Analysis and Proposed Fabrication of Two-Wheeler Hybrid Chassis

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***Abstract*— In this paper an effort is made to review different two-wheeler chassis frame, analysis on the techniques used on them and materials used for making chassis. There are number of automated techniques available for stress examining in chassis of the two wheelers. Analysis done under different set of conditions on the chassis made of different materials is being presented in the literature review. An attempt is made to provide an overview of various methodologies adopted for two-wheeler chassis frame and their analysis due to which further study on chassis will become easy. The objective is to figure out the type of material / cross-sections required at various places in a chassis through automation and to suggest a hybrid material / cross-section chassis.**

Keywords—finite element method, Hybrid Chassis, mechanical characteristics, automation, two- wheeler

I. INTRODUCTION

The frame of a two-wheeler chassis is a structure, or in other words a skeleton upon which parts like gear box and engine are mounted. The frame is an automotive which carries the load on the vehicle. For a frame to resist shock, vibration, twist and other stresses, it has to be strong so that it does not fracture easily. It manifest that frame should have high ultimate tensile strength. A frame is basically a support for the suspension system, springs and shock absorbers which as a result helps in keeping the wheels in contact with the road and buffers the rider from bumps and jerks. Therefore, chassis is considered as the most important part of a vehicle which holds all the parts and components together. Different techniques, Experimental modal analysis (EMA), Finite Element method (FEM) are used in determining the flaws in the design of the frame. Further on, studies being done on two wheeler chassis have shown which material is best suited. Using materials like Carbon fibre reinforced polymer (CFRP), Aluminium alloy A6063 and bamboo could enhance the performance of the two wheelers.

II. GENERAL ISSUE

The chassis of an automotive vehicle undergoes different loading conditions, static and dynamic: compressive, tensile, shear and fatigue. For understanding where the stresses are more developed, different techniques like Finite element method (FEM), Experimental modal analysis (EMA), the modal parameters, natural frequency and mode shape of the structure could be determined to get briefed about the issues of the frame. Material of the frame is also an important issue, using alternate materials magnesium, aluminium alloy A6063, carbon fibre reinforced polymer (CFRP), aluminium alloy A360,titanium, bamboo or a hybrid could make the frame lighter and enhance the vehicle's performance. To know which material is to be used in different parts of the frame, software like ANSYS, CATIA, Hypermesh, and Solidworks could be used for analysing and would help in constructing a hybrid frame which would be a combination of strong and light materials.

Fig. 1. Prototype model produced. [10]

III. LITERATURE REVIEW

In the study of "Design Optimisation of two-wheeler (Bike) chassis carried out experiments on alternate materials – aluminium alloy 6063, titanium, carbon fibre, magnesium, in order to reduce the weight of the chassis [1]. Various loading conditions like static and dynamic loadings were carried out on the chassis with the help of softwares like ANSYS and Hyperworks. They found that the stresses were

maximum at joint locations, and the values of stresses were less than permissible yield stresses, as a result the design was safe. After considering all the necessary conditions like cheap in cost and less in density of the materials, aluminium alloy 6063 was the best suited alternate material for the chassis and is expected to perform better with satisfying amount of weight reduction.

The study done on modern analysis of two wheeler chassis was carried out with the help of experimental model analysis (EMA) in order to determine the natural frequencies, damping and mode shapes of the both chassis of two wheeler namely as pulsar 150 cc and passion [2]. They used Finite Element Method (FEM) to find the natural frequency and mode shape. After completing the experiments on both the chassis with alternate material performed much better with satisfying amount of weight reduction. It was concluded that weight reduction would lead to better fuel efficiency of the vehicle. And the new chassis would have reduced vibrations when compared to the prevailing model. They concluded, out of the two chassis, pulsar 150cc was better and had safe design than passion as its deformation was less than the latter.

It was found that weight of the chassis frame could be reduced by using combination of steel and bamboo [3]. The bamboo was used where the stresses were within the permissible limit. The bike used in the experiment was Pulsar 180, after calculations low stresses area was determined and as a result the area was being replaced by bamboo. After fitment of bamboo columns it was concluded that weight was reduced about 2.071 Kg, so the frame reduced the weight and cost of the overall structure. And a layer of liquid cement was applied so that there was no reaction with water.

The experimentation done on two models, one with the original circular cross-section and with the rectangular cross-section [4]. The structural and modal analysis was done on both models of suspension frame using materials steel and carbon epoxy. It was found that the values of stresses were less than the permissible yield stress values that meant the design was safe. After comparing the results of both cross-sections, the rectangular cross-section had less displacement and stress values than circular cross-section. Out of steel and carbon epoxy, the latter had less stress values. It was concluded that rectangular cross-section and carbon epoxy was better for suspension frame.

In the study of "Structural analysis of two wheeler suspension frame" comparison was done, mechanical differences between a tubular and square frame, and experimentation with two materials, aluminium and steel [5]. After experiments it was found that the tubular frame had more deformation and stresses than the beam frame during acceleration, while braking it was opposite. During a curve, deformation was higher for the tubular one, but the stresses were higher for beam one. It was concluded, the more rigid the frame, it would allow more speed in straight line but less velocity in curve. As a result, less energy spent on deformation.

In their work they modelled a suspension frame used in two- wheeler [6]. Modelling was done in Pro/Engineer and structural and modal analysis was done on the suspension frame by using four different materials steel, Aluminium alloy A360, Magnesium and Carbon fibre reinforced polymer (CFRP). The stress values for all the materials were less than their respective permissible yield stress values, so the design was safe. By comparing the results of all the materials, stress obtained was same, but displacement was less for carbon fibre reinforced polymer than other three materials. It was concluded, CFRP is better material for suspension frame.

In the study of "Stress and rigidity analysis of bike chassis" did comparison of both existing and modified double cradle frame in static structural analysis by using Solidworks 2015 simulation module [7]. The main aim of the study was to minimize the effect of vibrations. The Finite element method (FEM) was used for determining the dynamic characteristics of the two wheeler chassis. After completing the analysis, chassis made of same material performed better with satisfying amount of deflection reduction. While comparing both of the frames, the existing frame had stress value of 192.99MPa and the modified frame had a stress value of 231.71MPa. But major changes in deflection were from 8mm to 5.1mm. As a result the modified frame reduced deflection by 35.84%.

The study showcased about materials alloy steel, Aluminium alloy A360, magnesium and Carbon fibre reinforced polymer (CFRP) in order to understand and determine which material is suitable for the frame [8]. The static and modal analysis was done on ANSYS software. By comparing stresses and factor of safety, carbon epoxy material was better. And from modal analysis, the fundamental frequency of carbon epoxy material was higher compared to other materials. Further, shock analysis was also done, and it was concluded that carbon epoxy material was safe for two-wheeler chassis frame under static and shock loads.

The study focused on right methodologies to reduce the motorcycle chassis vibration [9]. For reducing the vibrations and getting an insight about the system, techniques used were finite element modelling and experimental harmonic analysis. The methodology adopted in their study reduced

engine vibration in the range of 80 to 89%. It was concluded that Finite Element Modal Analysis was very useful in determining vibration sources correctly and reducing the overall vibration level.

IV. Technical Understanding

Different parts of the chassis bear different kinds of loading, mainly: tensile, compressive, shear and fatigue and therefore have tendency of failure. This is because of the fact that a single material/correction is not suitable with all kind of loadings. Different loadings can be encountered using either different materials or different corrections of materials.

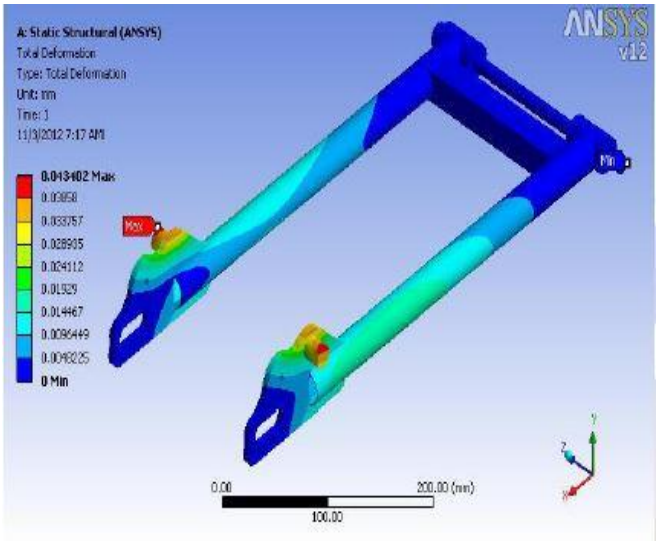

Figure 2: Structural analysis done on the chassis. [11]

V. Conclusion

As per the analysis carried out in this paper, titanium is the strongest material and durable material used for making frames of the two wheelers as it has highest tensile strength of 344MPa, Ultimate tensile strength of 434MPa and Young's Modulus of 116GPa. But the biggest drawback of titanium is that, it is heavy and production of titanium alloys is expensive. Therefore, it can be concluded that aluminium alloy AA 6063, carbon fibre reinforced polymer (CFRP), aluminium alloy A360 are inexpensive than titanium and can be used for constructing frames. And as per the review, CFRP is better since it has less density, high strength-to-weight ratio and rigidity. Thus, a hybrid chassis can be designed, made of different materials and different cross-section. By analysing the load acting at different cross-sections, alternate materials could be used accordingly. Furthermore, Mixture of two or more materials called as a Hybrid Material Chassis which comes out to be best type of chassis [12].

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