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Design and Development of Effective Low Weight Racing Bicycle Frame

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ABSTRACT: A Bi-cycle frame is prominent part in whole racing cycle system which is subjected to static and dynamic loads. The dependency of the performance is directly proportionate to weight of the cycle and frame structural design, Optimization of weight and structure of the frame is the best scope of optimizing the overall performance of the racing cycle, A monocoque design is advisable in racing utility hence we are targeting towards composite design and how its frame can be optimizes by using static and dynamic FEA Analysis .using the knowledge from literature review, we can know how the CAD model is prepared.

KEYWORDS: Bicycle frame, weight Optimization, Design of frame, Alternate Material.

I. INTRODUCTION

A Bi-cycle frame should have low weight, high lateral stiffness and moderate vertical stiffness. Because of chain load, frame lateral deformation during pedalling is bigger when the rider pushes on right pedal (a pro rider may apply a force up to two times his weight). Most of the bicycles built today utilize heat treated steel or aluminium or titanium alloy tubing to minimize their weight. The tubes are then welded together to create the desired fork or frame geometry. It is Notable part in whole racing cycle system which is subjected to static and dynamic loads.

Historically, the most common material for the tubes of a bicycle frame has been steel. Steel frames can be very inexpensive carbon steel to highly specialize using high performance alloys. Frames can also be made from aluminium alloys, titanium, carbon fibre, and even bamboo and cardboard. Occasionally, diamond (shaped) frames have been formed from sections other than tubes. These include I-beams and monocoque.

We will also obtain the knowledge how to make a finite element model in Hyper mesh by going through literature papers. The conditions required for applying various Constraints and how the loads are applied is briefed about in the technical papers referred. By using composite materials we can reduce the cost of cycle. Reverse engineer and extract dimension of frame Make a 2D model of Chassis, Designing the chassis using CATIA V5R19. Get the exact parameters of the material used.

Meshing the CAD model, Apply the Boundary conditions, Solve for the solution of meshed model using ANSYS '14. Re-Sequence of the above procedure with new composite material & optimized design and Result comparison Using the results achieved with two different materials the suitable material is selected. The Chassis with composite material is performing better with a satisfying amount of weight reduction. The weight reduction will hence lead to better manoeuvrability and performance of the vehicle. After analytical and virtual analysis fabrication of the frame will be developed through literature review.

A test base has to set up in hydro pneumatic press by application of which loads will be provided on particular loading points and hence forth stress and deformation on the frame will be noted. The validation of the results will be performed by comparing analytical results with technical issued papers. And Experimental results will be compares through results achieved through Ansys results. An additional impact test analysis will be validated through LS Dyane Analysis and Technical literatures.

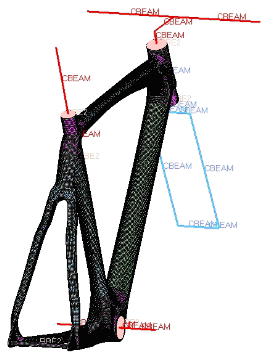

Fig.1 General Structure of bicycle frame

II. PROCESS METHODOLOGY

This gives us how we can use the size optimization, shape optimization, topology optimization. Below block diagram shows how we can use these techniques to improve the design and its shape. Let's see these one by one.

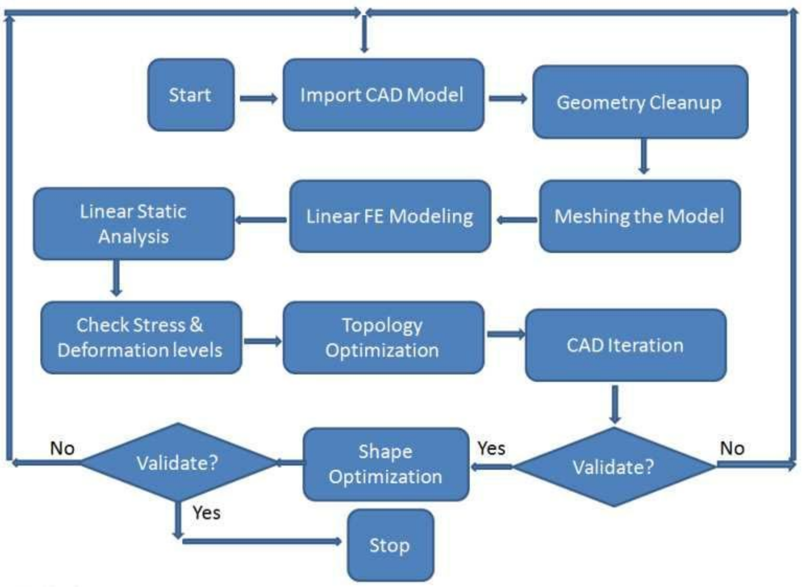

Fig.2 Methodology

1. Material Selection

As per the material survey the best suited material is the aluminium alloy. The mentioned material was chosen as the material for bicycle frame due to its low density and compatible yield strength. This material was chosen for designing frame and comparing its results with different materials as mild steel, EN8 etc. Thus this paper focuses on optimizing bicycle frame. Table1 and table2 indicates the material properties considered.

Optional Material

1. Al-6061-magnesiam and Silicon Major Alloying Element-density 2.70g/Cm^3.
2. Al-7005-Zinc-density-2.78g/cm^3- depending on the temper, may be slightly stronger.

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3. Bamboo fibre based composite material. [BF (30%) + PP]
Chemical Composition

Chemical Composition	Si	Fe	Cu	M_n	Mg	Cr	Zn	Ti	Al
Al6061	0.62	0.23	0.22	0.03	0.84	0.22	0.10	0.1	Bal
Al7075	0.4	0.5	1.6	0.3	2.5	0.15	5.5	0.2	Bal

Table.1 Chemical composition

Comparison of properties

Material	Density (g/cm3)	Young's Modulus (GPa)	Yield Strength (MPa)
Mild Steel	7.83	210	280-310
Al 6061	2.70	69	64-350
Al 7005	2.78	71	95-345

Table.2 Comparison of mechanical properties

2. Designing a CAD model-
Required CAD was developed using 3-D modelling software. The cad geometry has basic requirement for Head tube, top tube, bottom tube, chain stays, seat stays, bottom bracket shell and the two triangles commonly says diamond frame. This is the model of the bicycle frame. A bicycle frame is the main component of a bicycle, onto which wheels and other components are fitted. The modern and most common frame design for an upright bicycle is based on the safety bicycle, and consists of two triangles, a main triangle and a paired rear triangle. This is known as the diamond frame. Frames are required to be strong, stiff and light, which they do by combining different materials and shapes.

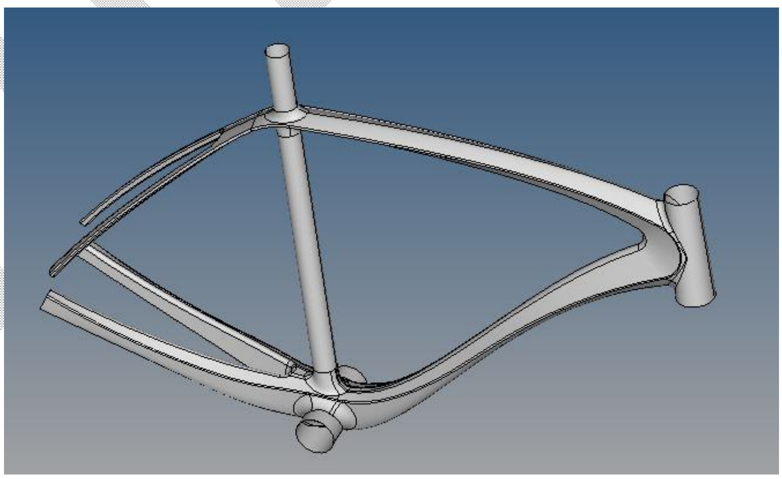

Fig.3 CAD model

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3. Meshing-

Geometry clean up was performed prior to meshing the model. Finite element model was developed using Hyper Works.

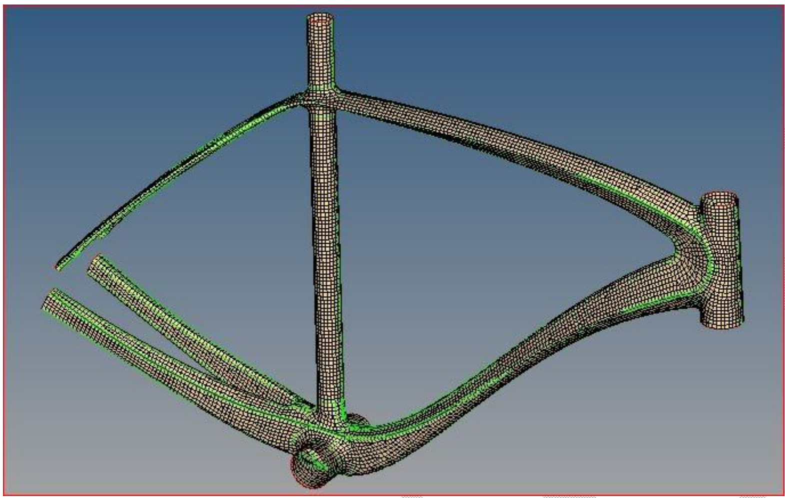

Fig.4 Meshed model

For better quality mesh combination of first and second order tetra elements were used. Surface meshing using triangular elements was performed to achieve better control on the meshing. Further this mesh was converted into a tetra mesh. Selective tetra elements were converted into second order and selective regions were finely meshed using first order elements controlling the number of nodes formed.

4. Preliminary analysis-

a) Static start up

A 700N rider is applying maximum effort to accelerate from a standing stop. Aerodynamic, rolling, and gyroscopic forces are assumed negligible. The bicycle is in vertical equilibrium with the front wheel pointed straight.

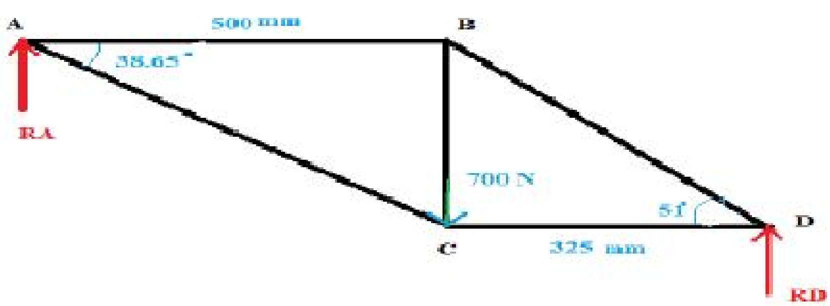

Fig.5 Static start up

b) Steady State Pedalling

A 700n Cyclist Seated On Bicycle and Is Assumed That Forces Due To Leg Dynamics 200n Force Applied At Pedal.

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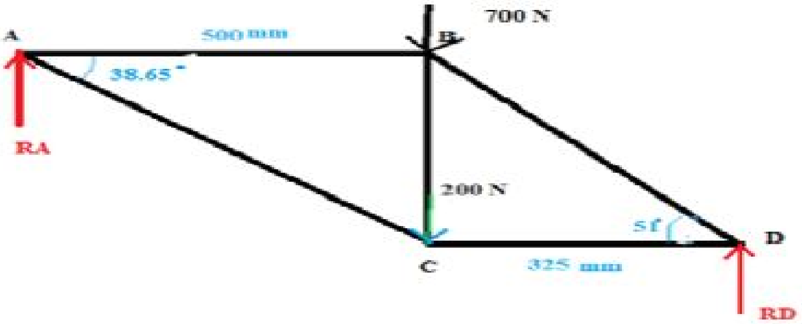

Fig.6 Steady State Pedalling

c) Vertical Impact

Vertical impact loads are represented by, multiplying the rider's weight by a certain 'G' factor. As a interest, an object dropped from an infinitesimal height onto a rigid surface would exert a two G impact load, assuming total energy transfer.

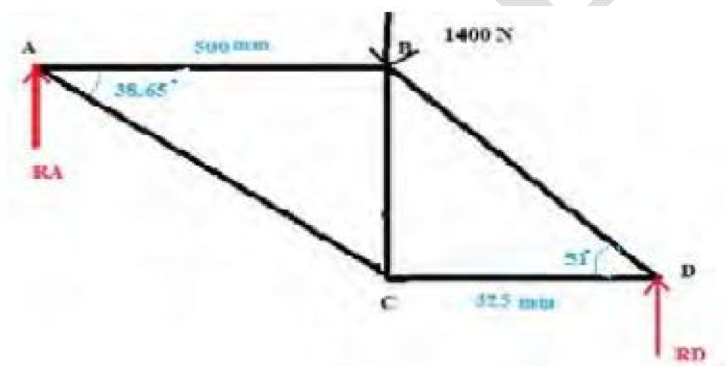

Fig.7 Vertical Impact

d) Horizontal Impact

The effect might be similar to low speed, head on collision on to a wall or curb. A load of 980N is applied to the front dropouts horizontally.

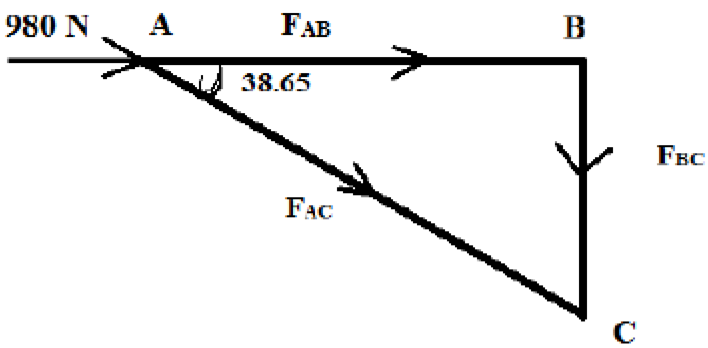

Fig.8 Horizontal Impact

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e) Rear Wheel Breaking

It is assumed that the tire skidding and thus rear pitch over is imminent, therefore all weight is concentrated on the rear wheel. Inertia load caused by deceleration are include in the analysis.

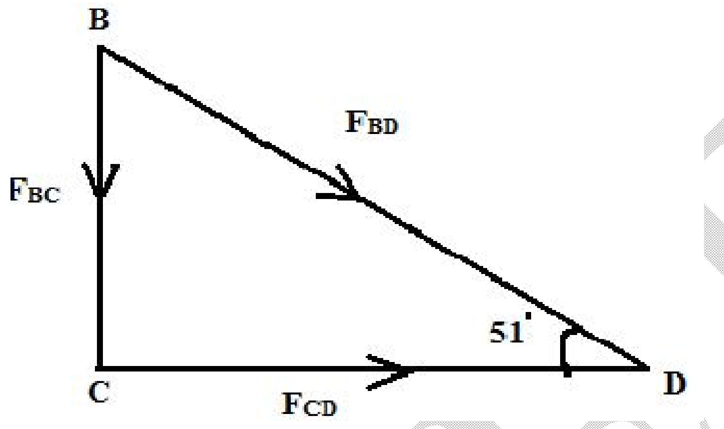

Fig.9 Rear Wheel Breaking

III. ANALYTICAL RESULTS

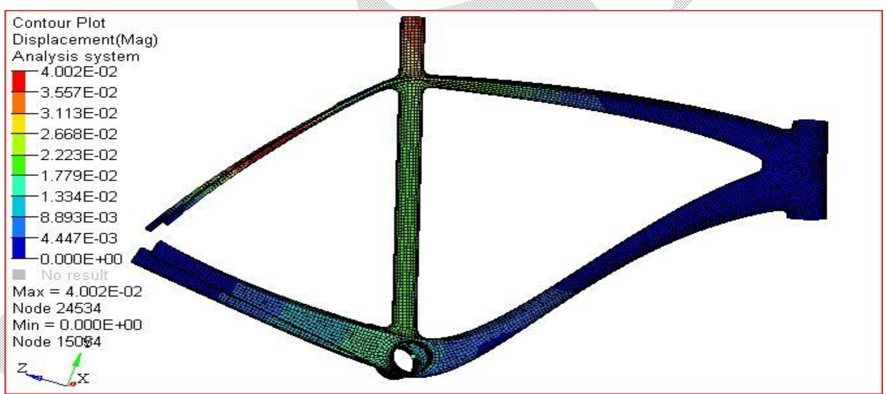

Fig.10 Analytical results

This is the analysis done using Ansys software. So we got the satisfactory results for this model except the onlu issue is the density of material is high. Several properties of a material help decide whether it is appropriate in the construction of a bicycle frame:

1. Density (or specific gravity) is a measure of how light or heavy the material per unit volume.
2. Stiffness (or elastic modulus) can in theory affect the ride comfort and power transmission efficiency. In practice, because even a very flexible frame is much more stiff than the tires and saddle, ride comfort is in the end more a factor of saddle choice, frame geometry, tire choice, and bicycle fit. Lateral stiffness is far more difficult to achieve because of the narrow profile of a frame, and too much flexibility can affect power transmission, primarily through tire scrub on the road due to rear triangle distortion, brakes rubbing on the rims and the chain rubbing on gear mechanisms. In extreme cases gears can change themselves when the rider applies high torque out of the saddle.

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3. Yield strength determines how much force is needed to permanently deform the material (for crash-worthiness).
4. Elongation determines how much deformity the material allows before cracking (for crash-worthiness

IV. CONCLUSION

A good result is found for the existing material. Results of all case reveals that the maximum stresses in the member of bicycle frame in top tube is which is less than yield strength in tension for the material selected i.e. Mild steel . So there is also scope to reduce the weight of the frame by considering the current stresses obtained.

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