Static analysis of pulsar 180 bike frame made up of Al 6063

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Abstract- *Objectives of the following paper is to study the performance improvement in vehicle balance and improved fuel efficiency of the automobile by replacing the existing mild steel chassis of the BAJAJ PULSAR by Aluminum alloy 6063. Chassis acts as a main structural component in vehicle and provides casing for parts like engine, gear box etc. It contributes around 15% in the total vehicle weight hence it is significant that improvement in the design of the chassis will provide good balancing and improved fuel efficiency. The parts are developed with Computer Aided Design software (CATIA) & analysis is done using Hypermesh & ANSYS software Analysis is done under static loading conditions. The study was done under loads of fuel tank, engine assembly, load of rider & pillion. From this proposed study, it is expected that the chassis with alternate material is performing better without disturbing strength of chassis with the satisfactory amount of weight reduction in it which will lead to better fuel efficiency.*

Keywords- Bike chassis, Deformation, Material, Stress, Static & dynamic Load conditions.

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 importantelement 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. 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 work include static analysis of Bajaj Pulsar 180 DTS-ichassis for weight reduction. This can be done by replacing current material (which is steel) byaluminium alloy Al 6063 as well as study of different loading conditions of bike. The material properties of both materials are as follows:

TABLE 1
MATERIAL PROPERTIES

Properties	Al 6063	Steel
Density	2.7 x 10-9	7.85 x 10-9
Poisson's ratio	0.33	0.3
Yield Strength(MPa)	325	380
Modulus of Elasticity(MPa)	0.70 x 105	210 x 105

TABLE 2
MATERIAL CHEMICAL COMPOSITION OF Al 6063

Chemical Composition, %							
Si	Cu	Fe	Mg	Mn	Zn	Ti	Al
0.33	0.11	0.61	0.36	0.050	0.32	0.024	98.15

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. FEA ANALYSIS

A. Dimensions of Al 6063 chassis are taken as that of conventional steel bike chassis. For Static analysis of chassis the loading conditions are assumed to be static and following procedure is followed which consist of three steps.

1. Preprocessing: In pre processing the basic requirements for the finite element analysis are fulfilled:

A 3-D model of chassis is modeled by using CATIA software, this model in IGES format is imported in Hyper Mesh for the preparation of FE model. Then geometry cleanup was done by using options like 'geom. cleanup' and 'defeater' to modify the geometry data and prepare it for meshing operation. Mixed type of elements which contains quadrilateral as well as triangular elements, have been used in analysis. These 2D elements are converted into 3D tetra elements. The sensitive regions have been re-meshed by manually considering the shape and size of the parts. Quality check of all the elements has been performed and mesh is accordingly optimized.Type of element used for meshing, size of element, no. of elements used in this analysis work is given in the following table 3.

TABLE 3
TYPE OF ELEMENT USED FOR MESHING

Element type	tetra
Element size	4
Nodes	79150
Elements	254922

The material properties of the part under analysis are defined. The material properties like Young's Modulus, Poison's ratio, Yield strength and density are to be defined.The boundary conditions are applied to the model. The constrains and loading condition are applied on the elements. The boundary conditions include weight of the rider and pillion, weight of the fuel tank and weight of the engine.

2. Solution: In solution stage the element formulation is done. The solver is selected for solving the formulation. Also the results are requested at this stage. It will solve a set of linear or nonlinear algebraic equations simultaneously to obtain nodal results. Then the

continuous quantity is approximated over each element by a polynomial equation. This gives a system of equations, which is solved by using matrix techniques to get the values of the desired quantities.

3. Post processing: The post processing stage is the most important stage in finite element method. In this stage the results are to be viewed. The results like deformation, equivalent stress and strain can be viewed.

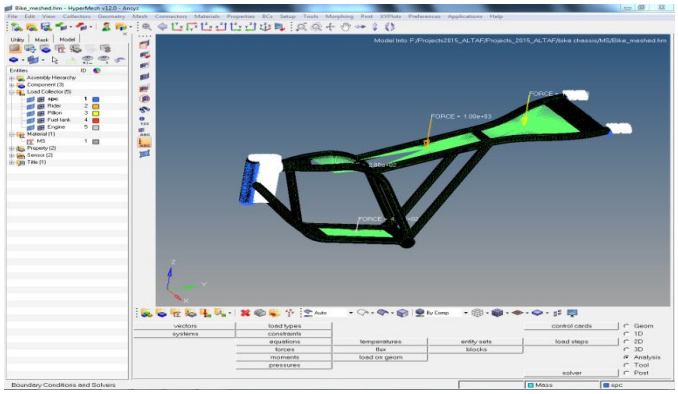

Fig. 1. Boundary conditions for analysis

A. Parameters Selected for chassis Experimentation:

From literature review selected parameter for chassis are as follows and its assembly is shown in fig.1. Load for selected chassis are following:
Weight of the rider = 700N
Weight of the pillion =700N
Weight of the fuel tank = 200N
Weight of the engine = 400N

Approximately,

It is necessary to find the deflection curve. The finite element analysis is done to find the deflection under defined load. The load will be increased in sub-steps as mention in table 5.The results of finite element analysis are as shown in the fig.2.

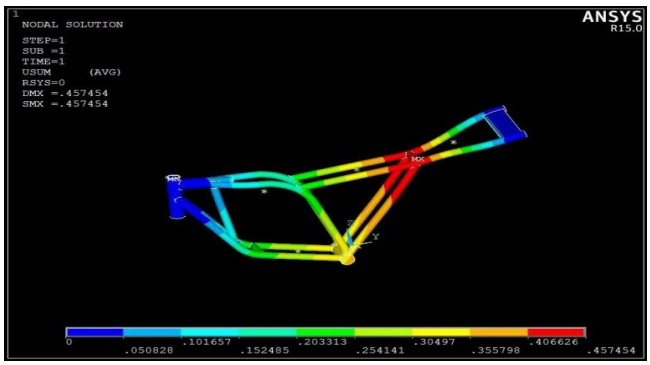

Fig. 2. ANSYS results for Al 6063 material chassis

III. RESULT AND DISCUSSION

1. Stress and deformation produced:- The finite element analysis is carried out on steel chassis as well as on Al 6063 pulsar bike chassis. From the analysis the equivalent stress (Von-mises stress) and displacements were determined and are shown in fig.2. And table 4 - 5 shows the comparative analysis of steel chassis and Al 6063 pulsar bike chassis.

TABLE 4
COMPARATIVE ANALYSIS OF STEEL AND Al 6063

Sr. No.	Parameter	Steel	Al 6063
1.	Load (N)	2200	2200
2.	Deformation(mm)	0.414	0.457
3.	Stress (N/mm^2)	43.06	41.88

TABLE 5
STRESS AND DEFORMATION PRODUCED ON Al 6063 MATERIAL CHASSIS

Sr. No.	Load	Deformation	Stress
1	500	0.08093	7.4012
2	900	0.152488	13.9818
3	1400	0.243101	22.3023
4	1800	0.343096	31.443
5	2000	0.381216	34.9225
6	2200	0.457454	41.881

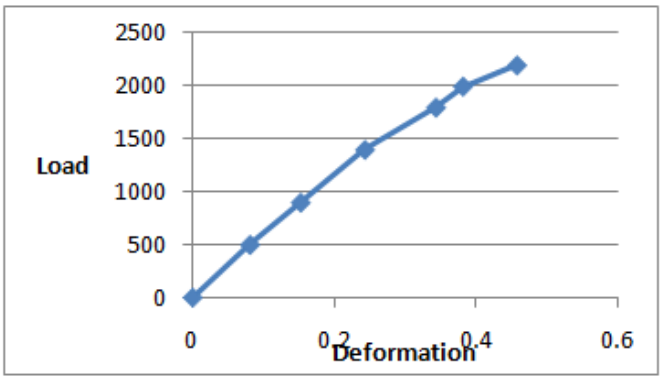

Fig. 3. Load-Deformation curve for Al 6063 material chassis

Table 4 whichshow that value of deformation and stress of both the material is near about similar. And table 5 shows that change in deformation and stress due to gradual increase in load on chassis of Al 6063 material. It is observed that for maximum load of 2200 N, deformation and stress are 0.45mm and 41.881N/mm2 respectively. Fig. 3 shows graph of load vs. deformation. And fig. 4 shows load vs. stress.

2. Weight reduction:- Table 6 shows differences in weight of

chassis of steel material as well as Al 6063 material. From table it is observed that Weight of steel chassis is 13 Kg while if it is replaced by Al 6063 material (8 Kg) with same dimensions there will be 34% weight reduction of chassis.

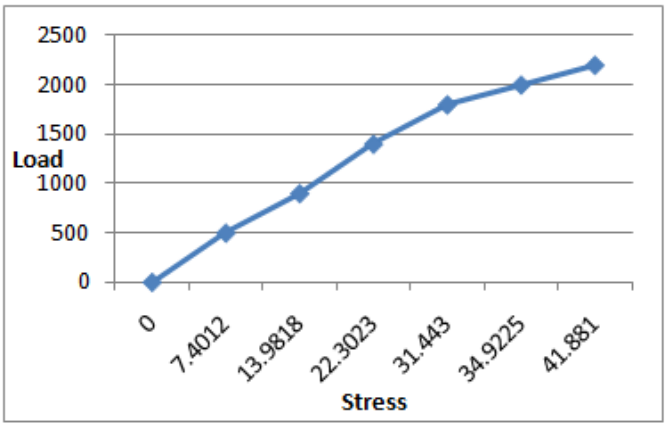

Fig. 4. Load-stress curve for Al 6063 material chassis

TABLE 6
COMPARATIVE ANALYSIS OF STEEL AND Al 6063

Material of chassis	Weight(Kg)	% difference
Chassis of Mild steel	13	34%
Chassis of Aluminium	8	

IV. CONCLUSION

From the results obtained it is concluded that by employing anAl 6063 material for Bajaj Pulsar 180 DTS-ibike chassis for the same loading conditions, there is a reduction in weight of 34%. This weight reduction is achieved without disturbing its strength. So, Fuel efficiency increases. Percentage error for deformation as well as stress between steel and Al 6063 material is below 15%, which is allowable.

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REFENCES

[1] D.Nagarjuna, Junaid Mohammed Farooq, A.S.N.Saiteja, P.Siddhartha Sri Teja, “Optimization of Chassis of an All-Terrain Vehicle”, International Journal of Innovative Technology and Exploring Engineering, January 2013. pp. 55-57.

[2] Deep Shrivastava, “Designing of All Terrain Vehicle (ATV)”, International Journal of Scientific and Research Publications, Volume 4, Issue 12, December 2014.

[3] CH.Neeraja, C.R.Sireesha, D.Jawaharlal, “Structural Analysis of Two Wheeler Suspension Frame”, International Journal of Engineering Research and Technology, August 2012.

[4] K.S.Sunil, Jaya Christiyan, “Integration of Reverse Engineering and 3D Printing for Development of Bike Chassis”, Journal of Mechanical Engineering Research and Technology, 2014. pp. 405-411.

[5] M.RaviChandra, S.Sreenivasulu, Syed Altaf Hussain, “Modeling and Structural analysis of heavy vehicle chassis made of polymeric composite material by three different cross sections”, International Journal of Modern Engineering Research, August 2012. pp. 2594-2600.

[6] Patel Vijaykumar V #1, Prof. R. I. Patel*2, “Structural Analysis of Automotive Chassis Frame and Design Modification for Weight Reduction” International Journal of Engineering Research & Technology (IJERT), Vol. 1 Issue 3, May – 2012.

[7] Dr.R.Rajappan, M.Vivekanandhan, “Static and Modal Analysis of Chassis by using FEA”, International Journal of Engineering and Science, 2013. pp. 63-73

[8] Mikel Burgui Oyaga, Alfredo Ursúa Rubio, “Analysis and design of a motorbike chassis” Pamplona, 27 de julio de 2011

[9] Jakub Smiraus, Michal Richtar, “Design of Motorcycle Active Chassis Geometry Change System”, Technical University of Ostrava, Number 5, Volume VI, December 2011. pp. 279-288.

[10] Chien-Ping Chung, Ching-Fang Lee, “Parameter Decision on the Product Characteristics of Bike Frame”, Asia Pacific Business Innovation and Technology Management Society, 2012. pp. 107-115.

[11] Gaurav Vasantrao Bhunte1 and Dr. Tushar R. Deshmukh2,”A Review on Design and Analysis of Two Wheeler Chassis” International journal for research

in emerging science and technology, volume-2, issue-1, january-2015.

[12] Forrest Dwyer, Adrian Shaw, Richard Tombarelli, "Material and Design Optimization for an Aluminum Bike Frame", April 26th, 2012.

[13] Niranjan Singh, Dr. Jagdev Singh, "Reverse engineering of brake rod of bajaj pulsar 150cc motor bike using solidworks and autodesk inventor",Journal of Engineering Research and Studies.

[14] Kiran Gopinath 1, Sumer Singh 2, "Form Development of a Two Wheeler (An Indian Preface)" International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 9, September – 2013.