfer alone.

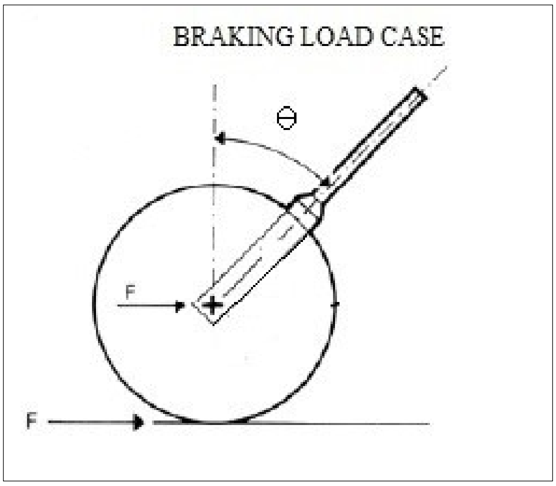


Fig:6 Braking Load Case

Given –
Rake Angle ө - 27 °
Initial velocity (U) – 0 kmph
Final velocity (V) – 60 kmph (16.6 mps)
Time (t) – 5.9 sec
Mass (M) – 284 kg
Therefore,
F = M x a x Cos ө ……………… (3)
Now,
To know acceleration (a), we use the below formula
V = U + a x t ……………… (4)
Put all value in above Equation
16.6 = 0 +( a x 5.6)
a = 2.9 m/s
Put Value Of M, ө and a in equation (3)
F = 284 x 2.9 x Cos (27°)
F = 752.81 N
The braking force on the front tyre can be split into two components when fed into the forks, one in line with the sliders which tends to compress the springs (this force is approximately 42% of the braking force. at 25 deg. rake), the second component at right angles to the forks which tries to bend the fork legs (roughly 91% of the braking force).
Therefore,
42 % of F
F = 752.81 x 0.42
F = 436.62 N ……………… (5)

Boundary conditions are the reference points for calculating the results of analysis.

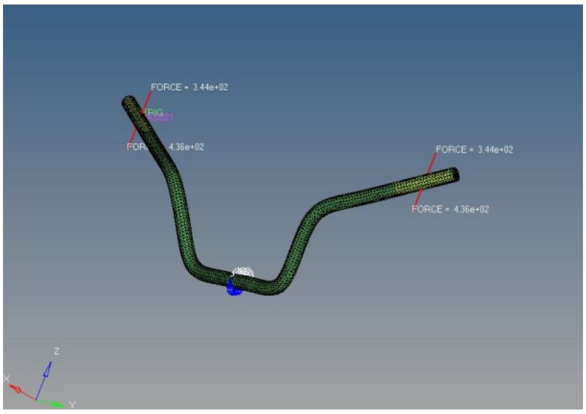


Fig 7: Boundary conditions applied on handle bar in Hyper mesh

Static Analysis: Meshed and boundary condition applied model is imported to the solver. Analysis process starts after applying run in the solver software. Solver deck is prepared for carrying static analysis and results are viewed in ANSYS. Below are the results for different materials. Static analysis for different material is done to know whether a material has stresses within safe limit or no. Once we select the material modal analysis is carried out to know the frequency range.

A. Analysis of handle bar with Mild Steel material:

Table 1: Material properties for Mild Steel

| **Property** | **Value** |
|---|---|
| Young's Modulus, E | $2.1\times10^5$ MPa |
| Poisson's Ratio ,ν | 0.3 |
| Density, ρ | 7850 $kg/m^3$ |
| Yield Stress, $\sigma_{yield}$ | 290 MPa |
| Ultimate Tensile Stress, $\sigma_{uts}$ | 390 MPa |

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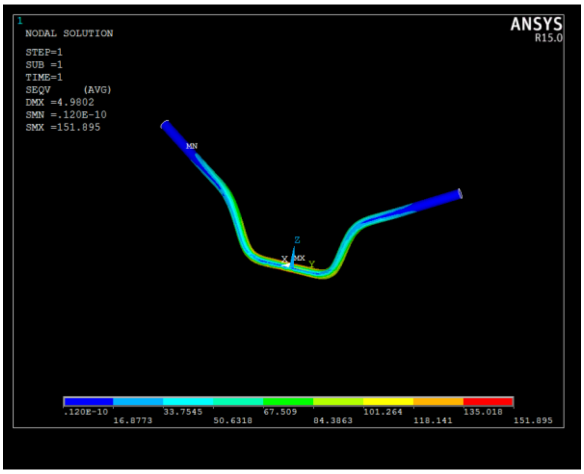


Fig 8: von-mises stress for handle bar (Mild steel)

Stress value for handle bar is 151.89 N/mm2 which is well below the critical value. Hence, design is safe. Deformation for handle bar with MS is 4.98 mm.

B. Analysis of handle bar with Aluminum material:

Table 1: Material properties for Aluminum

| Property | Value |
|---|---|
| Young's Modulus, E | 68.9 GPa |
| Poisson's Ratio ,ν | 0.33 |
| Density, ρ | 2700 kg/m3 |
| Yield Stress, σyield | 214 MPa |
| Ultimate Tensile Stress, σuts | 250 MPa |

Stress value for handle bar is 149.93 N/mm2 in figure 9 which is well below the critical value. Hence, design is safe. Deformation for handle bar with Al is 14.78 mm.

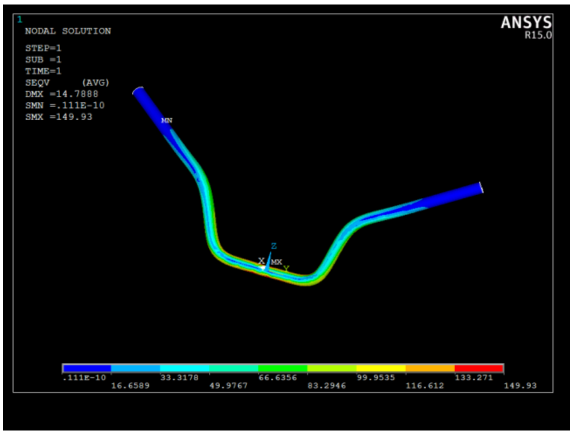


Fig 9: von-mises stress for handle bar (Aluminum)

C. Analysis of handle bar with Glass Fiber material:

Table 3: Material properties for glass fiber

| Property | Value |
|---|---|
| $E_1$ | 40 GPa |
| $E_2$ | 6 GPa |
| $E_3$ | 40 GPa |
| Poisson's Ratio ,ν | 0.24 |
| $G_{xy}$ | 15 GPa |
| $G_{yz}$ | 2.3 GPa |
| $Gz_x$ | 15 GPa |
| Density, ρ | 2000 $kg/m^3$ |

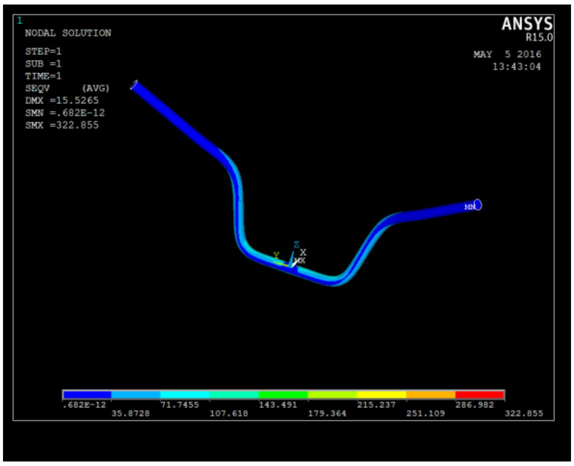


Fig 10: von-mises stress for handle bar (Glass fiber)

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Stress value for handle bar is 322.85 N/mm2 which is well below the critical value. Hence, design is safe. From fig, deformation of handle bar with glass fiber is 15.52 mm.

## VI. MODAL ANALYSIS RESULTS:

Solver deck for modal analysis is prepared in hyper mesh. It involves assigning material properties, applying constrains, etc. Once the deck is ready, it is exported into .cdb format of ANSYS for solution and post-processing.
Following are the results for modal analysis done on existing and composite handle bar.

Table 4– Frequency of handle bar

| **Frequency of existing handle bar** | **Frequency of composite handle bar** |
|---|---|
| 91.76 Hz | 79.84 Hz |
| 92.15 Hz | 80.51 Hz |
| 94.04 Hz | 83.026 Hz |
| 94.34 Hz | 84.32 Hz |
| 458.8 Hz | 348.58 Hz |
| 459.49 Hz | 349.5 Hz |

## VII. EXPERIMENTAL VALIDATION

1) Experimental Testing Of Existing Handle Bar

Bike handle bar is mounted by using clamps on the bench to perform the testing. The hammering test is carried out as stated above.shows in below images.

Fig 11: FFT Analyzer

The FFT analyzer is connected to a sensor which reads the vibrations on the component. The handle bar is hammered to give the vibrations by external means. As the vibrations flow in the handle bar there will be a peak amplitude which is the natural frequency of the component. Likewise the component is tested at three different points. Which the sensor is made to read and the readings are recorded in the FFT analyzer. Then the FFT analyzer is connected to data acquisition system and here the software is synced with FFT and the respective graphs are plotted

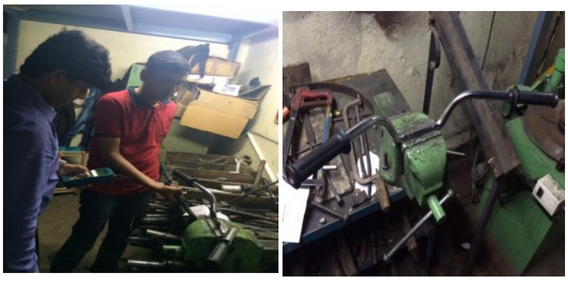

Fig 12: Actual experimental images of Existing handle bar

2) FFT Analyzer result of Existing handle bar

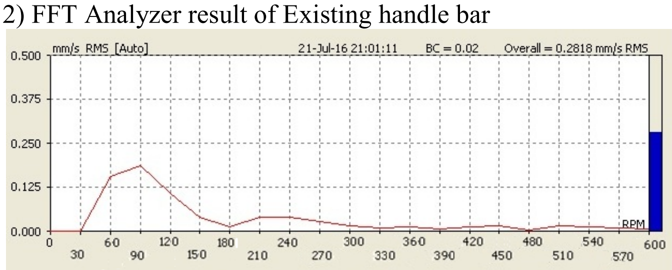


Fig 13: 1st mode Frequency Vs Amplitude graph
From above graph Frequency is 90Hz

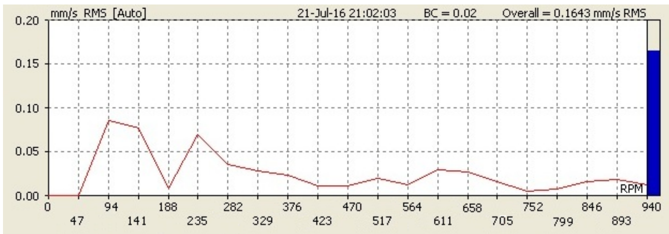


Fig 14: 2nd mode Frequency Vs Amplitude graph
From above graph Frequency is 94Hz

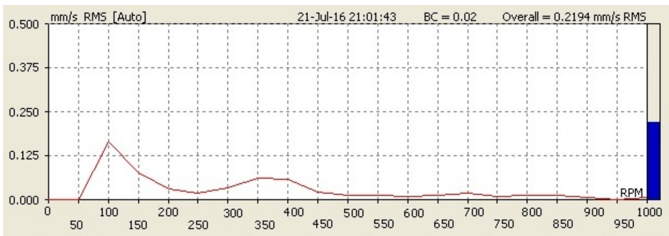


Fig 15: 3rd mode Frequency Vs Amplitude graph
From above graph Frequency is 100Hz

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3) Experimental Testing Of Composite Handle Bar

Bike handle bar is mounted by using clamps on the bench to perform the testing. The hammering test is carried out as stated above.shows in below images. The FFT analyzer is connected to a sensor which reads the vibrations on the component. The handle bar is hammered to give the vibrations by external means. As the vibrations flow in the handle bar there will be a peak amplitude which is the natural frequency of the component. Likewise the component is tested at three different points. Which the sensor is made to read and the readings are recorded in the FFT analyzer. Then the FFT analyzer is connected to data acquisition system and here the software is synced with FFT and the respective graphs are plotted.

Fig 16: Actual experimental images of Composite handle bar

2) FFT Analyzer Result Of Composite Handle Bar

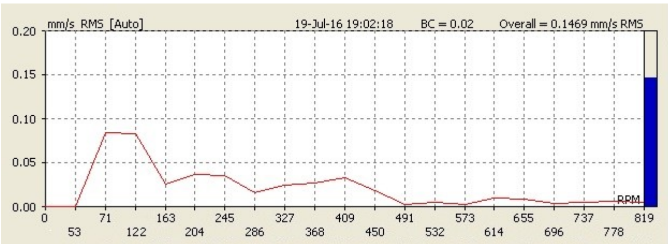


Fig 17: 1st mode Frequency Vs Amplitude graph

From above graph Frequency is 71Hz.

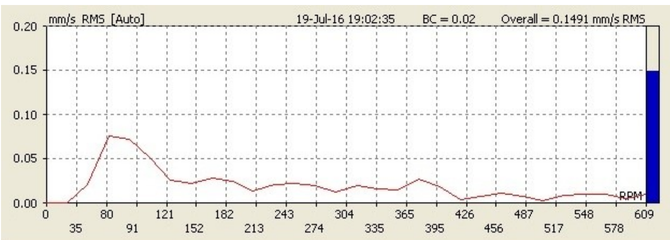


Fig 18: 2nd mode Frequency Vs Amplitude graph

From above graph Frequency is 80Hz.

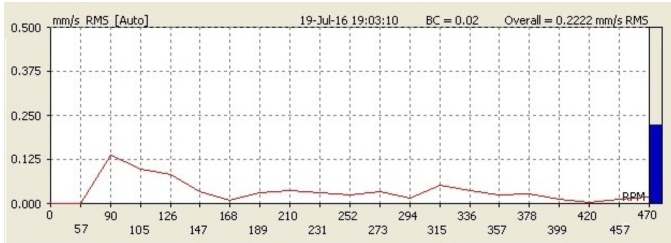


Fig 19: 3rd mode Frequency Vs Amplitude graph

From above graph Frequency is 90Hz.

## VIII. RESULT

1) FEA & Experimental Result Of Existing Handle Bar

Table 5– FEA and Experimental result of Existing handle bar

| **Frequency of Existing handle bar FEA(Hz)** | **Frequency of Experimental results of existing handle bar(Hz)** |
|---|---|
| 91.76 Hz | 91 Hz |
| 92.16 Hz | 94 Hz |
| 94.04 Hz | 100 Hz |

FEA & experimental result matching nearly.

2) FEA & Experimental Result Of Composite Handle Bar

Table 5– FEA and Experimental result of Existing handle bar

| **Frequency of Composite handle bar FEA(Hz)** | **Frequency of Experimental results of Composite handle bar(Hz)** |
|---|---|
| 79.84 Hz | 71 Hz |
| 80.51 Hz | 80 Hz |
| 83.026 Hz | 90 Hz |

FEA & experimental result matching nearly.

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- Natural frequency of both conventional and composite handle bar are extracted.
- Results of FEA and experimentation are compared and validated, which shows acceptable deviations.

## IX. CONCLUSIONS

- CAD model of Bike handle bar is modeled by using design calculations.
- FEA analysis is carried out for the forces calculated.
- The material of the handle bar is changed to aluminium and outer coating is of glass fiber and the model is analyzed for design safety.
- Natural frequency of both conventional and composite handle bar are extracted.
- The results were interpreted and compared study is made.
- Fabrication of the composite material bike handle bar is done and is tested using FFT analyzer.
- Results of FEA and experimentation are compared and validated, which shows acceptable deviations.
- Hence the objective is achieved.

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