# Design and Analysis of Elliptical Bicycle Frame

Ajith Arul Daniel S[1*], Manikandan AR[2],Vijay Ananth. S[1],Parthiban A[1]
[1]*Department of Mechanical Engineering, Vels Institute of Science, Technology & Advanced Studies – 600117- Chennai, India.*
[2]*Department off Mechanical Engineering, Agni College of Technology, Chennai 603103, India*

*Corresponding Author Mail id: ajith_danny@yahoo.com
Ph No +91 9489600652

***Abstract***

*Bicycle plays an important role in our life. It is one of the economic transport in worldwide. Now a days people are using bicycle for exercising. The new developments have been coming in the designing of bicycle. To reduce the weight and increase the strength of the bicycle more amount of research is going on. Bicycle frames are main load carrier in the bicycle. By optimizing the design parameters of the frame will improve the bicycle performance. The optimum design will reduce the weight of the bicycle and increase the strength. In this paper a new design has been developed for the bicycle frame. The shape of the frame is in elliptical form. The model were designed and analyzed in CATIA. Finally, the analyzed frames are then optimized to reduce weight without affecting their capacity to be resistant to mechanical stresses.*

***Keywords:*** *FEA, composite material, Design Optimization, Modal Analysis.*

## 1. Introduction

The Elite Cycle is an elliptical bicycle. By modifying the elliptical trainer motion and combining it with the functionality of a bicycle, the Elite Cycle delivers a high performance workout experience that closely mimics running outdoors while eliminating the impact. It provides the most comfortable, fun and efficient way to get out and stay active. The Elite Cycle is perfect for anyone who wants to get a great cardiovascular workout outdoors without damaging their body. It is particularly well-suited for runners who want to enjoy a running-like experience while giving their knees and joints a break from the wear and tear caused by running. The Elite cycle is also ideal for cyclists who want to get the experience of cycling without the discomfort caused by sitting on a conventional bike seat or riding in a hunched-over position. The Elite Cycle is easy to ride and more stable than it looks. Riding an Elite Cycle requires the same amount of balance as is required to ride a traditional bike or scooter. Like anything new and different, it takes some getting used to, but we've found that most people get comfortable within 5 minutes of riding it. Elite Cycle is very different from a traditional bicycle. Traditional bicycles usually have a big seat with a back rest whereas it has no seat at all. The traditional bicycle rider pedals with the legs parallel to the ground while the Elite Cycle rider's legs are perpendicular to the ground standing up and pedalling and rider stands for the whole time. The traditional bicycle rider's visibility is usually limited because they are lower to the ground making it, both harder to see them and harder for them to see around obstacles like cars, busses, trucks etc. In

## 2. Process Methodology

This mechanical setup consist of a frame a handle bar and a connecting rod. When compare to a common bicycle our proposed model has some modification to provide an rotating motion to the wheel with less human power when compare to an ordinary bicycle .so we modify the sprocket system which is kept slightly towards rear end so the person give less effort to pedal the cycle. By walking action the torque is transmitted to the sprocket and the wheels. For joining process we are using arc welding and linear bearings are used here to give smooth rotation to the pedal and connecting rods.

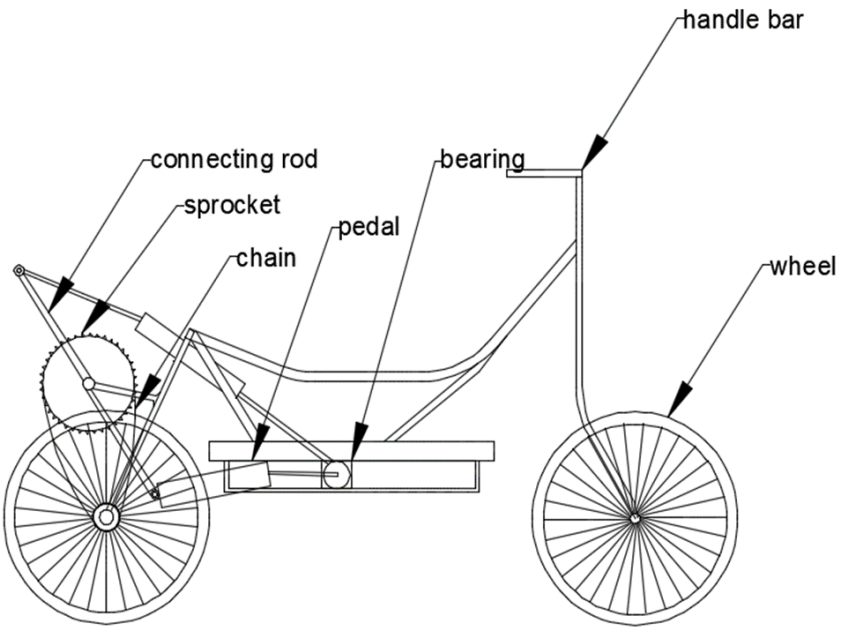



**Figure 2.1 Model Bicycle Frame**

## 2.1 Frame

A bicycle frame is the main component of a bicycle, on to 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.

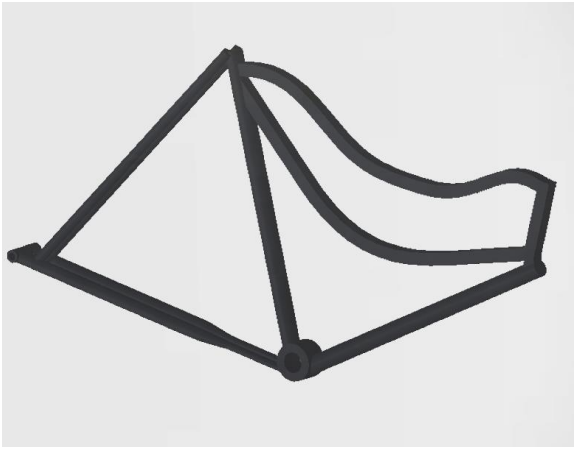


**Figure 2.2 Developed Bicycle Frame**

## 2.2Design of Chain:

Chain selected using this method will have a minimum life expectancy with proper installation and lubrication of 15000 hours. The calculations for determining the length of chain as per the assumed data as follows
Where,

Z1= Number of teeth on drive sprocket (i.e. Z1= 13),
Z2= Number of teeth on driven sprocket (i.e. Z2= 57),
f1= Application factor (i.e. f1=1),
f2= Tooth factor (i.e. f2=1),
p= Chain pitch (i.e. p= 0.5),
C= Centre distance between drive and driven sprocket (i.e. C=13inch), A bearing is a machine element that constrains relative motion to only the desired motion, and reduces friction between moving parts. The design of the bearing may, for example, provide for free linear movement of the moving part or for free rotation around a fixed axis; or, it may prevent a motion by controlling the vectors of normal forces that bear on the moving parts. Most bearings facilitate the desired motion by minimizing friction. Bearings are classified broadly according to the type of operation, the motions allowed, or to the directions of the loads (forces) applied to the parts.Bearing No. 6202 (Data book page.no 4.13)

**Table 2.1 Bearing Specification**

| | |
|---|---|
| Outer Diameter of Bearing (D) | 35 mm |
| Thickness of Bearing (B) | 12 mm |
| Inner Diameter of the Bearing (d) = 15 mm | 15 mm |
| $r_1$ = Corner radii on shaft and housing | |
| $r_1$ = 1(From design data book) | |
| Maximum Speed = 14,000 rpm (From design data book) | |
| Mean Diameter (dm) = 2S=25mm | (D + d) / 2=(35 + 15) / |

## 2.3 Wheel

A bicycle wheel is a wheel, most commonly a wire wheel, designed for a bicycle. A pair is often called a wheel set, especially in the context of ready built "off the shelf" performance-oriented wheels. Bicycle wheels are typically designed to fit into the frame and fork via dropouts, and hold bicycle tires. A typical modern wheel has a metal hub, wire tension spokes and a metal or carbon fibre rim which holds a pneumatic rubber tire.

## 2.4 Hub

A hub is the centre part of a bicycle wheel. It consists of an axle, bearings and a hub shell. The hub shell typically has two machined metal flanges to which spokes can be attached. Hub shells can be one-piece with press-in cartridge or free bearings or, in the case of older designs, the flanges may be affixed to a separate hub shell.

## 2.5 Axle

The axle is attached to dropouts on the fork or the frame. The axle can attach using a: Quick release - a lever and skewer that pass through a hollow axle designed to allow for installation and removal of the wheel without any tools (found on most modern road bikes and some mountain bikes). Nut - the axle is threaded and protrudes past the sides of the fork/frame. (often found on track, fixed gear, single speed, BMX and inexpensive bikes)

# 3. Result and Discussion

## 3.1 Designing of the Model

Required CAD model was developed using 3-D modelling software (i.e. CATIA V5). The cad geometry has basic requirement for Head tube, top tube, bottom tube, chain stays, bottom bracket shell and the two elliptical arcs commonly known as elliptical 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. Frames are required to be strong, stiff and light, which they do by combining different materials and shapes.

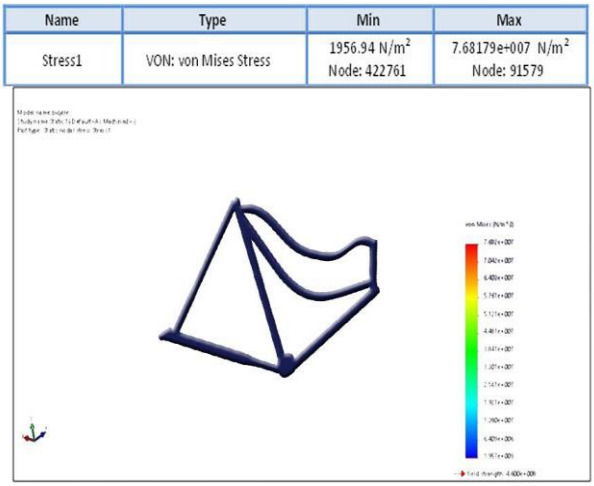
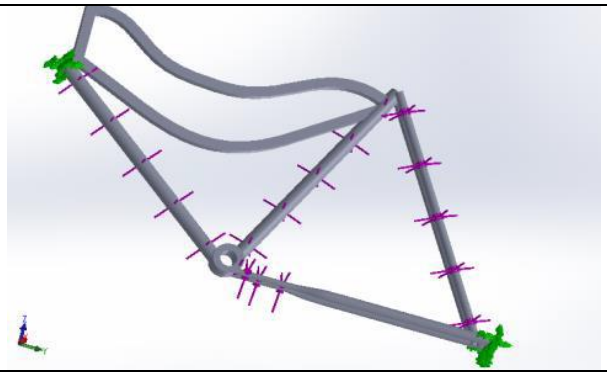



**Figure 3.1Meshed Model**

## 3.2 Meshing

For better quality mesh combination of first and second order tetra elements are to used. Surface meshing using triangular elements is to be performed to achieve better control on the meshing. Further this mesh will be converted into a tetra mesh. Selective tetra elements will be converted into second order and selective regions will be finely meshed using first order elements controlling the number of nodes formed. The above figure shows the completely meshed frame of the bicycle during the frame analysis with the information regarding the mesh size, element size and number of Jacobian points used

**Table 3.1 Mesh control details**

| Mesh Control Name | Mesh Control Image | Mesh Control Details |
|---|---|---|
| Control-1 |  | **Entities: 15 face(s)**<br>**Units: mm**<br>**Size: 2.99417 Ratio: 1.5** |

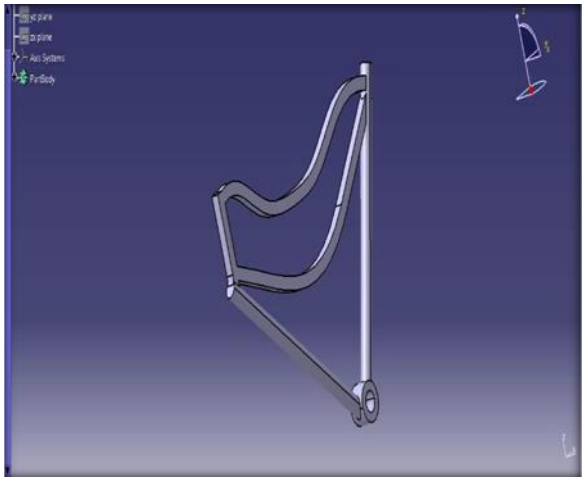


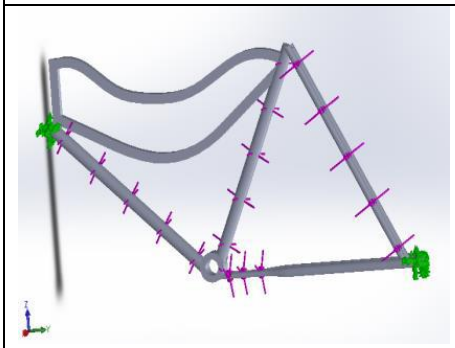
**Fig 3.2 Model of Frame**

## 3.3 Frame Analysis:-

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 stiffer 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.

**Table 3.2 Material information during frame analysis.**

| Model Reference | Properties | | Components |
|---|---|---|---|
|  | Name: | AISI 4130 Steel, normalized at 870C Isotropic | SolidBody 1(Combine20)(bicycle) |
| | Default failure criterion: | Max von Mises Stress | |
| | Yield strength: | 7.31e+008 N/m2 | |
| | Tensile strength: | 2.05e+011 N/m2 | |
| | Elastic modulus: | 0.285 | |
| | | 7850 kg/m3 | |
| | Poisson's ratio: | 8e+010 N/m2 | |

## 4. Conclusions

This project work has provided us an excellent opportunity and experience, to use our limited knowledge. We gained a lot of practical knowledge regarding, planning, purchasing, assembling and machining while doing this project work. We feel that the project work is a good solution to bridge the gates between institution and industries. We are proud that we have completed the work with the limited time successfully. The "FABRICATION OF ELITE CYCLE" is working with satisfactory conditions. We are able to understand the difficulties in maintaining the tolerances and also quality. We have done to our ability and skill making maximum use of available facilities. In conclusion remarks of our project work, let us add a few more lines about our impression project work. Thus we have developed a "FABRICATION OF ELITE CYCLE" which helps to know how to achieve low cost automation. The operating procedure of this system is very simple, so any person can operate. By using more techniques, they can be modified and developed according to the applications.

## 5. REFERENCES

[1] SagarPardeshi, PankajDesle "Design and Development of Effective Low Weight Racing Bicycle Frame", International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET).

[2] Matthew N. Godo, David Corson, Steve M. Legensky, "A Practical Analysis of Unsteady Flow Around a Bicycle Wheel, Fork and Partial Frame Using CFD" American Institute of Aeronautics and Astronautics.

[3] Shih-Wen Hsiao, Rong-Qi Chen, Wan-Lee Leng, "Applying riding-posture optimization on bicycle frame design" Department of Industrial Design, National Cheng Kung University, Tainan 70101, Taiwan, ROC

[4] Henri P. Gavin, "Bicycle Wheel Spoke Patterns and Spoke Fatigue", ASCE Journal of Engineering Mechanics, vol 122, no. 8, (August 1996) pp. 736–742.

[5] Peveler, W.W., Pounders, J.D., Bishop, P.A., 2007. Effects of saddle height on anaerobic power production in cycling.

[6]David Stevens, "The Stability and Handling Characteristics of Bicycles", The University of New South Wales, School of Mechanical and Manufacturing Engineering.

[7] Astrom, K.J., Klein, R.E. &Lennartsson, A. 2005, "Bicycle dynamics and control: Adapted bicycles for education and research". IEEE Control Systems Magazine 25(4), 26–47.

[8] Kooijman J. D., Schwab, A.L., J.P. Meijaard, J.P., 2006. "Experimental Validation of a Model for the Motion of an Uncontrolled Bicycle", MultibodySystDyn (2008) 19:115–132, Springer Science+Business Media, Inc. 29

[9] Papadopoulos, J. M. 1987, "Bicycle steering dynamics and self-stability: A summary report on work in progress", Technical report, Cornell Bicycle Research Project, Cornell University.

[11] Whipple, F. J. W. 1899, The Stability of the Motion of a Bicycle". The Quarterly. Journal of Pure and Applied Mathematics 30.