iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** VII **Month of publication:** July 2022

DOI: https://doi.org/10.22214/ijraset.2022.45550

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue VII July 2022- Available at www.ijraset.com

Study on Design and Analysis of In-Wheel Suspension System

Dr. B Nagaraju[1], I. Pavan Kumar[2], K N V S S Avinash[3], N Bhanu Prasad[4], A V Nagasai[5], A Prithvi[6], Md. Arshad Hussain[7]

[1]*Professor & Head of Department, Mechanical Department, Anil Neerukonda Institute of Technology & Sciences, Visakhapatnam-531162, A.P., India*

[4]*B.Tech, Mechanical Department, Anil Neerukonda Institute of Technology & Sciences, Visakhapatnam- 531162, A.P., India*

***Abstract:** In today's generation, fossil exploitation and fuel consumption has resulted to effects like global warming and pollution. And Bicycles are the best favorite choice when it comes to issues like health, environment and pollution. Several researches have been done in order to ride for the passenger comfortable over the years. Different variants have been developed for various applications like mountain bikes, commuter bikes and racing bikes. This paper presents the in-wheel suspension which is designed such that the suspension is integrated within the wheel for better comfort and higher shock-absorption purpose. Smooth ride is offered to you. Loop wheel springs are usually made up of a composite material carefully developed to offer optimum compression and lateral stability as well as strength and durability. The three loops in every wheel work along as a self-correcting system. This spring system between the hub and the rim of the wheel provides suspension that continuously adjusts to uneven terrain cushioning the rider from abnormalities in the road wheel. The spring configuration permits the torque to be transferred smoothly between the hub and the rim. For this paper the loopwheel is designed using C10 and C20 material in CATIA and the analysis is carried on in ANSYS Workbench 14.5 to determine the force acting in the wheel, the principle stresses and maximum deflection.*

***Keywords:** Loopwheel Suspension, Spring, Mild Steel*

I. INTRODUCTION

The first mechanically propelled two wheeled vehicle was build by Krikpatrick MacMillian, a Scottish blacksmith in 1839. In early 1860s, Frenchmen Pierre Michaux and Pierre Lallement took bicycle design in a new direction by adding a mechanical crank drive with pedals on a enlarged front wheel (the velocipede). Several inventions followed using rear-wheel drive, best known by rod-driven velocipede by Scotsman Thomas McCall in 1869.

From the beginning and still today, bicycles have been and are employed for many uses. In a utilitarian way, bicycles are used for transportation, bicycle commuting, and utility cycling. It can be used as a 'work horse', used by mail carriers, paramedics, police, messengers, and general delivery services. Military uses of bicycles include communications, reconnaissance, troop movement, supply of provisions, and patrol. The bicycle is also used for recreational purposes, such as bicycle touring, mountain biking, physical fitness, and play. Bicycle competition includes racing, BMX racing, track racing, criterium, roller racing, sportive and time trials. Bikes can be used for entertainment and pleasure, such as in organised mass rides, artistic cycling and freestyle BMX.

A. In-Wheel Suspension

The in-wheel suspension is one sort of suspension which has shock absorbers inside the wheel rim at an angle to every other. The in-wheel suspension provides a suspension effect much greater than the traditional telescopic suspension in bicycles. The spring permits the suspension to maneuver up once the wheel encounters a bump, and to quickly draw back down once the wheel passes the bump. The spring is often a coil of steel like most springs we're acquainted with, or it may well be a cylinder containing pressurized air. In either case, the more the spring it's compressed, a lot of force it takes to compress it, that is precisely what we'd like for a mountain-bike suspension. You do not wish the spring bottoming out after you land a giant jump. If the suspension were equipped with simply a spring, it might bounce up and down many times once every bump. Once compressed by a bump, a suspension needs how to dissipate the energy that's kept within the spring. The damper dissipates the energy and prevents the suspension from bouncing out of management.

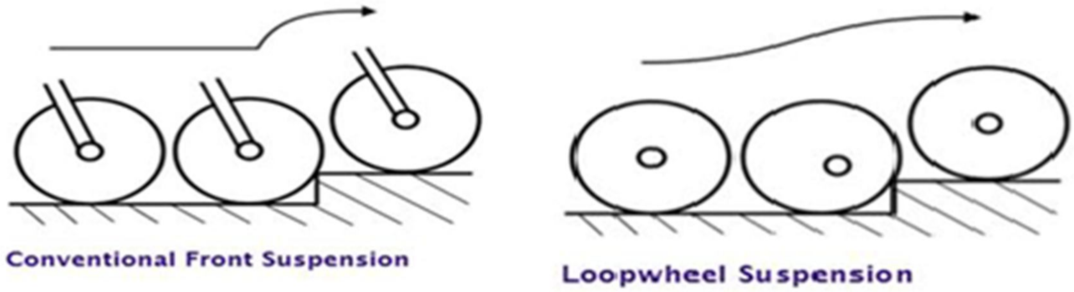

Figure 1: Conventional Wheel compared to Loopwheel

B. Mechanical Properties

The ability to classify and identify materials is crucial in the manufacturing industry. It helps you quickly choose the best materials for your design based on various factors including: load capacity, elasticity, hardness, strength and much more. The purpose of this article is to break down the mechanical properties that make each material unique. By becoming familiar with these terms, you'll be able to differentiate between materials and assess their usefulness for your design project.

C. Different Types of Materials

Most materials can be categorized into two types of materials: metals and non-metals. What are the two main types of metals? Ferrous and Non-ferrous metals The difference between ferrous and Non-ferrous metals is simple. Ferrous metals typically contain iron and other small materials and is often used in the mechanical industry, while non-ferrous contains no iron and is made up of other materials like copper, zinc, aluminum and magnesium.

Different materials studied for this paper are:

1) Aluminum Alloys
2) Mild Steel
3) Composite Material

II. LITERATURE REVIEW

Tharigonda Niranjan Babu et al.[1], stated that the introduction of composite materials has made it possible to reduce the weight of the leaf spring without any reduction in load carrying capacity and stiffness. Leaf spring is modelled in CATIA V5R20 software and it is imported in ANSYS 12.0. The conventional composite leaf springs were analyzed under similar conditions using ANSYS software and the results are presented. Deflection of composite leaf spring is less as compared to steel leaf spring with the same loading condition. Weight and cost are also less in composite leaf spring as compared to steel leaf spring with the same parameters. Conventional steel leaf spring is also found to be 5.5 times heavier then Jute EGlass/Epoxy leaf spring. Material saving of 71.4 % is achieved by replacing Jute EGlass/epoxy in place ofsteel for fabricating the leaf spring.

Baviskar A.C. et al.[2], shown in his paper that composite materials have more elastic strain energy storage capacity and high strength to weight ratio as compared with those of steel. Therefore, it is concluded that composite leaf spring is an effective replacement for the existing steel leaf spring in automobile. E-glass epoxy is better than using Mild-steel as though stresses are little bit higher than mild steel, E-glass epoxy is having good yield strength value. The prior cracking in the spring was extensive enough to reduce the strength of the spring to the point where normal dirt road forces were adequate to produce rupture. The weight of the leaf spring is reduced considerably about 85 % by replacing steel leaf spring with composite leaf spring.

K Rajesh et al.[4] studied the material properties of the composite material the glass epoxy and graphite epoxy and analysed the conventional to composite leaf spring. Developed, fabricated and tested leaf spring using composite material. Selection of composite material indicated that the glass/graphite epoxy had higher tensile and fatigue strength and lower coefficient of thermal expansion. And result declared that compared to steel leaf spring the laminated composite leaf spring weight reduction is achieved.

Kumar Krishna et al.[5] carried out on multi leaf spring having nine leaves used by a commercial vehicle. The finite element modelling and analysis of multi leaf spring has been carried out. It concludes two full length leaves in which one is with eyed ends and seven graduated length leaves. The material of the leaf spring is SUP9.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue VII July 2022- Available at www.ijraset.com

The FE model of the leaf spring has been generated in CATIA V5 R17 and imposed in ANSYS-11 for finite element analysis, which are most popular CAE tools. The FE analysis of the leaf spring has been performed by discretization of the model in infinite nodes and elements and refining the under defined boundary condition. Bending stress and deflection are the target results. A comparison of experimental and FEA results have been done to conclude.

Manas Patnaik et al.[6] has been carried out on a parabolic leaf spring of a mini loadtruck. The spring has been analyzed by applying a load of 3800N and the corresponding values of stress and displacement are computed. In this work, design of experiments has been applied under various configurations of the spring(i.e., by varying camber & eye distance). Camber and leaf span of a Parabolic leaf spring was found for Optimized tress and displacement values using Artificial Neural Networks.

A. Problem Statement.

The In-wheel suspension is one sort of suspension which has shock absorbers inside wheel rim at an angle to every other. The in-wheel suspension provides a suspension effect much greater than the traditional telescopic suspension in bicycles. The in-wheel suspension is one of the emerging suspension concepts in the industry, especially in bicycle suspension. Designing the suspension with price efficient material by analysis is the objective of this project.

B. Research Objective

The loopwheel belief has been commencing after making an allowance for every one of this harms facing during our day to day life. By observing sheet suspension in trucks etc. the new suggestion fashioned of ball circle which gives most suit during off thoroughfare vehicle as on path vehicle. The loop wheel project knows how to underestimate the shocks that has been fashioned during riding.

C. Methodology

1) *Data Collection:* Data collection phase involved the collection of reference material for this project concept.
2) *System Design:* The system design comprised of the development of the mechanism so that the given concept performs desired operation.
3) *Mechanical Design:* The parts in this part are designed for stress ans strain under given system forces and appropriate dimensions are derived.
4) *Drawing:* Productions drawing of the parts are prepared using AutoCAD, using the help of appropriate dimensional and geometrical tolerances
5) *Results:* Results derived from the study is processed and saved for the record. This can be used in future applications and improvements.

D. Design

Modeling for this paper was prepared by staring with dimensioning in AutoCAD followed by designing in CATIA V5R21.

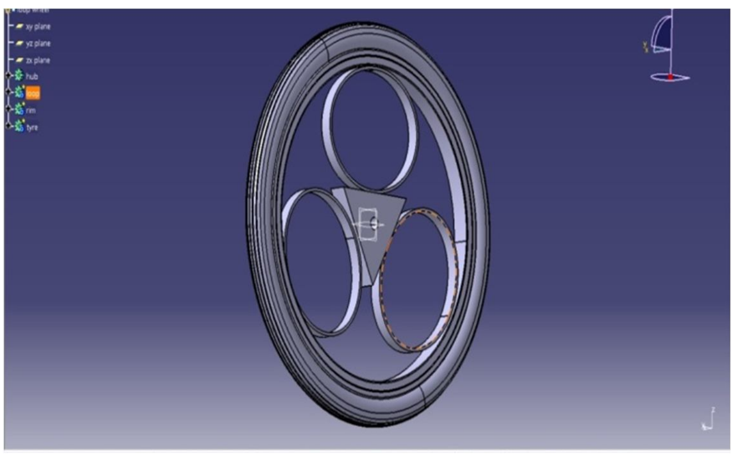

Fig: CATIA model of Loopwheel

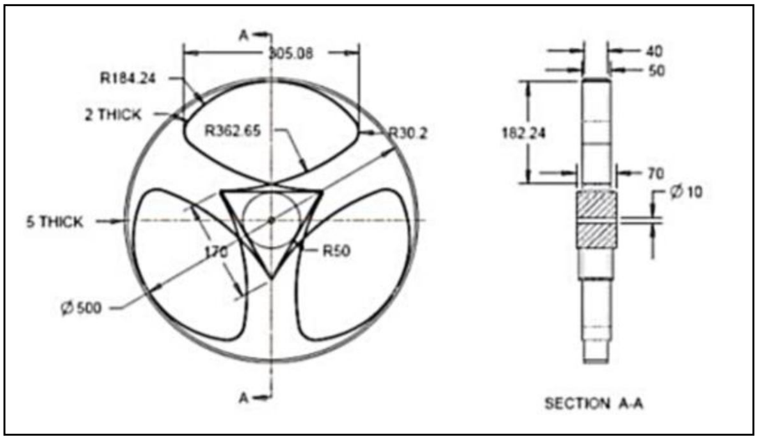

Fig: AutoCAD model of Loopwheel

E. Calculations

1) Material used: C10 material

a) Material Properties

Tensile strength = 365N/mm2

σ max = 365/1=365 N/mm2

Given data: for 75kg weight (person and body)

F = 370.22N

Major Axis of loop spring=L=300mm

Minor axis of loop spring=h=200mm

E= 210MPa

Number of spring strips, n= 1

Width of spring b = 25.4mm

Thickness of spring t = 5mm

b) Calculation of Maximum Principal Stress

$$\sigma_{max} = \frac{3FL}{2nbt^2} = \frac{3*370.22*300}{2*1*25.4*5^2}$$

$$= 183.45 N/mm^2 < 365 N/mm^2$$

c) Calculation of Maximum Deflection

$$\Delta max = \frac{3FL^3}{8Enbt^3} = \frac{3*370.22*300^3}{8*210*1*25.4*5^3} = 3.44 mm.$$

Above calculations were done considering half portion of spring hence total defection would be,

$$\Delta max = 3.44*2 = 6.88 mm.$$

Hence design is safe.

2) *Material used:* C20 material

a) *Material Properties*

Tensile strength = 560N/mm2

σ max = 560/1=560 N/mm2

Given data: for 75kg weight (person and body)

F = 370.22N

Major Axis of loop spring=L=300mm

Minor axis of loop spring=h=200mm

E= 200MPa

Number of spring strips, n= 1

Width of spring b = 25.4mm

Thickness of spring t = 5mm

b) *Calculation of Maximum Principal Stress*

σ max = 3FL / 2nbt2

= 3*370.22*300 / 2*1*25.4*52

= 262.36N/mm2 <560N/mm2

c) *Calculation of Maximum Deflection*

Δmax = 3FL3 / 8Enbt3

= 3*370.22*3003 / 8*200*1*25.4*53

= 5.90 mm.

Above calculations were done considering half portion of spring hence total defection would be,

Δmax = 5.90*2

= 11.80 mm.

Hence design is safe.

III. RESULTS

The safety of the design. Using impulse momentum principle, force was calculated when the cycle hits a rigid wall with a velocity of 30 kmph. The resultant Equivalent Stress (MPa) and Total Deformation as shown in table. The force obtained was 370.22 N. i.e. 75 Kg.,

Material	Maximum	Minimum	Average deflection
C10	6.82	0	3.41
C20	12.162	6.635	9.39

TABLE 1: Result of Deformation and Stress developed.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue VII July 2022- Available at www.ijraset.com

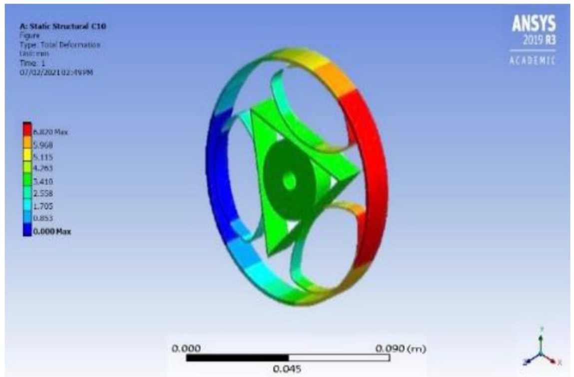

Figure 2: ANSYS Result of Deformation of C10 Material

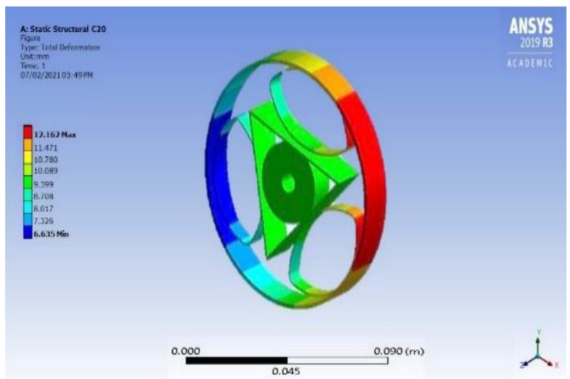

Figure 3: ANSYS Result of Deformation of C20 Material

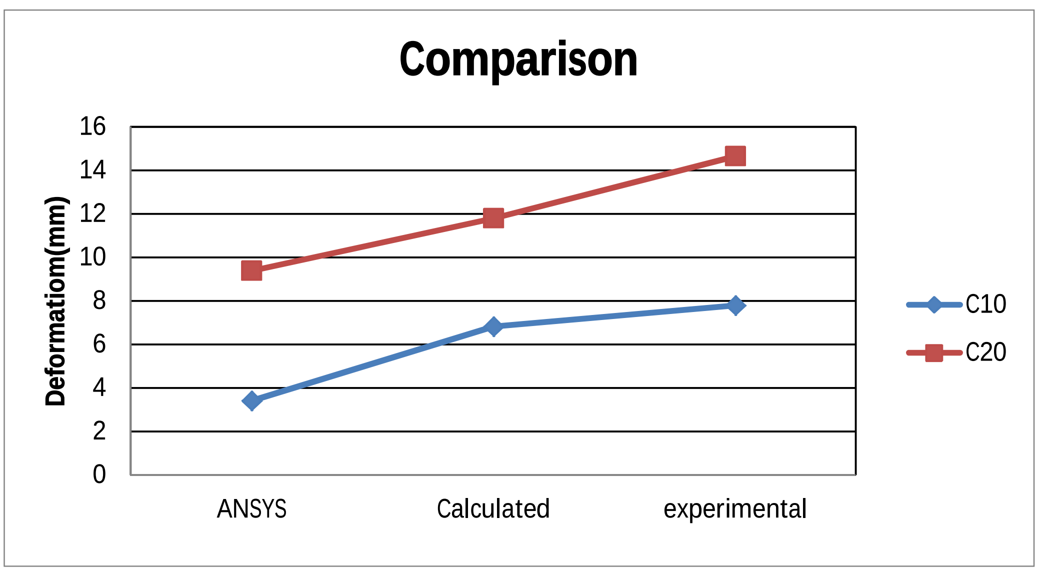

Figure 4: Graphical Comparison

IV. CONCLUSION

Smooth ride, sky-scraping shock captivation capacity is achieved by bicycle with loopwheel suspension system and avoids basics of other suspension system. Additionally this paper implies the applications like wheelchairs, mountain bikes for their scope to counter terrain and cushioning road abnormalities. Examination is done which shows that calculated and the ethics obtained by means of ANSYS 2019 R3 workbench is in accordance with other which implies that the outline is safe.

V. FUTURE SCOPE

Going back to the loop wheels problem of how best to make the springs and thinking that carbon composites were going to be the answer, I took inspiration from my immediate environment. One idea that carbon composite archery bows probably went through similar kinds of stresses as the springs in wheels. So let's try out for other designs like archery bow with carbon composites, no matter it is costly than steel but it is better effective than steel because of its material properties and simple of manufacture. A spring framework between the center point and the edge of the wheel pads the rider from knocks and potholes in the street. Since the suspension framework is situated inside.

REFERENCES

[1] Yung-Shung Liua, Tswn-SyauTsayb, Chao Chenc, Hung-ChuanPanc ("Simulation of a riding a full suspension bicycle for analyzing comfort and pedalling force") accepted 29 May 2013.
[2] Nicola Petrone, Federico Giuliano-("Methods for evaluating the radial structural behavior of racing bicycle wheel") University of Padova, Italy; accepted 16 May 2011.
[3] Pankaj Saini, Ashish Goel, Dushyant Kumar, "Design and Analysis of composite Leaf Spring for Light Vehicles", International Journal of Innovative Research in Science, Engineering and Technology, ISSN: 2319-8753, Vol. 2, Issue 5, May 2013, PP 1-10.
[4] Covilla, Steven Begga, Eddy Eltona, Mark Milinea, Richard Morrisa, Tim Karza, " Parametric finite element analysis of bicycle frame geometries".
[5] Song Yin, Yuehong Yin-(" Study on virtual force sensing and force display device for the interactive bicycle simulator"); accepted 10 June 2007.
[6] Gulur Siddaramanna, Shiva Shankar, SambagamVijayarangan, "Mono Composite Leaf Spring for Light Weight Vehicle – Design, End Joint Analysis and Testing", MATERIALS SCIENCE (MEDŽIAGOTYRA), ISSN 1392–1320, Vol. 12, Issue No. 3. 2006, PP 220-225.
[7] Suspension System- A Review", International Journal of Emerging Technology and Advanced Engineering, ISSN2250-2459, Volume 3, Issue 6, June 2013, PP 406-410.
[8] Mr. Tharigonda Niranjan Babu, Mr P. Bhaskar and Mr. S. Moulali, "Design and Analysis of Leaf Spring withComposite materials", International journal of engineering sciences & research technology, ISSN: 2277-9655, 3(8):August, 2014, PP 759-756.