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A review on redesign of automobile chassis for weight reduction

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ABSTRACT

In this study, different analysis techniques for automobile frame are studied under different loading conditions. The loading may be static or dynamic. Also studied analytical and experimental techniques available for automobile frame analysis. This overview helped to study how to reduce weight of automobile chassis. It contributes around 15% in the total weight of vehicle. It is thus significant to improve the design of the chassis to provide good balancing and improved fuel efficiency. The paper deals with the performance improvement of the existing chassis with certain design changes (trying different materials & changing structure).The parts are developed with Computer Aided Design software (CATIA) & analysis is done using Hypermesh & ANSYS software.

Keywords- ***a ANSYS, Bike chassis, Hypermesh, Material, Static & dynamic Load conditions***

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I. INTRODUCTION

A vehicle without body is called chassis. A chassis is nothing but an internal framework that supports a man-made object. It is analogous to an animal's skeleton. The chassis serves as a frame work for supporting the body and different parts of the automobile 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.[1] The frame also serves as a support for the suspension system, a collection of springs and shock absorbers that helps keep the wheels in contact with the road and cushions the rider from bumps and jolts.[2]

Weight reduction of bike is now important issue in automobile industries. Total weight of any bike is approximately 100-150 kg. As weight of chassis is near about 10-15% of total weight of bike, considerable weight reduction can be achieved by reducing weight of chassis. Also, while reducing the weight of chassis design should be such that it will give strength and stability to vehicle under different loading conditions (static and dynamic loading conditions). The different types of automobile chassis include:

A. *Backbone Frame*

The backbone frame comprises a single, wide main beam from which the engine is suspended. The backbone frame allows for great flexibility in design, since it is concealed inside the finished motorcycle. The engine just seems to hang in mid air. It is simple and cheap to make, and is used mainly on naked and off-road motorcycles ex-Hero Honda CD 100.

B. *Diamond Frame*

It is one of the most common type of frame found on Indian bikes. The diamond frame gets its name from the frame on a bicycle, where the shape that the frame makes is that of a diamond. Examples of bike with such frame are Bajaj Pulsar 135 LS, Hero CBZ Xtreme, Yamaha Fazer, TVS Flame, etc.

C. *Single Cradle Frame*

The single cradle is the simplest type of motorcycle frame, and looks similar to the first ever motorcycle frames.

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It is made from steel tubes that surround the engine with a main tube above and other, smaller diameter tubes beneath. If a single cradle becomes double at the exhaust, as frequently occurs, it is referred to as a split single cradle frame. Single cradle frames are usually found in off-road motorcycles ex- Bajaj Platina, Bajaj Discover 100, etc.

D. *Double Cradle Frame*

Double cradle frames are descended from single cradle frames. They consist of two cradles that support the engine one either side. Double cradle frames are commonly used in custom motorcycles and simpler road bikes. They offer a good compromise between rigidity, strength and lightness, though they have now been technically surpassed by perimeter frames. Ex- TVS Apache RTR 180, Bajaj Pulsar 180 DTS-i, etc.

E. *Perimeter Frame*

Motorcycle racing research has shown that major advantages are to be gained in terms of rigidity by joining the steering head to the swing arm in as short a distance as possible. This is the concept behind the perimeter frame. Two robust beams descend in the most direct way possible from the steering head to the swing arm, passing around the engine. The earliest perimeter frames were made from steel, but the need to improve rigidity to weight ratios led most manufacturers to adopt aluminium instead. The only two bikes with perimeter frame currently in India are the Bajaj Pulsar 200NS and the Yamaha R15. [3]

Weight of such frames can be reduced either by changing the material or by changing dimensions of chassis. This paper contains review of all research paper related to the above work.

There are different opinions of literature review about weight reduction of chassis. By referring this my work include static analysis of Bajaj Pulsar 180 DTS-i chassis for weight reduction. This can be done by replacing current material (which is Mild steel) by aluminium alloy Al 6063 as well as study of different loading conditions of bike. The material properties of both material are as follows:

TABLE I
MATERIAL PROPERTIES

Material	**Density**	**Modulus of Elasticity**	**Poissions ratio**	**Yield strength**
	Tons/mm^3	**Mpa**		**Mpa**
M.S.	7.85×10^{-9}	21000	0.3	390
Al 6063	2.7×10^{-9}	69000	0.33	325

Double cradle frame is used in pulsar 180 DTS-I bike of M.S. material having approximate weight of 15-17 kg and kerb weight of bike is 147 kg. For optimization of this study model is prepared using CATIA V5R19.Hypermesh and ANSYS ’14 is used for meshing and analysis of frame.

II. LITERATURE REVIEW

D.Nagarjuna et al, [1] 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. Material used for optimization is IS3074. 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. **C. H. Neeraja et al, [3]** have modelled a suspension frame used in two-wheeler. Modelling is done in Pro/Engineer. They have done structural and modal analysis on suspension frame using four materials Steel, Aluminium Alloy A360, Magnesium and carbon fiber reinforced polymer to validate our design. By observing the results, for all the materials the stress values are less than their respective permissible yield stress values. So the design was safe, by conclusion.By comparing the results for four materials, stress obtained is same and displacement is less for carbon fiber reinforced polymer than other three materials. So for design considered, CFRP is better material for suspension frame. **K.S.Sunil et al, [4]** this paper, deals with the development of bike chassis using reverse engineering and optimized the same with FEM. 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. . 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.

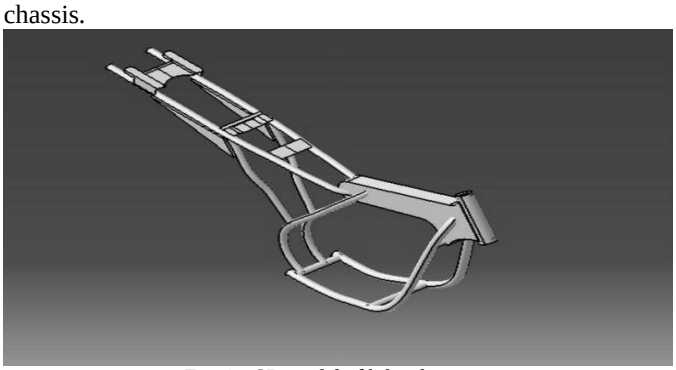

Fig. 1 – 3D model of bike chassis

M.Ravi Chandra et al, [5] This paper describes design and ana lysis 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

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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. He observed that 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. **Dr.R.Rajappan et al, [7]** 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 12.0for 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. **Mikel Burgui Oyaga et al, [8]** The objective of this project is to establish a method of calculation for designing a chassis of a motorbike in a manner in which can be measured all the parameters that are related to the design to get a chassis as light, strong and economical as possible, taking into account that the time available is limited. The first and most important conclusion he observed is that there is no method completely automatable to design and calculate a chassis. Also by removing some material, could be got lighter chassis and the results would continue being available. Other option could be change some bars for other with lower diameters and thickness. **Jakub Smiraus et al,[9]** 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.

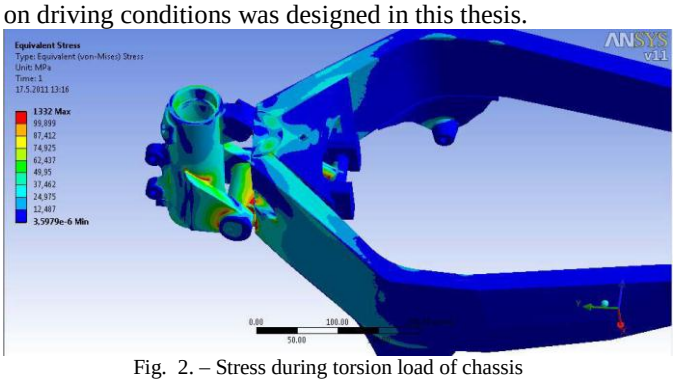

Fig. 2. – Stress during torsion load of chassis

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. 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, [10]** 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.CONCLUSION

From this review it is observed that most of cases are under study and still some research work is going on for getting sustainable progress in analysis of the chassis and differentiation between load analysis results to predict life of it.

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- So it is necessary to continue further study in the analysis
  and evaluation of the chassis to provide the best results.
- To predict life of a chassis there is need to have the results of both static as well as in dynamic loading conditions.
- There are number of ways to reduce the weight of chassis which include, changing the material of chassis, reduce the dimensions of bar at low loading conditions, Structural changes in chassis etc.

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