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Development Of Loop Wheel Reinvents.

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Abstract
In today's world, Bicycles are the most favorite 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 project report 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 steel 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 project report loop wheel manufactured using C20 steel material.

Keywords- *Loop wheel, Integrated suspension system, Triangular hub.*

I. Introduction

This project report presents a study of a In-Wheel suspension system which is placed inside a bicycle wheel. The In-wheel suspension system isolates the sprung mass from excitations similar to conventional suspension systems. In traditional suspension systems the isolation is provided by spacious and complicated mechanisms, and mainly in the vertical direction. However, the in-wheel suspension system, not only fits the suspension mechanism inside the unused space between a wheel's rim and hub, but also allows for isolation both in vertical and horizontal directions. The main focus of this project report is to study, investigate, and show the feasibility of applying such suspension system to a vehicle.

In this project report 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 steel 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 project report loop wheel manufactured using C20 steel material

This research is conducted on low speed, low load, and human-powered vehicles such as bicycle. This helps to escape from the complications of a complex system like a road vehicle. It also demonstrates the versatility of the in-wheel suspension idea. The objective of the project is to scrutinize a simple but practical in-wheel suspension system and demonstrate its applicability. The research begins with the static and dynamics modeling of an in-wheel suspension system. Dist – Amravati.. The Static model evaluates the response of the suspension system and investigates the influence of various design parameters on the in-wheel suspension. The study is then continued to improve the design by replacing its rigid mechanism links with optimized compliant structures. This reduces the system's complexity and weight while boosting its performance.

II. Literature Review

"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.

"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. Pedaling is much smoother and not as jerky, because the springs release energy more evenly. This makes for a very comfortable, easy ride.

"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.

1. IDENTIFIED GAPS IN THE LITERATURE

After referring available reference material, it is found that researcher do the work with composite material for making loop, in order to reduce the weight of Bicycle. For cost effective manner here decide to do the experimentation with large diameter wheel the change in material i.e. C20. One research paper found with C20 material but experimentation is done for smaller wheel diameter. Hence scope for Loop suspension system for Large diameter wheel with material as C20.

2. CONCEPTS OF IN-WHEEL LOOP

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.

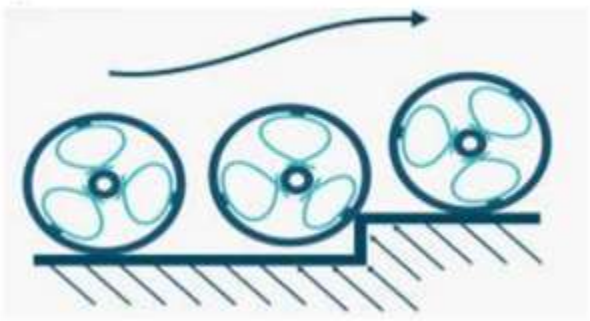

Figure 1. Working of loop wheel

Although the origin of the wheel may be obscure, its invention as a load carrying device marked the advent of machinery. Today the wheel is an essential part of most machines in the form of gears, pulleys, cams, sprockets, bearings, and other rotating devices. However, it is still most conspicuous as a load carrier; and, from a technical perspective, the bicycle wheel stands out as one of the most elegant of these. The wire-spoked bicycle wheel was introduced more than a century ago to replace wooden wheels with thick, rigid spokes. Tensioning the wires made these wheels possible, and with them came the lightweight bicycle that we know today. Wire spokes not only reduced weight but also improved durability. Today's wire wheels can carry more than a hundred times their own weight. In off-road bicycling, skilled riders often jump from high obstacles,

subjecting their wheels to forces of more than a quarter ton. Although the bicycle is the world's most common vehicle, few people understand how its wheels achieve their unusual strength. Constant and better comfort throughout can be achieved by making certain simple necessary changes in the regular design of the front wheel suspension system. The significant change is introduction of a tangential suspension system in the wheel itself. This ensures that it absorbs shocks from all the directions.

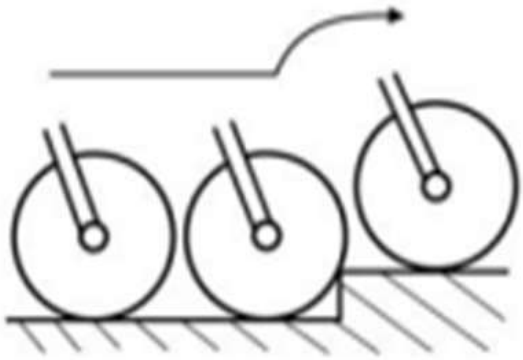

Figure 2.: Normal wheel Design

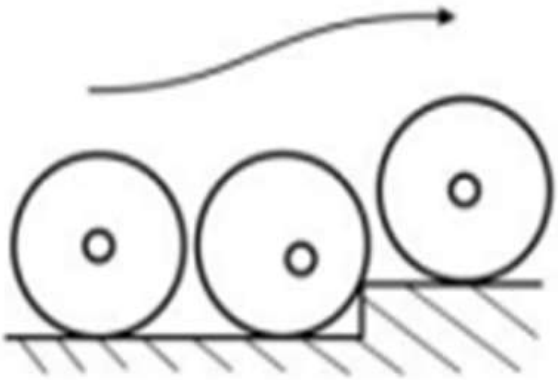

Figure 3.: Modified Wheel

All the shocks, coming in travel through the center that is the hub. In regular design the hub is fixed with rigid spokes joining it to the rim and hence, practically takes no part in providing suspension. Here, understanding the importance of hub, it has been given the ability to move and recoil back to its original position. This floating hub has the ability to move not by resting on fixed spokes of that of a regular bicycle. Here, the fixed spokes of the bicycle is replaced with spring like material that has damping ability. It is known that a leaf spring is a simple form of spring commonly used for the suspension in

wheeled vehicles. A spring made of a number of strips of metal curved slightly upwards and clamped together one above the other. Here instead of clamping the springs together, they are used individually.

III. Methodology And Materials

The main target was to achieve the desired deflections in the suspension for a particular weight of driver. Considering the application C20 material is selected for loop. The thickness of the loop is determined by assuming it to be a cantilever beam and designing it for bending failure and the design was then analyzed in Ansys software. The stiffness of the loop can be changed by simply shifting the mounting positions of the loop at the wheel's hub end. By changing the effective length of the loop we can change the stiffness and hence control the hub travel. The wheel was designed considering the impact forces coming from the ground and lateral forces while cornering. By checking the stresses and nature of deformation for 3 loops only. Using more number of loop will lead to unnecessary increase in weight. The analysis was done on Ansys v15.0 software to check the stresses and deformation in the system. A custom hub is designed to accommodate the entire loop with the help of nut and bolts.

IV. Design And Development

4.1. Design –

Dimension of cross section of the leaf is to be determined. The width of the leaf material was kept as 35mm as it cannot be more than the width of the wheel.

Considering front impact case, using impulse momentum theorem,

F X t = m X v

Time of impact, t=0.5 sec

Mass of cycle including rider, m= 100 kg

Max. Velocity, v = 30 kmph = 8.3 m/s

For 100 kg, F= 981N

For determining the thickness of the Leaf, let us consider it as a cantilevered

Major axis loop (L) =300mm (12inch)

Minor axis loop (h) =195mm (7.8inch)

Width of spring (b) =25mm (1inch)

E=200 mpa

Calculation of maximum principle stress.

$V\sigma max = 3FL/2nbt^2$ $560=3*981*300/2*1*31.25* t^2$

t=5.0 mm

For 100 kg weight 5.0 mm thickness of the leaf is required

m=100 kg

v=30kmph=8. 3m/s

F=981N

Bending stress

$^{\delta}b = 1.5WL/bt2$

$=1.5*981*300/31.25*(5.0)^2$

$=565.05N/mm^2$

Thickness of spring t = 5 mm

I. Calculation of maximum principal stress:

$\sigma max = 3FL/2nbt^2 = 3*370.22*300/2*1*25.4*5^2$

$= 262.36\ N/mm^2 < 560\ N/mm^2$

II. Calculation of maximum deflection:

$\Delta max = 3FL3/8nbt^3 = 3*370.22*3003/8*1*25.4*5^3$

$= 5.90$ mm.

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

$\Delta max = 5.90*2 = 11.80$ mm.

Hence design safe.

6.2 DEVELOPMENT OF LOOP WHEEL REINVENTS –

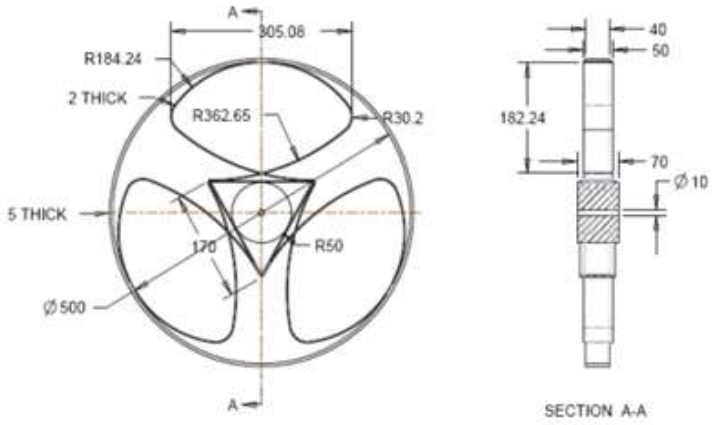

Figure 4.: Drawing of Loop-Wheel**.**

6.2.1 COMPONENT USED IN IN-WHEEL LOOP SUSPENSION SYSTEM

A. 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.

Figure 5.: Wheel Rim of Bicycle.

B. 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.

Figure 6.: In-Wheel Loop of Bicycle

C. 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 loop springs on it.

Figure 7.: In-Wheel Hub of Bicycle

6.2.2 FABRICATION OF PROTOTYPE

For fabrication of prototype as per concept and design selecting the bicycle BSA/SLR having 20” inch diameter wheel. As shown in given figure.

Figure 8:- Selection Bicycle for Prototype.

Selection of proper hub for loop support. Here a drum of **Luna TFR** model is selected for making a hub for In-Wheel Loop Suspension system mounting centrally over the front axle of Bicycle.

Figure 9 :- Selection Hub for Prototype.

Selection of proper material for making loop for In-Wheel suspension system. Here a selecting C20 material which is commonly found in making of leaf spring in automobile. Selection of leaf used in Baja Auto for making of loop.

Figure 10: - Selection Loop Material for Prototype.

Here after selecting of leaf of Baja Auto convert the thickness of leaf as per design value of thickness of Loop. For this purpose the leaf is insert in Furness and make it red hot for rolling purpose and then pass through between the roller to reduce the thickness of that leaf upto 5 mm. A three strip are made of 20mm width for making loop.

Preparation of Hub is done for mounting of loop in between wheel rim and hub as shown in figure. A Plate of aluminum 40 mm width and 8 mm thickness is used as base plate for loop mounting over Drum. Do the proper welding for plate mounting over Drum.

Figure 11 :- Mounting of plate over Drum.

Making the loop by using 5 mm thickness strip and arrangement is done as shown in figure. Use the nut and bolt for fixing the strip over hub and with rim. This gives the flexibility for replacement of loop in case of damage and breakup.

Figure 12 :- Preparation of In-Wheel Loop Suspension System.

Making the loop by using 5 mm thickness strip and arrangement is done as shown in figure. Use the nut and bolt for fixing the strip over hub and with rim. This gives the flexibility for replacement of loop in case of damage and breakup.

Figure 13 :- Complete In-Wheel Loop Suspension System in Bicycle.

V. Conclusions

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 suggest that the design is safe. In loop design, the stresses developed in loop spring under the safe limit of material stress limit and hence the design is accepted but the layout of spokes in conventional wheel enables proper stress distribution than loop spring.

The main problem in the loop design was the high expected deflection occurring due to lateral forces. However from analysis, we can clearly see that the deformation of loop is 5.90 mm in one side and by considering side it is 11.8 mm, Hence the problem is satisfactorily resolved. The loop or the spoke being the weakest component, even after failure of loop, the replacement of the component is simple and less expensive due to flexibility in design.

The drawback of the loop design in terms of stress and deformation against the conventional wheel design is balanced because of its ability to absorb shocks from any direction.

VI. Scope For Future Work.

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 easy of fabrication.

A spring system between the hub and the rim of the wheel cushions the rider from bumps and potholes in the road. Since the suspension system is located inside the wheel i.e instead of the frame, could boast the same comfort level as a traditional spoked wheel bike, making them much more attractive to inexperienced bike commuters but for bicycle safety issue are not tested here for short and long turning radius. So, there is more scope for study on dynamic behavior of bicycle for different diameter of wheel.

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