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Static and Dynamic analysis and optimization of Pulser180 Bike Chassis

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ABSTRACT
The chassis is what truly sets the overall style of the two-wheeler. Automotive chassis is the main carriage systems of a vehicle the chassis serves as a skeleton upon which parts like gearbox and engine are mounted. It can be made of steel, aluminum or an alloy. It keeps the wheels in line to maintain the handling of the two-wheeler.This project deals with design of chassis frame of a two wheel vehicle and it's Optimization. Various loading conditions like static and dynamic loadings to be carried out on the chassis and the design has been optimized by reducing the weight of the chassis.

I.INTRODUCTION-

A chassis consists of an internal framework that supports a man-made object. It is analogous to an animal's skeleton. An example of a chassis is the under part of a motor vehicle, consisting of the frame (on which the body is mounted) with the wheels and machinery.

In the case of vehicles, the term chassis means the frame plus the running gear like engine, transmission, driveshaft, differential, and suspension. A body, which is usually not necessary for integrity of the structure, is built on the chassis to complete the vehicle. The automotive chassis is tasked with holding all the components together while driving and transferring vertical and lateral loads, caused by accelerations, on the chassis through the suspension and the wheels. Therefore the chassis is considered as the most important element of the vehicle as it holds all the parts and components together. It is usually made of a steel frame, which holds the body and motor of an automotive vehicle.

II. Literature Survey: -

Following is a list of researchers who has worked in area of weight optimization of automotive chassis. The combination with the following literature research on the latest use of alternate materials is expected to make the investigation as complete as possible.

CH.Neeraja et al. [1] they had worked on structural analysis and weight optimization of two wheeler suspension frame. The two-wheeler chassis consists of the frame, suspension, wheels and brakes. The chassis truly sets the overall style of the two-wheeler. The frame serves as a skeleton upon which parts like gearbox and engine are mounted. It can be made of steel, aluminum or an alloy. It is essential that

the frame should not buckle on uneven road surfaces and that any distortions which may occur should not be transmitted to the body. The frame must therefore be torsion resistant.

A suspension frame was modeled using 3D modeling software Pro/Engineer. To validate the strength of a frame, structural analysis is done by applying the wheel forces. In this analysis ultimate stress limit for the model is determined. Analysis is done for frame using four materials alloy steel, aluminum alloy A360, magnesium and carbon fiber reinforced polymer to verify the best material for frame. Modal analysis is also done to determine different mode shapes for number of modes. Analysis was done in ANSYS software.

Through this study it was found that all the materials have stress values less than their

respective permissible yield stress values. So the design is safe. By comparing the results for four materials, stress obtained is same and displacement is less for carbon fibre reinforced polymer than other three materials. The material has less density compared to the other materials used for manufacturing of chassis and frame, and is best suited for process of manufacturing, and can withstand very high loads. Using carbon fiber reinforced polymer frequently in the upcoming days the cost of manufacturing of frame can be reduced.

M.Ravi Chandra et al. [2] had worked on modeling and structural analysis of heavy vehicle chassis and have used polymeric composite material for its weight optimization. Chassis frame forms the backbone of a heavy vehicle, its principle function is to safely carry the maximum load for all designed operating conditions. This paper describes design and analysis of heavy vehicle chassis. Weight reduction is now the main issue in automobile industries. The three different composite (Carbon/Epoxy, E-glass/Epoxy and S-glass /Epoxy) heavy vehicle chassis have been modeled by considering three different cross-sections namely C, I and Box type cross sections. For validation the design is done by applying the vertical loads acting on the horizontal different cross sections. Software used in this work is PRO–E 5.0 for modeling, ANSYS 12.0 for analysis.

By employing a polymeric composite heavy vehicle chassis for the same load carrying capacity, there is a reduction in weight of 73-80%, natural frequency of polymeric composite heavy vehicle chassis are 32-54% higher than steel chassis and 66-78% stiffer than the steel chassis. Based on the results, it was inferred that carbon/epoxy polymeric composite heavy vehicle chassis has superior strength and stiffness and lesser in weight compared to steel and other polymeric composite materials and other cross sections considered in this investigation. From the results, it was observed that the polymeric composite heavy vehicle chassis is lighter and more economical than the conventional steel chassis with similar design specifications.

D.Nagarjuna et al. [3] they had worked on weight optimization of an all-terrain vehicle chassis. An all-terrain vehicle (ATV), also known as a quad, quad bike, three-wheeler, or four-wheeler, is defined by the American National Standards Institute (ANSI) as a vehicle that travels on low pressure tires, with a seat that is straddled by the operator, along with handlebars for steering control. As the name implies, it is designed to handle a wider variety of terrain than most other vehicles. This paper deals with design of chassis frame for an all-terrain vehicle and its optimization. Various loading tests like Front Impact,

Rear Impact, Side Impact, Roll over test etc. have been conducted on the chassis and the design has been optimized by reducing the weight of the chassis.

Optimization of design has been achieved using IS3074 material. There has been considerable decrease in weight of roll cage which helps it in moving faster. Optimization has been achieved by reducing the diameter of chassis bar wherever less load is acting and where there are less deformations. In this way the weight of chassis has been reduced from 84 kg to 64 kg by performing various loading analysis test on roll cage.

K.S.Sunil et al. [4] had worked on integration of reverse engineering and 3D printing for development of bike chassis. This paper, deals with the development of bike chassis using reverse engineering and optimized the same with FEM. Chassis is the back bone of two wheeler. The chassis 3D model was developed with the help of reverse engineering technique using CATIA V5 R20. The FEM simulation was done using ANSYS software. The simulation predicts the stress distribution, displacement and natural frequency. The weight optimization of the chassis plate, i.e. which is used to mount the engine was done.

This paper was mainly concentrated on the bike chassis design and development methods using RE and 3D printing Technique. In the optimization the weight of the chassis plate was reduced by 10.28%. From the static analysis it was found that the maximum stress was 217.029Mpa and having displacement of 0.07 mm for a maximum load of 250 Kg, and from modal analysis chassis was able to withstand maximum frequency of 236.697Hz. Further for the visualization of the model, rapid prototyping technology called fused deposition modeling (FDM) was used to produce prototype of the chassis.

Wang Li-rui et al. [5] had worked on simulation and improvement of vehicle frame using FEM. In order to develop and improve the design of a vehicle frame, this paper illustrates the modeling and simulation of a new type of vehicle frame. Modeling of the frame was done via UG NX6.0, and simulation of the frame was done through ANSYS 12.0 to reduce the weight of the frame, 6061 aluminum alloy, which contains Mg and Si, was used to manufacture the frame. Moreover, carbon fiber was applied in manufacture of the chair and other accessories to additionally reduce the weight. Based on the simulation results, component was designed to strengthen the frame. Based on the results and improvements, the design was accomplished.

Hyperworks was used to validate the model using another shell element type algorithm. However, the validation shows a slight difference in the displacement in the three dimensions. Moreover, since this vehicle, which is based on the frame, will join the competition to compete for the lowest oil consumption, the frame seems to be a little bit heavy. This means further improvement can be made if more appropriate materials are available. Simulation using ANSYS 12.0 and Hyperworks has successfully validated the model in static conditions and dynamic conditions with the safety index in mind. After improvements above, all statistics, including displacement, stress and load distribution are within the material limitations. The model was found to be appropriate for the vehicle to join the competition.

Dr.R.Rajappan et al. [6] had worked done on static and modal analysis of truck chassis using FEM. Truck chassis is a major component in a vehicle. In truck chassis different type of failures occur due to static and dynamic loading condition. In this present work static and dynamic load characteristics are analyzed using FE models from this work. High stress area, analyzing vibration, natural frequency and mode shape are identified by using finite element method. Modal updating of truck chassis model was done by adjusting the selective properties such as mass density and Poisson's ratio. Predicted natural frequency and mode shape will be validated against previously published result. Finally, the modifications of the updated FE truck chassis model were proposed to reduce the vibration, improve the strength, and optimize the weight of the truck chassis. Software used in this work is PRO–E 5.0 for modeling, ANSYS 12.0 for analysis.

The material used is AISI 4130 alloy with quenched and tempered treatment. The paper has looked into the determination of the dynamic characteristic the natural frequencies and the mode shapes of the truck chassis, investigating the mounting locations of components on the truck chassis and observing the response of the truck chassis under static loading conditions. For the linear static analysis, the stress distribution and deformation profile of the truck chassis subjected to two loading conditions: truck components loading and asymmetrical loading had been determined. Maximum stress occurred at the mounting brackets of the suspension system while the maximum translation occurred at the location where the symmetry and asymmetry load is acting. The maximum stress of the truck chassis is 16KN while the maximum translation is 2.013mm. These values are acceptable as compared to the yield strength of the chassis material and the tolerance allowed for the chassis.

Jakub Smiraus et al. [7] had worked on designing of motorcycle active chassis geometry. A significant breakthrough in motorcycle chassis design took place at the end of 90s, when new materials, e.g. aluminium alloy or various composites, were utilized. This brought about up-to-now unprecedented strength while sustaining or even decreasing weight of particular parts. It was then, when development of fast yet perfectly controllable and safe motorcycles was made possible. Modern motorcycles have a number of electronic systems supporting their driving stability. However, the idea of trying to affect the driving stability with the use of up-to-now changeless parameters such as wheelbase or trail is quite new. Such an innovative solution of motorcycle suspension with variable geometry dependent on driving conditions was designed in this thesis.

The designed system with steering geometry changes might be a pioneering idea in construction of the 21st century motorcycle chassis. The trail adjustment along with changes in wheelbase and ground clearance of the bike open up many options in the field of negative effects regulation resulting from the dynamic characteristics of motorcycle motion. With the introduction of composite materials and latest aluminium alloys, there come the possibilities of suspension construction with variable values of steering axis angle or wheelbase. The main idea in the construction of the designed suspension is to smoothly change the parameters of the chassis during the drive.

Chien-Ping Chung et al. [8] had investigated about parameter decision on product characteristics of bike frame. Parameters decision for products that can effectively reduce costs and enhance quality plays an important role in product competitiveness. This paper aims to discuss the parameters decisions of a

bike frame. This study first applied the statistical method and simulation software ANSYS to acquire the experimental data of bike frames. The simulation processes of the experimental design used the response surface methodology (RSM), and then conducted data analysis to determine the optimal response surface according to the successful application of statistical analysis results. This study simulated product assembly functions by experimental design, and proposed solutions for product parameters.

This study took the BBD experimental matrix method of RSM, which has the merit of appropriate experiment frequency, and then, applied mathematics programming software to acquire the optimal solution model. By simultaneously applying RSM and mathematical programming, it is possible to acquire the strengths of both these methods. This study presents a new method to determine design parameters of products, which can lower unnecessary cost expenditures and achieve higher efficiency, thus, enhancing the competitive power of manufacturers and leading to higher profits.

III. Concluding remark of Literature Survey-

In this, the primary features of to collect the literature survey of research work, and referring different books and earlier research works published in reputed journals for the dissertation work.

From the literature review it is observed that mass or weight reduction is an important issue in automotive industry. Chassis is a prominent structure for bike body, which takes the loads during serious accidents, costly recalls; chassis also has an impact on product image. There is a great potential for optimizing weight of chassis by using alternate material without affecting its structural behavior. The design and analysis of model, conditions required for applying various constraints and how the loads are to be applied is briefed about in the technical papers referred.

From these literature surveys, the properties of various alternate materials like carbon fiber, aluminium alloy, titanium have been studied and been compared with conventional mild steel. Also it is observed that the work has not been carried out for weight optimization of complete chassis, only chassis components weight has been optimized by using software simulations.

So, there is scope to optimize the weight of chassis by using alternate material while maintaining its strength and finally suggest the best alternate material for the chassis.

IV. Problem Statement

Mass or weight reduction is becoming an important issue in automotive industry. Weight reduction will give substantial impact to fuel economy, efforts to reduce emissions and therefore, save environment.

Chassis is a prominent structure for bike body, which takes the loads during serious accidents, costly recalls, chassis also has an impact on product image. Commonly used material for chassis is steel which is heavy in weight or more accurately in density. There are various alternate materials like composites, aluminium alloys, titanium, carbon fibre, magnesium, etc. which are lesser in weight and provides high strength and thus can be used for chassis. Various compositions can be tested and experimented so that the overall weight of the vehicle can be reduced for better fuel efficiency.

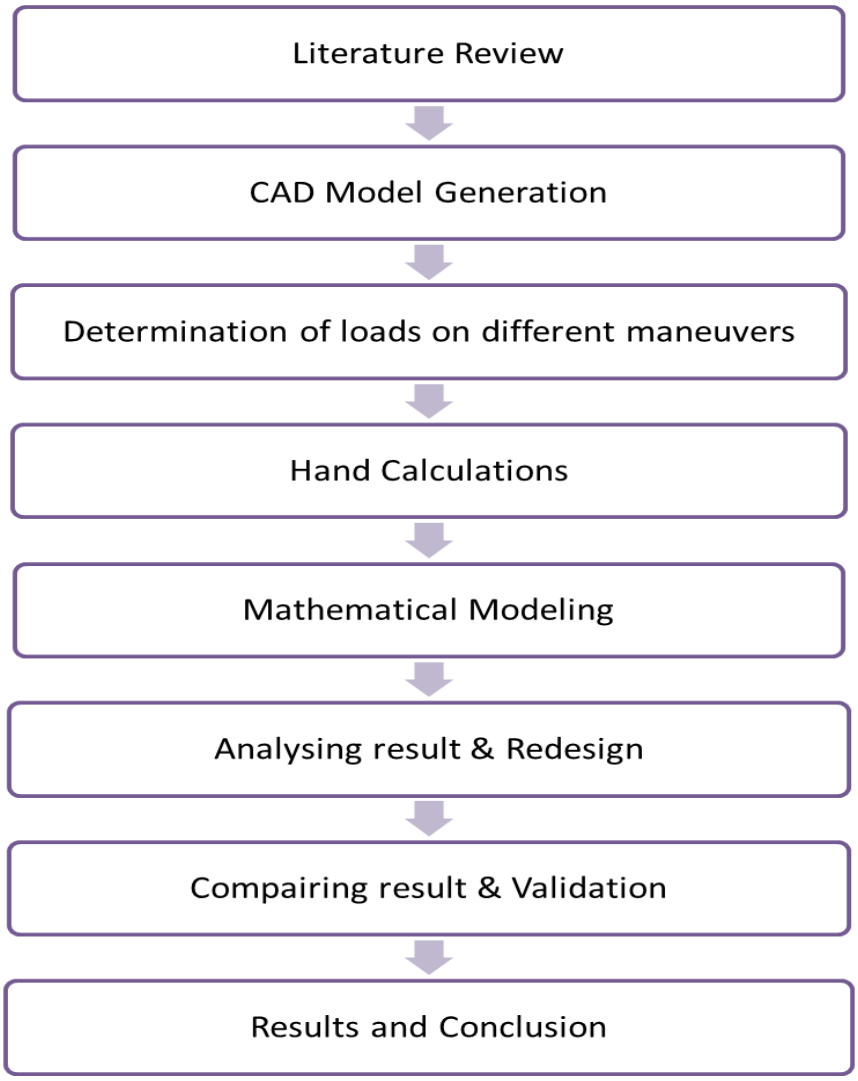
V. Proposed Work to fill up problems-

It is proposed to do static analysis on Bike Chassis, as per the following.

- **Theoretical Analysis: -** Running the problem of Bike Chassis and Prepare a CAD model from input parameters.
- **FEA Analysis: -** Solve for the solution of meshed CAD model using ANSYS for better performance.
- **Fabrication of Bike Chassis: -** Fabrication of Bike Chassis as a compact job and optimizing weight to improve performance.
- **Experimental Testing Analysis: -** Testing the Bike Chassis under actual conditions on UTM (Universal Testing Machine) for same loading conditions.
- **Validation of results:** - The results of old and new design is compared and validated.

Methodology:-

It is proposed to carryout the work as per algorithm given below.



VII. Expected/ Possible Outcome:

Redesigned Bike Chassis is expected to perform better with 20% to 30% weight reduction. The weight reduction will hence lead to better fuel efficiency.

VIII. Conclusion:

From the review of the Research papers it is concluded that there is scope for reducing weight of vehicle by changing the material. By taking material having lower mass and without compromising the performance it is possible to replace conventional steel material (MS) with Aluminium6330.We will be studying effect of replacing MS with Aluminum6330 through analysis in CAD/CAE tools. Using these tools will help us to determine stressed region for further optimization.

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