Performance Analysis of ISO-TRUSS Bicycle Frame

Shaikh Mohd Zuber[1], M.Shakebuddin[2]
[1]Dept of Mechanical Engineering
[2]Assistant Professor, Dept of Mechanical Engineering
[1, 2] Anjuman college of Engineering, Nagpur

Abstract- *The Aim of this project is to design a bicycle frame to minimize the mass of the frame, and to improve comfort, maximizing lateral stiffness in the load transfer maximizing the strength capabilities of the frame to allow for a higher load capacity or better load distribution, that are needed to provide the rider comfort and safety. The aim is to determine the load capacity of the bicycle frame. To find the stress concentration and week portions of the bicycle frame. By analyzing the conventional bicycle frame and the strength and capability of the product, new frame will be designed using ISO-TRUSS so as to reduce the weight and maximize the strength.*

Keywords– ISO-TRUSS, Bicycle Frame, ABS Material, Eight-Node Structure

I. INTRODUCTION

Throughout the history of cycling, there have been constant improvements in design of cycle frame on technologies. Most improvements through the years have been modifications to layout of the mechanisms on the bicycle. This includes overall shape of the Cycle, design of a frame structure, and material improvements. A bicycle frame is the main component of a bicycle, onto which wheels and other components are fitted. Strength has been gaining importance in the design of bicycle frame.

The innovation in the design of bicycle frame is still going on, the reason behind this is that the manufacturers and construction designers have innovative ideas related to minimize aerodynamic drag, to improve comfort, minimizing the mass of the frame, maximizing lateral stiffness in the load transfer from the hands and feet to the drive, maximizing the strength capabilities of the frame to allow for a higher load capacity or better load distribution, and adjusting the vertical compliance of the frame to tune the softness of the ride [1,2] that are needed to provide rider comfort and safety ride.

An Iso Truss_ structure is a three-dimensional tubular circumferentially and longitudinally periodic grid structure that is particularly well suited for fabrication with advanced composite materials, such as carbon fiber, Kevlar_ fiber, or fiberglass, with epoxy, vinyl ester, polyester, or polyurethane resins. These structures exhibit tremendous performance per unit structural weight. Fig. 1 identifies the basic geometric parameters of an Iso Truss_ with 8 nodes, although the number of nodes is arbitrary. A longitudinal member is a straight member parallel to the length of the Iso Truss_. The longitudinal members of the Iso Truss_ carry the axial and bending loads. A helical member is a piecewise linear member spiraling around the longitudinal axis. The helical members resist torsion and shear loads and improve the compressive strength of the Iso Truss_ by decreasing the buckling length of the longitudinal.

They have unique advantages over monolithic materials, such as high strength, high stiffness, long fatigue life, low density, corrosion resistance, wear resistance, and environmental stability.

A bicycle, often called a bike or cycle, is a human-powered, pedal-driven, single-track vehicle, having two wheels attached to a frame, one behind the other. The bicycle has undergone continual adaptation and improvement since its inception. These innovations have continued with the advent of modern materials and computer-aided design, allowing for a proliferation of specialized bicycle types. Bicycles can be categorized in many different ways: by function, by number of riders, by general construction, by gearing or by means of propulsion. The more common types include utility bicycles, mountain bicycles, racing bicycles, touring bicycles, hybrid bicycles, cruiser bicycles, and BMX bikes. Less common are tandems, low riders, tall bikes, fixed gear, folding models, amphibious bicycles and recumbents. Unicycles, tricycles and quadra-cycles are not strictly bicycles, as they have respectively one, three and four wheels, but are often referred to informally as "bikes". The bicycle is extraordinarily efficient in both biological and mechanical terms. The bicycle is the most efficient human-powered means of transportation in terms of energy a person must expend to travel a given distance. From a mechanical viewpoint, up to 99% of the energy delivered by the rider into the pedals is transmitted to the wheels, although the use of gearing mechanisms may reduce this by 10–15%. In terms of the ratio of cargo weight a bicycle can carry to total weight, it is also an efficient means of cargo transportation.

II. LITERATURE REVIEW

1) Mangesh S. Gavade, S. Roy , S. H. Barhatte and S. S. Mujumdar

The paper discusses tensile load carrying capacity of an open lattice structure Iso Truss through finite element modeling and analysis. Iso Truss is Web like structure consisting of isosceles triangle within the geometry of its structure. Iso Truss provides a light weight structure when carbon fiber is used as the working material. The tensile strength of Iso Truss for two set of position of longitudinal members with respect to bay length is studied. The study concludes that Iso Truss with internal and external longitudinal members carry more tensile load compared to the Iso Truss with only internal longitudinal member. Also the Strength to Weight ratio for Iso Truss with internal and external longitudinal is higher than Iso Truss with only internal longitudinal members.

2) Bharati A. Tayade, T.R.Deshmukh

This paper deals with the various design of bicycle frame. The modelling of bicycle frame is done in Computer Aided Design software CATIA and analysis of frame is done using the analysis software Ansys. This analysis is done by considering conditions like static start up, steady state paddling, vertical impact, horizontal impact, rear wheel braking etc. This paper gives us the stress, strain, factor of safety of particular bicycle frame.

The work presented by Derek Covill, et.al. Outlined a FE model using beam elements to represent a standard road bicycle frame. The model simulates two standard loading conditions to quantify the vertical compliance and lateral stiffness characteristics of 82 existing bicycle frames recently in 2014, M. V. Pazare deals with the stress analysis of bicycle frame by using Finite Element Method. The analysis of frame is carried out in ANSYS software, and the F.E.A. results are compared with theoretical results. And it is found that there is good agreement between analytical and F.EA results.

3) Knipppers, Cremers, Gabler, Liehard

The objective of this project is to study the strength comparison of composites (HT Graphite epoxy, S-Glass Epoxy) with Aluminum for both circular and elliptical cross-section of the frame member. The design of bicycle frame is modeled in Solid works software and the static analysis is done in ANSYS. The load is applied on frame as Static start up. With the help of results likewise Von-Misses stress, Von-Misses strain and Total Deformation, the best cross-sectional member with good material property of the frame is identified.

In this paper the Strength has been gaining importance in the design of bicycle frame. Composite materials which are composed of reinforced fibers and plastics matrix have high strength-to-weight and stiffness-to-weight ratios. They have unique advantages over monolithic materials, such as high strength, high stiffness, long fatigue life, low density, corrosion resistance, wear resistance, and environmental stability.

III. RESEARCH METHODOLOGY

The research methodology may be summarized as,

1) Objectives of work
2) Identification of Problems
3) Data Accumulation.
4) CAD Model Generation
5) Static Analysis of MH system Using FEA Approach.
6) Calculations.
8) Result Discussion.
9) Conclusion.

IV. PROBLEMS STATEMENT

A. Bicycle are popular form of recreation and transport for people. The goal of this project is to design a low weight bicycle frame for easy ride with maximum load conditions

V. FORMULATION AND CALCULATION

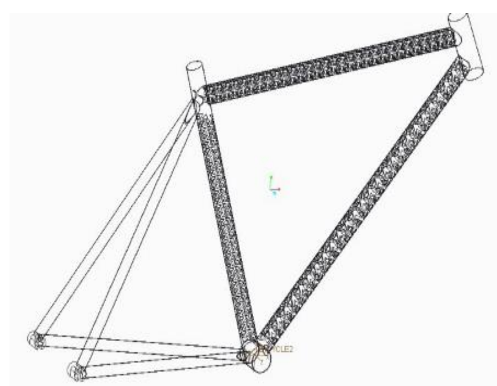

Fig Wire Diagram of Iso Truss Bicycle frame

1) <u>CASE1: Bending Moment Calculation</u>

Bending Moment = M/Z

M=W X L

W = 100 Kgf = 980.665N
L = 549 mm
M = 980.665 x 549 mm
M = 538380 N-mm

Z = 3.14/32 x Do x Do x Do x (1-K x K x K x K)

Do = Outer Diameter
Di = Inner Diameter

K = Di/Do

Z = 3.14/32 x 32 x 32 x 32 x (1 - 0.975 x 0.975 x 0.975 x 0.975)
Z = 309.83 mm3

Bending Moment = M/Z
Bending Moment = 538380/309.83

Bending Moment = 1737.66 N/mm2

1) CASE: Twisting Moment Calculation

Tmax = 3.14/16 x Shear Stress Do x Do x Do (1 – K x K x K x K)
Shear Stress = 10 Mpa.

Tmax = 3.14/16 x 10 x 32 x 32 x 32 x (1 – 0978 x 0.978 x 0.978 x 0.978)

Tmax = 6196 N-mm

VI. CAD MODEL

1) The CAD model for Iso Truss Bicycle frame is,

Fig4:

VII. FINITE ELEMENT ANALYSIS

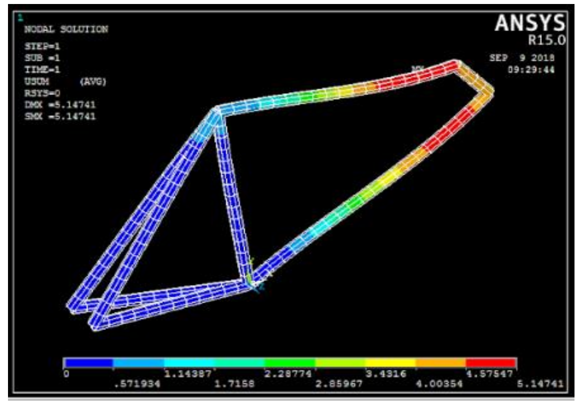

Fig7: Meshed model

VIII. CONCLUSION AND SUGGESTED FURTHER WORK

1). CONCLUSION.

In this case study, I found the appropriate solution for ISO Truss bicycle frame using the following approach.

First, deals with the literature in respect of simulation of static and dynamic analysis histories involved in the chassis design and analysis of bending, torsion and fatigue life analysis.

Secondly, it covers the some of the research work in the development of static and dynamic simulation of frame analysis for off - highway application with emphasis of on the prediction of fatigue life and stress distribution of the critical area.
It also covers some of the earlier works of modeling, design and analysis of an frame.

2). SUGGESTED FURTHER WORK.

Although a lot of work has been done to design a perfect standard design of Isotruss Bycycle frame, there still remains undeniable scope of future enhancement and improvement in this design. These improvements if pursued will lead to better operation, better design, and reduced cost, diverse application indifferent engineering fields. Thus with these benefits in sight, the scope of the future work on this Isotruss Bicycle frame cannot be ignored. Following are the list of activities that can be individually Or collectively carried out by researchers to achieve the above mentioned benefits.

1. The structure of the body can be designed with different material than structural steel such as

composites, this will reduce the weight of the body significantly.

2. Most of the times structures fail due to fatigue loading, hence there is a scope for improvement of the fatigue life of Iso truss bicycle frame.

REFERENCES

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[3] Knipppers, Cremers, Gabler, Liehard; *Numerical Study on Materials and Design Optimization of a Bicycle Frame*.