Design and Analysis of Loop Spring Suspension System in Bicycle

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ABSTRACT

In today's world, Bicycles are the most favourite choice when it comes to causes like health, pollution, and environment. Several researches have been done in order to make the ride comfortable. Different types of cycles have been developed for various applications like Commuter Bikes, Mountain Bike, and Racing bike. This paper presents the Loop wheel which is designed such that the suspension system is integrated within wheel for higher shock-absorbing performance and better comfort. Loop wheels offer you a smoother ride. 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. In this paper loop wheel manufactured using C20 material and the analysis is done on ANSYS Workbench 14.5 to determine the forces acting on wheel, maximum deflection, principle stresses.

Keywords: *Loop wheel, Integrated suspension system, Triangular hub, ANSYS Workbench 14.5*

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1. INTRODUCTION

A wheel which is a circular part is meant to rotate on an axle bearing. Wheels, in conjunction with axles, enable heavy objects to be moved [simply] facilitating movement or transportation while supporting a load, or performing labour in machines. A wheel greatly reduces friction by facilitating motion by rolling along with the use of axles. For the wheels to rotate, a moment has to be applied to the wheel about its axis, either by means of gravity, or by applying another external force or torsion. The loop-wheel suspension concept represents new approach to off-road mobility taking advantage of modern high strength composites. The loop-wheels excellent ride qualities were overshadowed by their very poor durability and high rolling resistance. New design options are presented which promise further improvement in durability, on road and off-road mobility, noise and vibration suspension, lower part count and lower cost for wide range of attractive applications ranging from low speed agricultural trailers to high mobility on/off road motor vehicles

2. LITERATURE REVIEW

[1] "Mono Composite Leaf Spring for Light Weight Vehicle – Design, End Joint Analysis and Testing" by Gulur Siddaramanna, Shiva Shankar, Sambagam Vijayarangan

Author says, A single leaf with variable thickness and width for constant cross sectional area of unidirectional glass fiber reinforced plastic (GFRP) with similar mechanical and geometrical properties to the multi leaf spring was designed, fabricated (hand-layup technique) and tested. Computer algorithm using C-language has been used for the design of constant cross-section leaf spring. The results showed that an spring width decreases hyperbolically and thickness increases linearly from the spring eyes towards the axle seat. The finite element results using ANSYS software showing stresses and deflections were verified with analytical and experimental results. Compared to the steel spring, the composite spring has stresses that are much lower, the natural frequency is higher and the spring weight is nearly 85 % lower with bonded end joint and with complete eye unit.

[2] "Design and Analysis of Composite Leaf Spring for Light Vehicles" by Pankaj Saini, Ashish Goel, Dushyant Kumar

The author says that, the Automobile Industry has great interest for replacement of steel leaf spring with that of composite leaf spring, since the composite materials has high strength to weight ratio, good corrosion resistance. The material selected was glass fibre reinforced polymer (E-glass/epoxy), carbon epoxy and graphite epoxy is used against conventional steel. The design parameters were selected and analyzed with the objective of minimizing weight of the composite leaf spring as compared to the steel leaf spring. From the static analysis results it is found that there is a maximum displacement of 10.16mm in the steel leaf spring and the corresponding displacements in E-glass / epoxy, graphite/epoxy, and carbon/epoxy are 15.mm, 15.75mm and 16.21mm.. Among the three composite leaf springs, only graphite/epoxy composite leaf spring has higher stresses than the steel leaf spring.E-glass/epoxy composite leaf spring can be suggested for replacing the steel leaf spring from stress and stiffness point of view.

[3] "Design and Analysis of a Leaf Spring for automobile suspension system- A Review" by Baviskar A. C., Bhamre V. G., Sarode S. S.

The author says 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

[4] "Design and Analysis of Leaf Spring with Composite materials" by Mr. Tharigonda Niranjan Babu, Mr P. Bhaskar, Mr. S. Moulali

The author says 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 E-Glass/epoxy in place ofsteel for fabricating the leaf spring

[5] "Urgent Operational Requirement: Build your own loop wheel"

The Loop wheels are a new concept wheel for a bicycle. The spokes of a conventional wheel have been replaced with carbon fibre loops which not only attach the outer rims to the centre hub, they also provide suspension. The result is maximum comfort over bumps and less vibration from the road. Replacing the spoked wheels with Loop-wheels provides full suspension in a bike which hasn't got room for a traditional suspension system, but each Loop-wheel weighs only about 300g more than its spoked equivalent. Unlike suspension forks, which only work in one plane, Loop-wheels provide tangential suspension. That is, they work in every direction. So they respond to a force hit head-on in the same way as they do to a force from above or below. By using loop-wheel bicycle rider gets comfortable ride because Tangential suspension. Pedalling is much smoother and not as jerky, because the springs release energy more evenly. This makes for a very comfortable, easy ride.

[6] "Loop wheels: because sometimes it's good to reinvent the wheel."

Loop wheels are a new type of bicycle wheel that have been designed to make cycling more comfortable. Loop wheels feature a spring system between the hub and the rim of the wheel which provides suspension – cushioning the rider from bumps and potholes in the road. The spring configuration allows for the torque to be transferred smoothly between the hub and the rim. Front and rear Loop-wheels have different spring rates. A front and rear loop-wheel can be used together as a set, or you can use a single loop-wheel alongside a conventional spoked wheel. Loop-wheels provide suspension on a bike which has none, or can be fitted in addition to suspension forks to give a smoother, more comfortable ride.

3. HOW IT WORKS???

The spring system between the hub and the rim of the wheel provides suspension that constantly adjusts to uneven terrain – cushioning the rider from bumps and potholes in the road. In effect, the hub floats within the rim, adjusting constantly as shocks from an uneven road hit the rim of the wheel. The spring configuration allows the torque to be transferred smoothly between the hub and the rim. We have developed loop wheels with consideration that the weight of the rider and cycle body to be equally distributed over the wheels of the bicycle. Every loop wheel is designed for same compression rate.

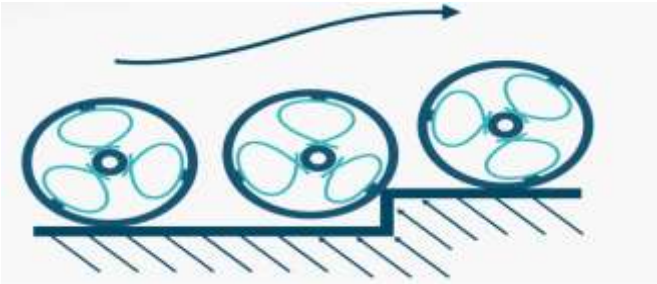

Figure 1. Working of loop wheel

4. COMPONENTS USED

1. Wheel Rim

The rim is commonly a metal extrusion that is butted into itself to form a hoop, though may also be a structure of carbon fiber composite. Bicycle wheels are typically designed to fit into the frame and fork via dropouts, and hold bicycle tires.

2. Loop Spring

A loop spring is a simple form of spring commonly used for the suspension in wheeled vehicles. Originally called a laminated or carriage spring, and sometimes referred to as a semi-elliptical spring or cart spring. A leaf spring is welded directly to the triangular hub at both ends.

3. Triangular Wheel Hub

A Triangular hub is the centre part of a bicycle wheel. It consists of an axle, bearings and a hub shell. The hub is the centre of the wheel, and typically houses a bearing, and is where the axle is mounted inside it. The axle is hollow, following the wheel at very close tolerances. Triangular faces in outer sides are provided to rest leaf springs on it**.**

Figure 2.Wheel rim

Figure 3. Loop spring

Figure 4. Triangular wheel hub

5. CALCULATIONS

Material used: C20 material
Material Properties:

Tensile strength = 560N/mm^2
σ max = 560/1=560 N/mm^2
Given data:
F=370.22N
Major Axis of loop spring=L=300mm
Minor axis of loop spring=h=200mm
E= 200MPa
Width of spring b = 25.4mm
Thickness of spring t = 5mm

I. Calculation of maximum principal stress:

$$\sigma max = \frac{3FL}{2nbt^2}$$
$$= \frac{3*370.22*300}{2*1*25.4*5^2}$$
$$= 262.36 \text{ N/mm}^2 < 560 \text{ N/mm}^2$$

II. Calculation of maximum deflection:

$$\Delta max = \frac{3FL^3}{8nbt^3}$$
$$= \frac{3*370.22*300^3}{8*1*25.4*5^3}$$
$$= 5.90 \text{ mm.}$$

Above calculations were done considering half portion of spring hence total defection would be,
Δmax
= 5.90*2
= 11.80 mm.
Hence design safe.

6. ANALYSIS

Analysis has been done on ANSYS Workbench 14.5 to determine the Maximum deformation. Results were obtained as follows:

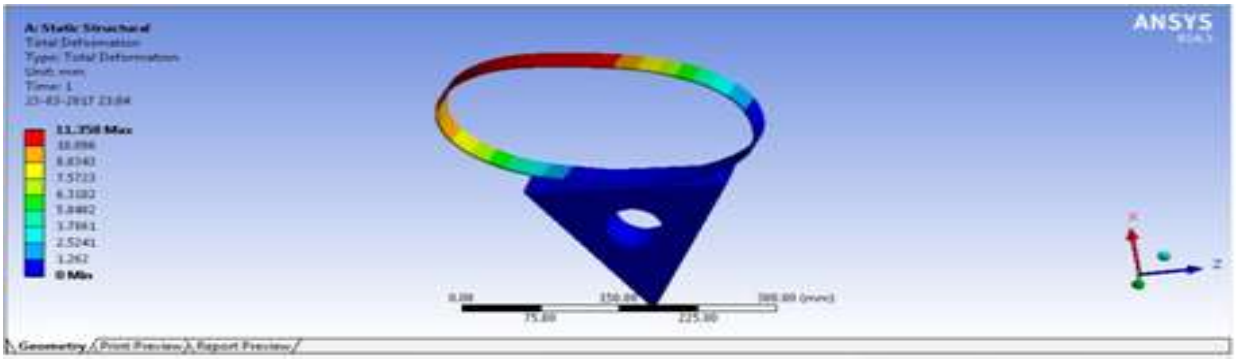

Figure 5. Deformation distribution

Maximum Deformation obtained was 11.358mm and the calculated deformation was 11.8mm.

This shows that the results obtained from theoretical calculations and ANSYS are in accordance with each other.

The results are tabulated below:

Results for Deformation

	ANSYS	Theoretical
Maximum Deformation	11.358 mm	11.800 mm

7. CONCLUSION

Bicycle with loop wheel suspension system provides smoother ride, high shock absorption capacity, avoids the necessity of additional suspension system. Also this loop wheels can find their applications in wheel chairs, mountain bikes because of their capacity to adjust to uneven terrain, cushioning the rider from abnormalities in the road. Analysis on deformation has been done which shows that the calculated and the values obtained using ANSYS are in accordance with each other which suggests that the design is safe.

8. ACKNOWLEDGEMENT

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