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# Design and FEA of Motorcycle Frame Using Carbon/Flax Hybrid Composite as a light weight substitute to steel.

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**Abstract -** *Frame of a motorcycle is the skeleton on which all the other parts of the motorcycle are mounted it is conventionally made of steel which is heavy in weight which in turn makes the motorcycle fuel-consuming. These days more focus is towards making the vehicle fuel-efficient by making it lightweight and including more renewable parts to the vehicle. Carbon-flax hybrid composite provides a Suitable option to this as it has good mechanical performance as well as eco-friendly and light in weight in comparison to steel. In this project, Steel is replaced with carbon-flax hybrid composite for motorcycle frame. Frame is designed using SolidWorks. FEA of frame is done for various loads under static condition with carbon-flax hybrid composite as a material using ANSYS R18.1. This project tries to find whether hybrid composites could be a potential option to convention steel in designing motorcycle frame.*

***Key Words*: ANSYS, SolidWorks, Hybrid composite, Hybridisation, Sandwich Structure, Frame.**

## 1.INTRODUCTION

Frame of a motorcycle is the skeleton on which the other parts of a motorcycle is mounted. It is the basic component which provides the shape and dimension to any motorcycle. It should have optimum strength and stiffness to bear all the loads and doesn't deform in static and dynamic loading conditions and should provide structural stability to the vehicle. Nowadays, more attention is given towards the fuel-efficiency, for that weight is the primary concern. Frame in itself contains much weight so designers are focusing more towards making the frame light. Light weight composite materials are providing an alternative to metals as they are light weight and have good strength and stability. Generally motorcycle frames are made of steel alternate materials are also being used like Aluminium, Titanium etc. Nowadays several composite are being used like Carbon-fiber, S-glass, E-glass for weight optimization. Moving a step ahead this project searches the scope in hybrid composites of carbon and natural fiber which are rigid and have sufficient mechanical strength, as well as ecofriendly

### 1.1 Carbon-flax hybrid composite

It is formed with the hybridization of flax, which is a natural fiber with carbon fiber to form a hybrid composite. It is light in weight and have good strength. It is extensively used in automobiles, high performance sports clothes etc.
In this project conventional steel is replaced with carbon-flax hybrid composite for motorcycle frame. Firstly 3D model of frame is designed using SolidWorks then a FEA Analysis is done using Ansys R18.1. For various loads under static condition. Stresses and deformation are obtained and the viability of carbon-flax material is checked for motorcycle frame.

## 2. OBJECTIVE

I. Designing and analyzing a 3-D model of Double Cradle motorbike frame by applying several static loads for steel.

II. Optimization for weight reduction to be done by replacing the existing steel material with light weight material i.e. Carbon-flax hybrid composite.

III. Designing and analyzing a 3-D model of Double Cradle motorbike frame by applying several static loads for Carbon-flax hybrid composite.

## 3. MATERIAL PROPERTIES AND DESIGN SPECIFICATIONS

**3.1 Material property-** Carbon-flax hybrid composite is formed by hybridization of flax which is a natural fiber which offer low density and having better ecological properties. Natural composites offer low density and better damping property. High strength and stiffness and could be used as substitute to conventional steel. Here typical sandwich structure composite is used for this purpose. Natural Flax fiber is sandwiched with carbon fiber.

**Table -1:** Physical properties of steel and carbon-flax hybrid composite

| Physical Properties | Steel | Carbon-flax Hybrid composite[1] |
|---|---|---|
| Youngs modulus(GPa) | 210 | 27.6 |
| Shear modulus(GPa) | 79.3 | - |
| Tensile strength(MPa) | 550 | 345 |
| Compressive strength(MPa) | 427.6 | 343 |
| Poisson's ratio | 0.3 | 0.45 |
| Specific Mass(kg/dm$^3$) | 7.8 | 1.5 |

**3.2 Design specification-** Yamaha FZ is used for this project having following specifications.

**Table-2:**Engine specifications [2]

| | |
|---|---|
| Displacement (CC) | 149 cc |
| Max power | 13.2 Ps @ 8000 rpm |
| Max torque | 12.8 Ps @ 6000 rpm |
| Bore | 57.3 mm |
| Stroke | 57.9 mm |
| Valve per cylinder | 2 |
| Fuel delivery system | Fuel Injection |
| Fuel type | Petrol |

**Table-3:** Weight and Dimension[2]

| | |
|---|---|
| Length *Height*Width | 2073 x 700 x 1050 |
| Wheel base | 1330 mm |
| Ground clearance | 160 mm |
| Kerb weight | 150 Kg |
| Fuel capacity | 12 L |

## 4. MODELLING AND ANALYSIS

**4.1 Modelling of bike frame-** A 3-d model of the motorcycle frame is being prepared with a few changes in the original design.

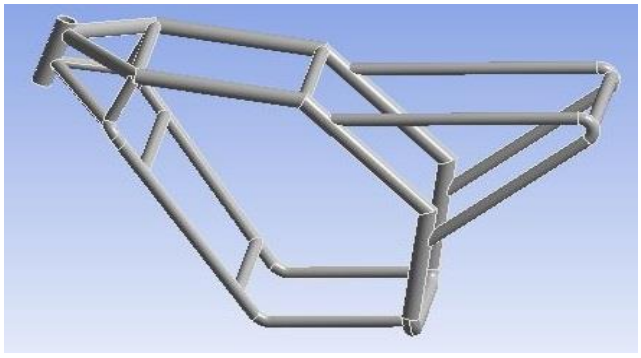

**Fig-1:** CAD model of motorcycle frame

**4.2 Analysis-** Finite element analysis is done using ANSYS. Firstly, the existing design having steel as the material is analyzed. For this the CAD model is imported to ANSYS, after which certain boundary conditions are fixed along with static load. Meshing is of the designed structure is done.

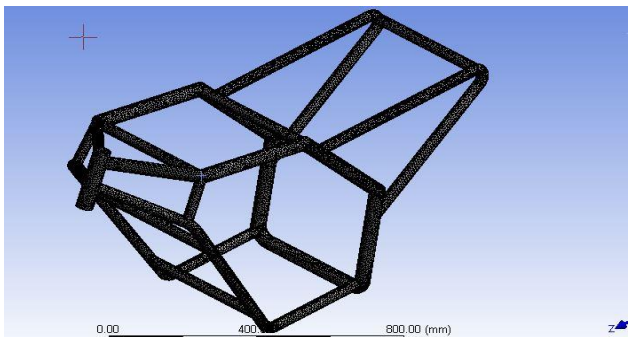


**Fig-2:** Meshing of frame.

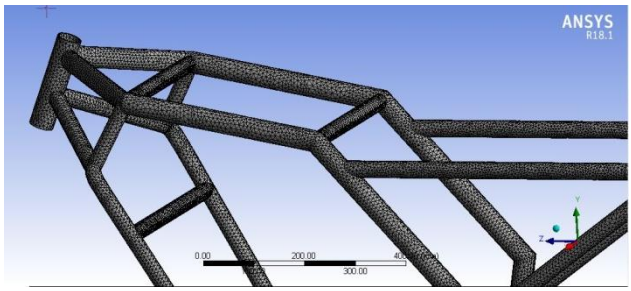


**Fig-3:** Detailed view of meshing

Total number of nodes 225809 and total elements are 129632. There are two fixed supports and three boundary conditions.

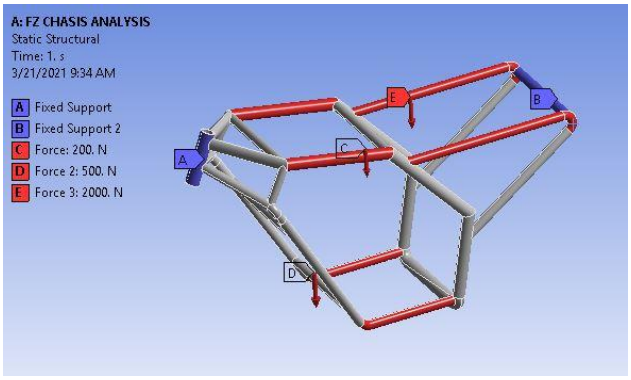


**Fig -4:** Fixed support and boundary conditions.

Boundary conditions are rider weight(2000N), fuel tank (200N), engine weight(500N). After applying all the condition final FEM is used to analyze the frame to find the von-misses stresses and total deformation for steel and Carbon-flax hybrid composite respectively.

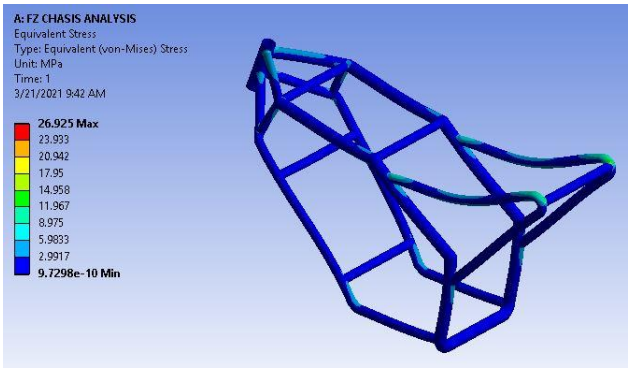


**Fig-4:** Von-misses stress for steel.

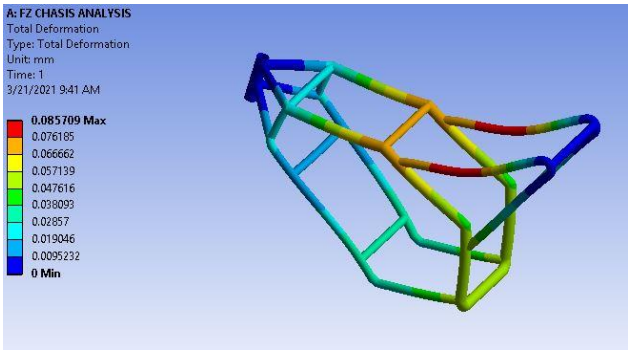


**Fig-5:** Total deformation for steel.

It is evident from the analysis that design is stable and safe for steel under provided condition. Now the above conditions are applied by replacing the material of bike from steel to Carbon-flax hybrid composite.

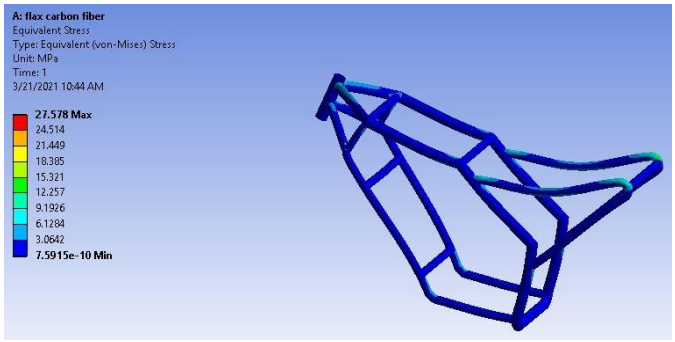


**Fig-6:**Von-misses stress for Carbon-flax hybrid composite.

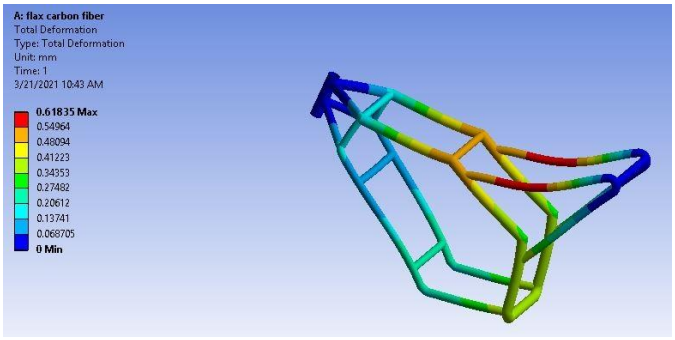


Fig-7: Total deformation for carbon-flax hybrid composite

### 4.3 Results

**Table-4:** Results of analysis

| Material | Von-Misses stresses | Total Deformation | Maximum permissible stresses | FOS |
|---|---|---|---|---|
| Steel | 26.925MPa | 0.085709mm | 250MPa | 9.28 |
| Carbon-flax hybrid composite | 27.578MPa | 0.61835mm | 145MPa | 5.25 |

### 4.4 Discussion

Above finite element analysis shows that the Von-misses stress are low for steel which proves that it has better strength but it is also evident that Carbon is approximately at par in strength with a 2.4253% difference in von-misses stresses. We found a little more deformation in the composite but is not a matter of concern as it is in the permissible limit. A 0.532641 mm shows that composite deforms more under stress in comparison to steel.

## 5. CONCLUSION

It is concluded that carbon-flax hybrid composite is a light material composite is at par to steel in strength. Deformation is a concern for carbon-flax hybrid composite, it can be seen that the maximum deformation is occurring at the riders tube, Which can be improved by providing an extra rod support from below. FOS of 5.25 is decent and motorcycle frame can be designed on it but when compared to steel which is having FOS of 9.28 ,it is low. It is concluded that carbon-flax hybrid composite can sustain the load of rider, fuel tank and engines and have sufficient rigidity to be intact as a motorcycle frame. As it is lighter as compared to steel hence it will be less fuel consuming. Carbon-Flax hybrid composite is used in several automobile parts, in making high strength sport gears can be used for making motorcycle Frame.

## REFERENCES

[1] M.Rouway, M.Nachtane, M.Tarfaoui, N.Chakhchaoui, LH.Omari, F.Fraija, O.Cherkaoui, " Prediction of Mechanical Performance of Natural Fibers Polypropylene Composites: A comparison study". International conference on advances in Energy Technology, Environment IOP Conf. Series: Materials Science And Engineering 948(2020) 012031 doi:10.1088/1757-899X/948/1/012031

[2] Mr. Inzamam Mulla, Prof. A. M. Qureshi, "Design Analysis And Optimization of Two-wheeler Chassis for Weight Reduction", International Research Journal of Engineering and Technology (IRJET) Volume: 06 Issue: 06 | June 2019. e-ISSN: 2395-0056, p-ISSN: 2395-0072

[3] Madina Shamsuyeva , Ole Hansen, and Hans-Josef Endres, "Review on Hybrid Carbon/Flax Composites and Their Properties". Hindawi, International Journal of Polymer Science, Volume 2019, Article ID 9624670, 17 pages, https://doi.org/10.1155/2019/9624670.

[4] Ali Amiri, Taylor Krosbakken, William Schoen, Dennis Theisen and Chad A Ulven," Design and Manufacturing of a Hybrid Flax/Carbon Fiber Composite Bicycle Frame", Journal of Sports and Engineering and Technology Proc| MechE part Part P: J sports engineering and technology1-11 | MechE 2017 DOI:10.1177/1754337117716237.

[5] Prakash Katdare, S.C.Shilwant, "Design Optimization of Two Wheeler (Bike) Chassis", International Engineering Research Journal (IERJ) Special Issue 2 Page 4273-4277, 2015, ISSN 2395-1621.