ISSN 2395-1621

Performance Analysis of a Handle Bar Using Finite Element Methods to Enhance the Strength

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ABSTRACT

Majority of Indian population depends on a two wheeler for their transportation due to economic reasons. Because of improper design of vehicle and bad road conditions, people in the age group of 30 to 45 years have pains developed in their body. The percentages of people having musculoskeletal pain problems are found to be 13.33%. Designing the handle bar assembly of a two wheeler holds many challenges together with valuation of the structural strength of the mating components. While the handle bar is subjected to buckling, the housing and the other frame experiences tensile, compressive and shear stress. The situations during braking and the forces generated due to road bumps and pot holes can increases the problem.

FEA and experimental tests are good methods for novel product development. FEA methodology can be used to decrease design cycle time, quantity of prototypes and more importantly testing time and its related charges. The Aim of this seminar is to improve a design and a prototype for a handle bar assembly of two wheeler which come across strength requirement.

The handle bar vibrations can be contained within the prescribed limits using computational methodology for problem solving. CAE software such as Hypermesh as a pre-processor, MSC Nastran or Radioss as a solver and Hyperview as a post-processor are considered for this dissertation work. Using this methodology, nature, amplitude, and frequency of the vibrations can be predicted during the design phase. Material properties, thickness for the handle bar and the associated boundary conditions with the adjacent parts are fed into the computing interface while input and output conditions are assigned in the appropriate dialogue box of the software interface. Mathematical modeling shall provide as a preliminary tool for investigation. Physical experimentation shall offer as a source for validation being used as an alternative methodology for finding solution. The physical setup for the existing case shall be used for experimental investigation and validation.

ARTICLE INFO

Article History

Received :18th November 2015

Received in revised form :

19th November 2015

Accepted : 21st November , 2015

Published online :

22nd November 2015

Keywords— Put your keywords here, keywords are separated by comma.

I. INTRODUCTION

Two wheeler handle-bar assemblies is user's first touch point to the vehicle, also it is very complex in construction and important in functionality and safety point of view. As handle-bar assembly consists of head lamp, mirrors, clutch and brake levers, speedometer with plastic coverings which are meant to be for aesthetic appeal. Whole handle bar assembly is more susceptible to the failures as it experience numerous forces such as bumps, braking, engine vibrations, rider force, road excitations etc. To simulate vehicle operating condition, modal frequency response analysis enables to analyze the strength of structural mountings within assembly for the excitation frequency range on the vehicle.

Growing competition in automotive market makes it more and more necessary to reduce the development time and cost of the product development process. One of the most costly phases in the vehicle development process is the field durability test. High expenses for this phase can be attributed to the number of prototypes used and time/efforts needed for its execution. Also, multiple iterations during designing, building and prototype testing are no longer affordable against the time and cost constraints for developing a competitive product. Today, analytical tools in the form of computer simulation have been developed to such a level that they reliably predict performance.

Fig. 1 Typical Two wheeler Handle bar Assembly

A. Problem Definition:

The ride comfort and handling is dictated, besides other factors, by the nature and intensity of the vibrations perceived by the rider. The human fatigue or the depreciation in human performance is linked to the vibrations in the system, especially the area in contact with the maneuvering subsystems or controls on the vehicle. For a two-wheeler/ motorcycle, the handle bar offers a means for steering the vehicle while in motion. The problem for this work is to minimize the adverse effects of vibrations magnified with the occurrence of resonance in the maneuvering elements of the system i.e. the handle bar and the base. The existing methodology involving extensive experimentation is time consuming and proves to be expensive. Alternative means of assessment needs to be explored.

B. Objective of project:

- Study the existing system
- Mathematical Model for the existing System
- Benchmarking Analysis for the existing system
- Identify design alternative/s for improvement
- Validation through physical experimentation over the existing

C. Scope of work:

The scope of this work is to study the existing design and analysis to find out the natural frequencies. Analytical method shall be used for the work. Preliminary stress calculations shall be evaluated using mathematical model for benchmarking case. The validation shall be completed by conducting the experimentation over the existing system. FFT analyzer shall be used for measurement of natural frequencies.

II. LITERATURE SURVEY

Harale Shivraj. N Gyanendra Roy [1] describe in this analysis the handle bar assembly is excited with acceleration derived from road load data over an operational frequency range to evaluate the strength of mountings on handle-bar in vibration. Frequency response analysis on handle bar assembly is carried out using Altair solver code Radioss Bulk data. In this analysis the handle bar assembly is excited with acceleration derived from road load data over an operational frequency range to evaluate the strength of mountings on handle-bar in vibration. Model is prepared using Hyper Mesh and Post processing is done using Hyper View and Hyper Graph. The simulation results are also well correlated by the experimental results in which failure location and pattern is exactly matched. Further modifications have been incorporated in design to meet the strength requirement.

S. Agostoni, A. Barbera, E. Leo, M. Pezzola, M. Vanali [2] In this paper it is shows that how to reduce driver vibration exposure acting on modal response of structures physically in Contact with driver, as handlebar, footpad and saddle.

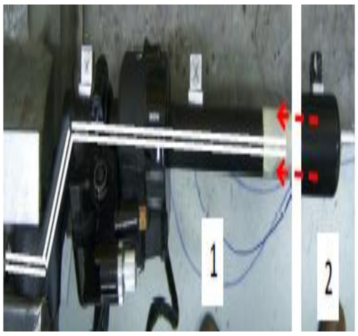


Fig 2 Handlebar; (1) fixed beam, (2) insertion of steering balance into extremity of handlebar.

Cal Stone., [2] and Maury L. Hul, “Rider & bicycle Interaction Loads During Standing Treadmill Cycling” journal of applied biomechanics, in their paper they made available measurements of rider prompted loads during stand-up cycling. Double strain gauge dynamometers were employed to measure these loads on a large motorized treadmill, the cycling condition simulated hill climbing while stand-up cycling. Comparing the results to those previously published for seated cycling revealed that the loading for standing cycling differed fundamentally from that for seated cycling in certain key respects. One respect was that the maximum magnitude normal pedal force reached substantially higher values, exceeding the weight of the subject, and the phase occurred later in the crank cycle. Another respect was that the direction of the handlebar forces alternated indicating that the arms dragged up and back during the power stroke of the corresponding leg and pushed down and forward during the upstroke. This paper will help to understand loading conditions during cycling.

David Lopez, [4] Jovan Mayfield & Pierre Marc Paras "Stress Analysis of a Bicycle" Polytechnic institute of New York University, found that separating the bicycle into smaller segments of beams with stresses and moments to be the most effective way in constructing and designing the bicycle.

III. Vibration Analysis

The assembly receives vibration from engine and road which then transfers to the internal mounting locations. It is important to understand dynamic characteristics and the components sensitive to vibration. The dynamic equation for the system can be expressed as follows Where m, c, k are mass matrix, damping matrix and stiffness matrix respectively. X and F are displacement and force vectors respectively. The purpose of vibration analysis is to determine the strength of mountings.

IV. FE Model development

Drawings of handle bar (Existing)

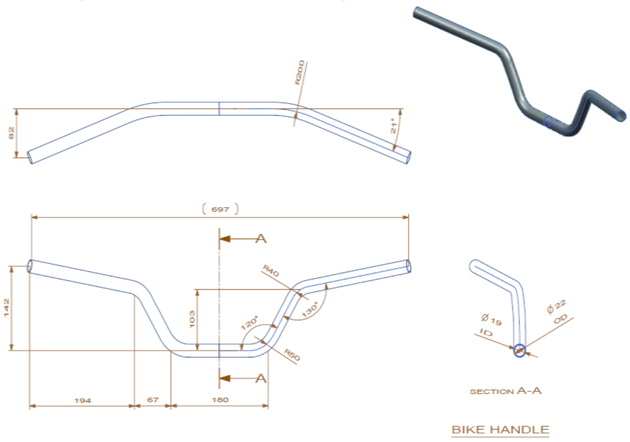


Fig. 3 Different views of handle bar

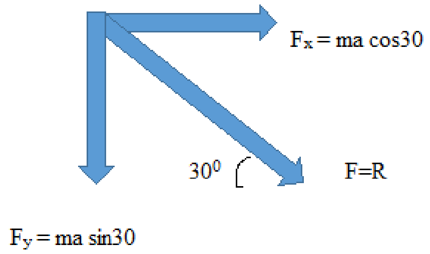
The handlebarare made of stainless steel. FE model has been developed by using preprocessing software HyperMesh. Metal parts are modelled with shell elements CQUAD, CTRIA by extracting mid surfaces.

A. Preparation for analysis:

Loading condition: Following figure shows the load applied by rider's hand over handle bar of a bike.

Fig. 4 Load acting over handle bar

While braking, the rider in motion is try's to change the speed of the combined mass m of rider plus bike. This creates a negative acceleration "a" in the line of travel, the acceleration "a" causes an inertial forward force F on mass m (F=ma). Considering Motorist of wt. 120 kg traveling at speed of 90 km/h, suddenly apply the break and come to rest in 5 sec.



B. Loads and Boundary Conditions

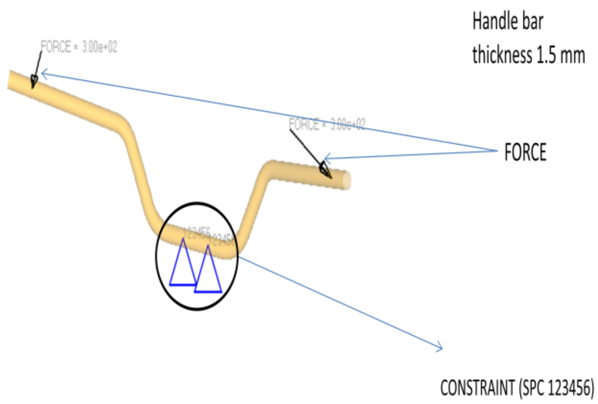
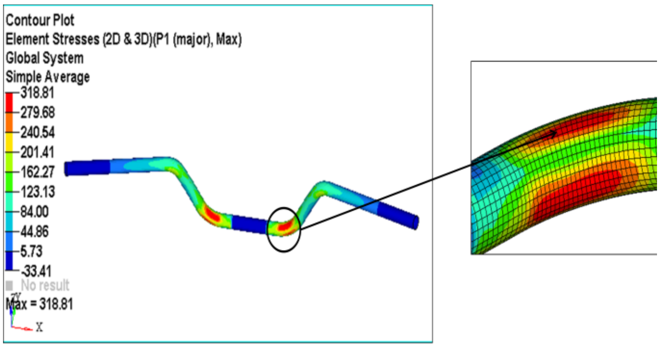


Fig. 5 FE Model and Boundary Conditions of Handle-Bar

C. FINITE ELEMENT ANALYSIS

Analysis using solver RADIOSS:

In this analysis stress pattern and displacement of different parts of handle bar has been observed, with variation in geometry, material & loading conditions.



Max Principal stress = 318.81n/mm2

Fig. 6 Stress& displacement pattern in handle bar

V.RESULT & DISCUSSION

Results obtained by FEA analysis tabulated below

TABLE 1

RESULTS OF FEA ANALYSIS, DIFFERENT LOAD CASES FOR DIFFERENT THICKNESS OF HANDLE BAR

SR. NO.	THICKNESS	LOAD IN NEWTON	STRESSES
01	1.5 MM thick	700N	631.33 N/mm²
02		300N	308.16 N/mm²
03	2.5 MM thick	700N	326.31 N/mm²
04		300N	153.77 N/mm²
05	3 MM thick	700N	266.20 N/mm²
06		300N	125.15N/mm²

VI. CONCLUSION.

- For baseline design stress found maximum than yield value i.e. greater than 250n/mm2.
- Baseline design has failed.
- Hence to pass this, Design change is required.

A. Modified design

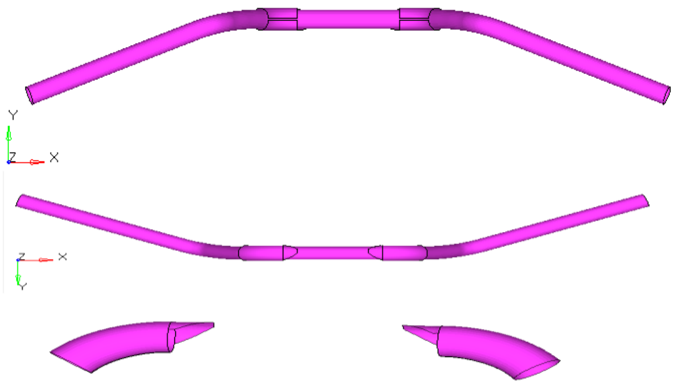


Fig 7 Modification (clips) in handle bar

TABLE 2

RESULTS OF FEA ANALYSIS, FOR LOAD CASE AFTER MODIFICATION IN HANDLE BAR

SR. NO.	THICKNESS	LOAD IN NEWTON	STRESSES
01	3 MM thick	700N	225 N/mm²
02		300N	122.2 N/mm²

- 3D modelling of the tube drawing process helped in visualization and conceptualization. The modelling saves the research time and minimizes the risk of design failure.
- Simulation of the process helps to check the design of dies and plug as well helps to visualize the deformation of handlebar.
- The effect of dimensions of specimen on the buckling/bending stresses of the handlebar was studied under dry condition and the following conclusions are drawn.
- Baseline design was not able to take the load, hence design is changed i.e. clip of thickness is added at the bending location as shown in above slide.
- Also handle bar thickness is increased to 3mm.
- For revised design, stresses are quite lower than yield value i.e. 250n/mm2.
- Hence ensured safe design.

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