Finite Element Analysis and Optimization of Motorcycle Frame for Weight Reduction

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Abstract - *The Frame of a motorcycle which carries the load of all the other parts hence make it one of the most important part of the motorcycle. The frame is steel made and heavy making the motorcycle less fuel efficient. In this work an attempt is being made to optimize the frame of motorcycle by removing the excess material from the frame. The material is removed by making holes in the existing steel structure where the stresses are comparatively low. A 3D model of the frame is designed using solidworks and Analysis is done using Ansys. Weight optimization of 11.37% is achieved. Design is found to be safe and within permissible limits.*

1.INTRODUCTION

Frame of any automobile is the base which carries the load of all the other components of automobile. It provides the shape to the vehicle. The frame of the motorcycle finds its root in bicycle and with the time it has gone many changes according to the need of the customer. one of the basic attempt for this design change is to minimize the weight while making it strong and stiff enough to sustain all the static and dynamic loads. The frame of common motorcycles is made of steel. This makes it heavy. It is an inherent problem of design that we always find extra material due to Which the weight of the component is increased several times . So there is always an scope to remove the excess material from the component and optimize it. In this work a similar attempt has been made with the motorcycle Frame. In this optimization of frame for weight reduction has been done my making holes by finding the less stressed areas of the frame. The modeling is done on solidworks and static analysis is done on Ansys. In this project firstly the frame is designed using Soliworks and imported to Ansys While using Steel as a material. The static analysis is performed by applying static load to the frame and section with less stress has been pointed out. Now the excess material is removed from these less stressed area using Solidworks and again analyzed for the static loads applied previously Using excess. Being light weight it will increase the efficiency of the motorcycle several times. The analysis is done on Ansys R 18.1 Von-misses stress and deformation is found and weight comparison is done to find the percentage reduction in weight that has been achieved and optimization achieved.

1.2 CAD

Computer Aided design is described as use of computer or take the aid of computer for designing, modeling and analysis. CAD reduces the error in the design, modification made easy and effort has been reduced. Make the work less time consuming and cost-effective. Accurate results are obtained without making actual prototypes and experimental works.

2. OBJECTIVE OF WORK

I. Designing a model of frame using Solidworks and evaluate the stresses and deformation in the system
II. Bringing changes to the frame for optimization for weight reduction.
III. Static Analysis of optimized system for checking its feasibility.

3. DIMENSIONS AND SPECIFICATION OF FRAME USED

For this work frame of Yamaha Fz is used which is a double-cradle frame made of steel. It has following dimensions.

Table- 1: Dimensions and weights

Length*Height*Width	2073X700X1050 mm
Wheel Base	1330mm
Ground clearance	160
Fuel Capacity	12L
Kerb Weight	150 kg
Frame weight	21.98kg

4. MATERIAL USED

In this work steel is used as the material to design the frame of motorcycle. Yamaha FZ conventionally uses the steel frame having following properties

Table-2 : Property of steel used in frame

Young' s Modulus (GPa)	210
Shear Modulus (GPa)	79.3

Tensile Strength(MPa)	550
Compressive strength(MPa)	427.6
Poison's ratio	0.3
Specific mass(Kg/dm3)	7.8

5. MODELING OF FRAME

Modeling of frame is done using solidworks. With the suitable dimensions and certain design changes.

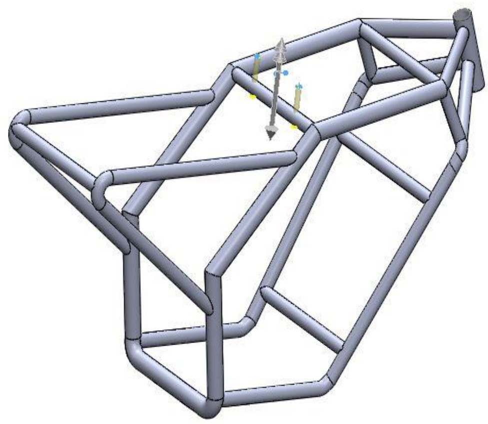

Fig-1 : Model of frame

After modeling frame is imported to Ansys for static Analysis under suitable boundary and loading conditions.

6. STATIC ANALYSIS OF STEEL FRAME

6.1 Meshing- After importing the frame to the Ansys firstly the meshing is done for the frame. The meshing done have tetrahedron element shape with a size of 5mm having total number of nodes 225810 and total elements are 129633 respectively. Now the properties of the steel is defined for the frame in this system and boundary and loading conditions are applied.

6.2 Boundary Conditions

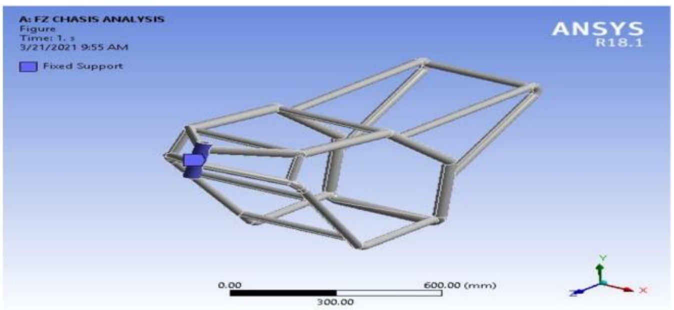

Fig.2- Boundary Condition 1- fixed support at steering rod

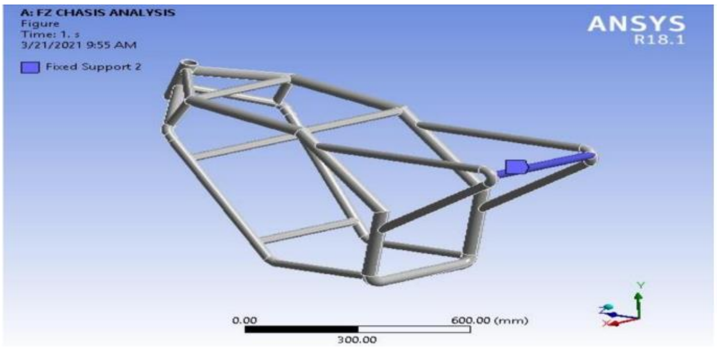

Fig. 3 - Boundary condition 2- Fixing rear end

5.3 Loading condition

There are three loading conditions.

1. Riders weight of 2000N
2. Weight of Fuel Tank 200N
3. Weight of the Engine 500N

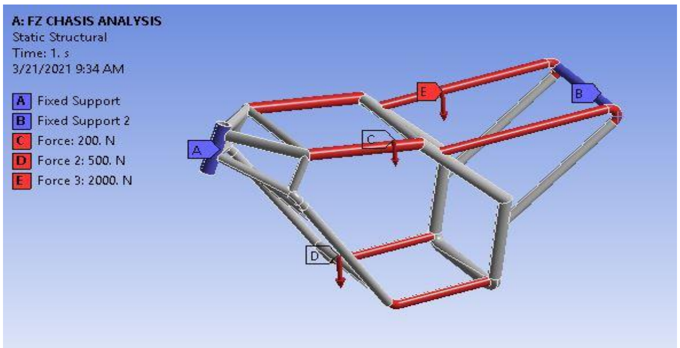

Fig.4- Loadings on Frame

5.4 Von-misses stresses and deformation

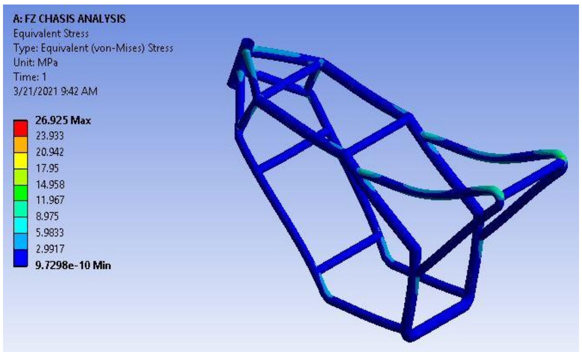

Fig. 5- Von-misses stress in steel frame

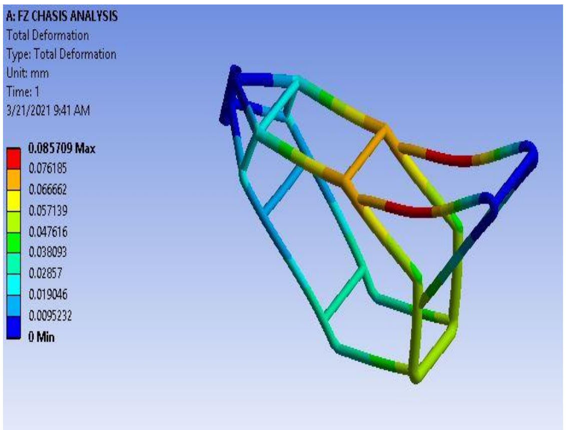

Fig. 6- Deformation of steel frame

6 REMODELING OF FRAME

After analyzing the frame now the optimization of frame is performed in this holes are created within the frame on the tubes at several places of a specified diameter of 15mm. This is done by Solidworks.

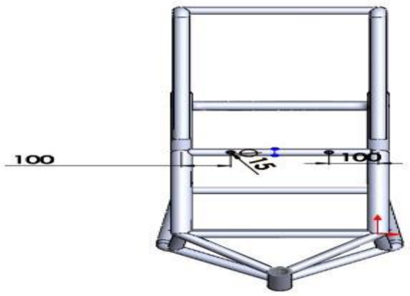

Fig.7- Creating holes in frame using specified dimension

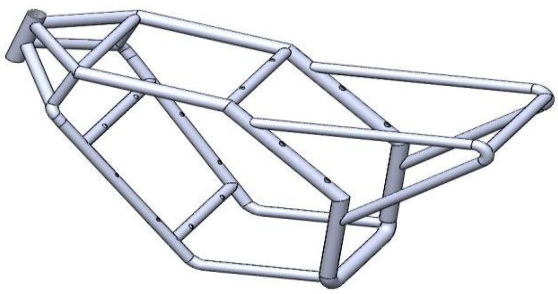

Fig.8- Remodeled frame

Now this model is imported to Ansys for analysis to check the feasibility of the changes brought the amount of weight reduced is found. The Analysis is performed keeping the same boundary conditions and loading conditions

7. STATIC ANALYSIS OF REMODELED FRAME

7.1 Meshing- Again the meshing of the frame is required due to trimming of few sections.

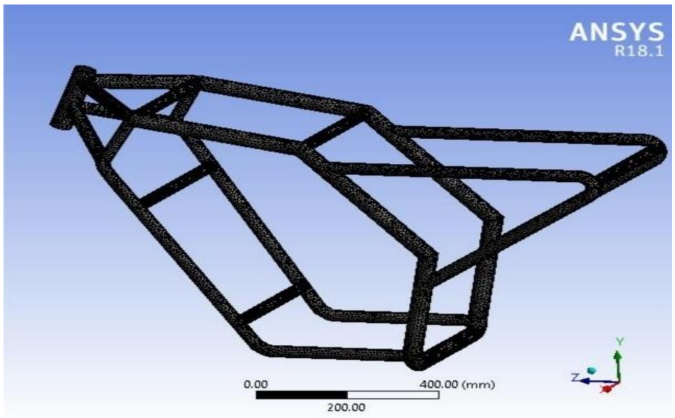

Fig. 9- Meshing of optimized frame

Table. 3 - Details of Meshing of optimized frame

Elements	143402
Nodes	273822
Element size	5mm
Shape	tetrahedron

7.2 Von-misses stress and deformation optimized frame

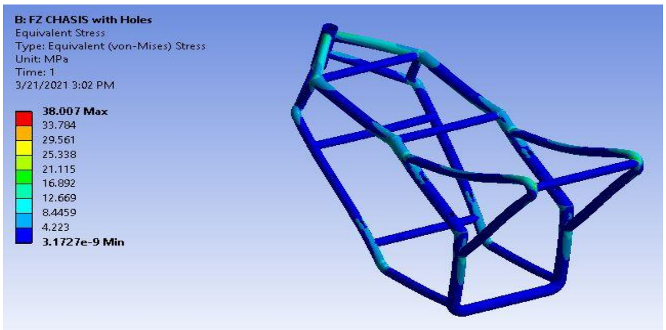

Fig. 10 - Von-misses stresses developed in optimized frame

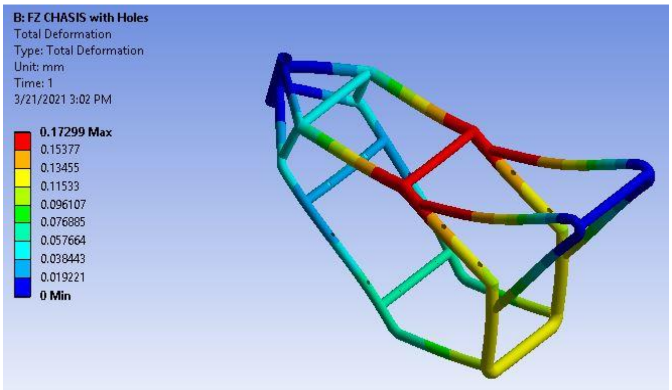

Fig. 11- Deformation in optimized frame

8. RESULTS AND DISCUSSION

Table.4 - Comparison of stresses between existing and optimized frame

Frames	Von-Misses stresses(MPa)	Maximum permissible stress (MPa)	FOS
steel Frame	26.925	250	9.285
Optimized frame	38.007	250	6.578

The von-misses stresses generated in frames are 26.925MPa and 38.007 MPa. It is evident that von-misses stress generated more in optimized frame. Factor of safety of 9.285 and 6.578 signifies that both the designed frame is safe and have sufficient strength. the permissible stress is 250 MPa. The design is safe.

Table .5- Deformation comparison

Frame	Total deformation	Deviation from steel frame	Percentage deviation
Optimized	0.17299mm	0.087281mm	101.84%

Total deformation of steel frame is 0.085709mm while the deformation for optimized frame is 0.17299 mm which is much more than the deformation of steel. A deviation of 101.84% is found

Table. 6- Weight reduced

Frame	Weight	Weight reduced	Percentage reduction
Optimized	19.48 kg	2.5 kg	11.37%

9. CONCLUSIONS

It is evident from the above data that aim of this work is achieved as a reduction of 11.37% which is 2.5 kg is obtained through this optimization of weight. The excess material removed doesn't affect the strength of the motorcycle frame and successfully adhered the loading conditions without failing. The deformation has increased by 101.84% which is quiet high in comparison to steel frame but this deformation of 0.17299mm is quiet low and under the permissible ranges. The maximum deformation and stress is found to be at the rider tube section. Factor of safety for the optimized is 6.578 which is quiet high this indicates that frame can bear more loads without failing. Hence the optimization of frame is found to be successful. This reduced frame weight can help in increasing the overall efficiency of motorcycle.

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