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Design and Fabrication of Loop Wheel Suspension System

Prof. S.D. Dhekale[1], Mr. Vaibhav K. Thorat[2], Mr. Jayant C. Waghulade[3], Mr. Sagar M. Lahane[4], Mr. Atul R. Gengaje[5]

[2,3,4,5]Student, Department of Mechanical Engineering of D.Y.Patil Institute of Engineering and Technology, Ambi
[1]Assistant Proffesor, Department of Mechanical Engineering of D.Y.Patil Institute of Engineering and Technology, Ambi, Maharastra, India

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Abstract - A Loop wheel is a wheel with integral suspension, designed for higher shock-absorbing performance and better comfort. Loop wheels offer you a smoother ride. They're more comfortable than usual wheels: the carbon springs absorb exhausting vibration, in addition to the bumps and the shocks. They're extraordinarily robust and durable.Loop wheel springs are made up of a composite material, carefully developed to offer optimum compression and lateral stability as well as strength and durability. Designed connectors attach the springs to the rim and hub. The loops in every wheel work along with self-correcting system. The spring system between rim and hub of the wheel provides suspension that continuously adjusts to uneven terrain cushioning the rider from abnormalities in the road. In effect, the hub floats inside the rim, adjusting continuously as shocks from the uneven road hit the rim of the wheel. The spring permits the torque to be transferred smoothly between rim and hub.

Fig 1 Wheel(a)

INTRODUCTION

A wheel is a circular part that's meant to rotate on an axle bearing. The wheel is one of the essential parts of the wheel and axle which is one of the six simple machines. Wheels, with axles, enable heavy objects to be moved simply facilitating movement while supporting a load, or performing labour in machines. Wheels are also used for various alternative functions, such as a ship's wheel, steering wheel, potter's wheel and flywheel. Common examples are found in transport applications.

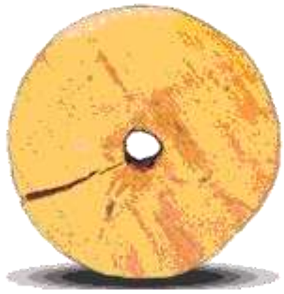


Fig 1. Wheel(B)

For the for 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. he wheel is perhaps the most vital mechanical invention of all time. Nearly each machine designed since the start of the industrial Revolution involves a single, fundamental principle embodied in one of mankind's really important inventions. It's exhausting to imagine any mechanized system that might be possible without the wheel or the concept of a symmetrical part moving in a circular motion on an axis. From small watch gears to vehicles, jet engines and a disk drives, the principle is always the same. Based on diagrams on ancient clay tablets, the earliest documented use of this essential invention was a potter's wheel that was used at ur in Mesopotamia as early as 3500 B.C.. the earliest use of the wheel for transportation was most likely on Mesopotamian chariots in 3200 B.C. A wheel with spokes initially appeared on Egyptian chariots around 2000 B.C., and wheels appear to have been developed in Europe by 1400 B.C. with no influence from the middle East. As the result the very concept of the wheel seems so straightforward, it's simple to assume that the wheel would have merely "happened" in each culture once it reached a specific level of sophistication. However, this is often not the case. the Great Inca, Aztec and Maya civilizations reached a very high level of development, but they ne'er used the wheel. In fact, there's no known proof that the utilization of the wheel existed among native folks in the western hemisphere until well after contact with Europeans. Even in Europe, the wheel evolved quite little until the dawn of the nineteenth century. However, with the arrival of the Industrial Revolution the wheel became the central element of technology, and came to be employed in thousands of the way in innumerous different mechanisms.

History

A wheel is a circular part that's meant to rotate on an axle bearing. The wheel is one of the essential parts of the wheel and axle which is one of the six simple machines. Wheels, with axles, enable heavy objects to be moved simply facilitating movement while supporting a load, or performing labour in machines. Wheels are also used for various alternative functions, such as a ship's wheel, steering wheel, potter's wheel and flywheel. Common examples are found in transport applications. For the for 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. he wheel is perhaps the most vital mechanical invention of all time. Nearly each machine designed since the start of the industrial Revolution involves a single, fundamental principle embodied in one of mankind's really important inventions. It's exhausting to imagine any mechanized system that might be possible without the wheel or the concept of a symmetrical part moving in a circular motion on an axis. From small watch gears to vehicles, jet engines and a disk drives, the principle is always the same. Based on diagrams on ancient clay tablets, the earliest documented use of this essential invention was a potter's wheel that was used at ur in Mesopotamia as early as 3500 B.C.. the earliest use of the wheel for transportation was most likely on Mesopotamian chariots in 3200 B.C. A wheel with spokes initially appeared on Egyptian chariots around 2000 B.C., and wheels appear to have been developed in Europe by 1400 B.C. with no influence from the middle East. As the result the very concept of the wheel seems so straightforward, it's simple to assume that the wheel would have merely "happened" in each culture once it reached a specific level of sophistication. However, this is often not the case. the Great Inca, Aztec and Maya civilizations reached a very high level of development, but they ne'er used the wheel. In fact, there's no known proof that the utilization of the wheel existed among native folks in the western hemisphere until well after contact with Europeans. Even in Europe, the wheel evolved quite little until the dawn of the nineteenth century. However, with the arrival of the Industrial Revolution the wheel became the central element of technology, and came to be employed in thousands of the way in innumerous different mechanisms. In Britain, a large wood wheel, measuring about one m (3.3 ft) in diameter, was uncovered at the must Farm plot in East Anglia in 2016. The specimen, geological dating from one,100–800 years BCE, represents complete and earliest of its kind found in United Kingdom. The wheel's hub is present. A horse's spine found in vicinity suggests the wheel might have been a part of a horse-drawn cart. The wheel was found in a settlement built on stilts over wet terrain, indicating that the settlement had some kind of link to dry terrain.

Although they didn't develop the wheel correctly, the Olmec and surely other american cultures appear to have approached it, as wheel-like worked stones are found on objects recognised as children's toys carbon dating to around 1500 B.C.. It's thought that the first obstacle to greater-scale development of the wheel in the Americas was the absence of domesticated large animals that can be used to pull wheeled carriages.[citation needed] The nearest relative of cattle present in Americas in pre-Columbian times, the American bison, is tough to domesticate and was ne'er domesticated by Native Americans; many horse species existed till about 12,000 years ago, but ultimately became extinct. the sole large animal that was domesticated within the New World, the llama, failed to spread beyond on the far side the Andes by the time of the arrival of Columbus.

Fig 2 Old Wheel

Early wheels were easy wooden disks with a hole for the shaft. owing to the structure of wood, a horizontal slice of a trunk isn't appropriate, because it doesn't have the structural strength to support relevant stresses without failing; rounded items of longitudinal boards are needed. The spoked wheel was invented recently, and allowed the structure of lighter and swifter vehicles. in the Harappan civilization of the Indus valley and North western India, we discover toy-cart wheels made from clay with lines that are understood as spokes painted or in relief, and a symbol interpreted as a spoked wheel in the script of the seals, already in the last half of the third millennium BCE. The earliest noted samples of wooden spoked wheels are in the context of the Andronovo culture, carbon dating to c. 2000 BCE. shortly after this, horse cultures of the Caucasus region used horse-drawn spoked-wheel war chariots for the larger part of three centuries. They travelled deep into the Greek peninsula where they joined with the present Mediterranean peoples to provide rise, eventually, to classical Greece after the breaking of Minoan dominance and consolidations led by pre-classical Sparta and Athens. Celtic chariots introduced an iron rim round the wheel in the first millennium BCE. The spoked wheel was in continuous use without major modification till the 1870s, when wire wheels and pneumatic tires were invented. The invention of the wheel has additionally been vital for technology generally, vital applications along with the water wheel, the wheel the spinning wheel, and the astrolabe or torquetum. more modern descendants of the wheel embrace the propeller, the jet engine, the regulator and also the turbine.

Problem Definition

In the conventional bicycles there no any type of suspension system. The spokes attached to rim has less load bearing capacity for special purpose cycles. The aim of the project is to design new type of wheel with hub, rim and tyre to provide suspension as well as to support rim and provide better bearing capacity.

Objective

1) To design better shock-absorbing performance.
2) To give smoother ride.
3) To increase load bearing capacity.

Scope

In this project we will design and fabricate a loop-wheel bicycle which will be able to have extra feature of shock absorption and also the better load bearing capacity. The project will contain a bicycle with an improved wheel. The wheel will be replaced from conventional spoked-rim system to leaf spring or loop spring. The wheel will consist Axle, Hub, Rim, Tyre and Leaf/loop springs. All parts will be mounted in wheel so as to maintain its center of gravity.

Literature review

Mono Composite Leaf Spring for Light Weight Vehicle – Design, End Joint Analysis and Testing

Author says, the automobile industry has shown increased interest in the replacement of steel spring with fiberglass composite leaf spring due to high strength to weight ratio. Therefore; the aim of this paper is to present a low cost fabrication of complete mono composite leaf spring and mono composite leaf spring with bonded end joints. Also, general study on the analysis and design. 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 multileaf spring, was designed, fabricated (hand-lay up 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. The design constraints were stresses (Tsai-Wu failure criterion) and displacement. 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.Author concludes that,

- The development of a composite mono leaf spring having constant cross sectional area, where the stress level at any station in the leaf spring is considered constant due to the parabolic type of the thickness of the spring, has proved to be very effective.
- The study demonstrated that composites can be used for leaf springs for light weight vehicles and meet the requirements, together with substantial weight savings.
- The 3-D modeling of both steel and composite leaf spring is done and analysed using ANSYS;
- A comparative study has been made between composite and steel leaf spring with respect to weight, cost and strength;
- The analytical results were compared with FEA and the results show good agreement with test results
- From the results, it is observed that the composite leaf spring is lighter and more economical than the conventional steel spring with similar design specifications.
- Adhesively bonded end joints enhance the performance of composite leaf spring for delamination and stress concentration at the end in compare with bolted joints.
- Composite mono leaf spring reduces the weight by85 % for E-Glass/Epoxy, 91 % for Graphite/Epoxy,and 90 % for Carbon/Epoxy over conventional leafspring.

"Design and Analysis of Composite Leaf Spring for Light Vehicles"

Reducing weight while increasing or maintaining strength of products is getting to be highly important researchissue in this modern world. Composite materials are one of the material families which are attracting researchers and beingsolutions of such issue. In this paper we describe design and analysis of composite leaf spring. The objective is to compare thestresses and weight saving of composite leaf spring with that of steel leaf spring. The design constraint is stiffness. TheAutomobile Industry has great interest for replacement of steel leaf spring with that of composite leaf spring, since thecomposite materials has high strength to weight ratio, good corrosion resistance. The material selected was glass fiberreinforced polymer (E-glass/epoxy), carbon epoxy and graphite epoxy is used against conventional steel. The design parameterswere selected and analyzed with the objective of minimizing weight of the composite leaf spring as compared to the steel leafspring. The leaf spring was modeled in Auto-CAD 2012 and the analysis was done using ANSYS 9.0 software. Author concludes, as reducing weight and increasing strength of products are high research demands in the world, composite materials are gettingto be up to the mark of satisfying these demands. In this paper reducing weight of vehicles and increasing the strength of theirspare parts is considered. As leaf spring contributes considerable amount of weight to the vehicle and needs to be strongenough, a single composite leaf spring is designed and it is shown that the resulting design and simulation stresses are muchbelow the strength properties of the material satisfying the maximum stress failure criterion. From the static analysis results it is found that there is a maximum displacement of 10.16mm in the steel leaf spring and thecorresponding displacements in E-glass / epoxy, graphite/epoxy, and carbon/epoxy are 15.mm, 15.75mm and 16.21mm. And allthe values are below the camber length for a given uniformly distributed load 67 N/mm over the ineffective length. From the static analysis results, we see that the von-mises stress in the steel is 453.92 MPa. And the von-mises stress in Eglass/epoxy, Graphite /epoxy and Carbon/epoxy is 163.22MPa, 653.68 MPa and 300.3 MPa respectively. Among the threecomposite 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. A comparative study has been made between steel and composite leaf spring with respect to strength and weight. Compositemono leaf spring reduces the weight by 81.22% for E-Glass/Epoxy, 91.95% for Graphite/Epoxy, and 90.51 % for Carbon/Epoxy over conventional leaf spring.

"Design and Analysis of a Leaf Spring for automobile suspension system- A Review"

The aim of this review paper is to represent ageneral study on the design, analysis of leaf spring. Thesuspension system in a vehicle significantly affects thebehavior of vehicle, i.e. vibration characteristics includingride comfort, stability etc. Leaf springs are commonly usedin the vehicle suspension system and are subjected tomillions of varying stress cycles leading to fatigue failure.A lot of research has been done for improving theperformance of leaf spring. Now the automobile industryhas shown interest in the replacement of steel spring withcomposite leaf spring. In general, it is found that fibreglass material has better strength characteristic and lighter inweight as compare to steel for leaf spring. In this paper there is reviewed some papers on the design and analysisleaf spring performance and fatigue life prediction of leafspring. There is also the analysis of failure in leaf spring.Also the analysis of leaf spring with ansys is done. Theautomakers can reduce product development cost and timewhile improving the safety, comfort, and durability of thevehicles they produce. The predictive capability of CAEtools has progressed to the point where much of the designverification is now done using computer simulation ratherthan physical prototype testing. Author concludes as, the composite leaf spring is lighter thanconventional steel leaf spring with similar designspecifications but not always is cost- effective overtheir steel counterparts. Composite materials havemore elastic strain energy storage capacity and highstrength to weight ratio as compared with those ofsteel. Therefore, it is concluded that composite leafspring is an effective replacement for the existingsteel leaf spring in automobile.

1] 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.
2] 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.
3] The weight of the leaf spring is reduced considerably about 85 % by replacing steel leaf spring with composite leaf spring. Thus, the objective of reducing the unstrung mass.

"Design and Analysis of Leaf Spring with Composite materials"

Author says, in automobile sector tends to increasing competition and innovation in design and tends to modify theexisting products by new and advanced materials. Leaf springs are special kind of springs used in automobilesuspension systems. The main function of leaf spring is not only to support vertical load but also to isolate roadinduced vibrations. It is subjected to millions of load cycles leading to fatigue failure. The introduction of compositematerials has made it possible to reduce the weight of the leaf spring without any reduction in load carrying capacityand stiffness. Therefore the objective of this paper is to present a general study on the performance comparison ofcomposite (E-Glass/Epoxy and Jute E-Glass) leaf spring and conventional leaf spring. Leaf spring is modeled inCATIA V5R20 software and it is imported in ANSYS 12.0. The conventional composite leaf springs were analyzedunder similar conditions using ANSYS software and the results are presented. The automobile chassis is mounted on theaxles, not direct but with some form of springs. Thestresses and deflection of steel leaf spring andcomposite leaf spring are found with great difference.Deflection of composite leaf spring is less ascompared to steel leaf spring with the same loadingcondition. Weight and cost are also less in compositeleaf spring as compared to steel leaf spring with thesame parameters. Conventional steel leaf spring isalso found to be 5.5 times heavier then Jute EGlass/Epoxy leaf spring. Material saving of 71.4 % isachieved by replacing Jute E-Glass/epoxy in place ofsteel for fabricating the leaf spring. Composite leafspring can be used on smooth roads with very highperformance expectations.

"Loop-wheel suspension system development status"

The loop-wheel suspension concept represents new approach to off-road mobility taking advantage of modern high strength composites. A normally cylindrical and barrel shaped filament would composite ring properly installed in a vehicle can combine a function of load distribution over a large foot prints as well as spring suspension in a simple one piece structure. The loop-wheels excellent ride qualities were overshadowed by their very poor durability and high rolling resistance. Refinement in the manufacturing process and in material selection have since led to lifetimes of 22000to 32000 km for 1 m diameter loop-wheel and to acceptable rolling resistance in 1 laboratory tests. 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. And they conclude that after successful development of manufacturing process for very durable yet light weight filamentary composite Loop-wheels, their successful demonstration in a small scale. To share this technology with interested licenses there is wide range of opportunities from low cost agricultural to most demanding high mobility applications which can take advantage of loop-wheel's potential as a smooth running, light weight mobility concept with integral spring suspension, large foot print and excellent obstacles negotiation.

"Urgent Operational Requirement: Build your own loopwheel"

Loop-wheelsare 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. Loop-wheel is beneficial over conventional spoked wheels.Most folding bikes do not have suspension because conventional suspension forks add weight and bulk to the bicycle. That is particularly unwelcome in a bicycle which needs to fold down to a compact size. 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. So rider get a much more comfortable ride with no impact on folding, and only a small weight gain. 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. This gives you confidence in a really smooth ride. People find they can tackle bumps, kerbs and cobbles much more easily on Loop-wheels than on normal, spoked wheels. By using loop-wheel bicycle rider gets comfortable ride because Tangential suspension, and people find they can take bumps, kerbs and cobbles more easily on Loop-wheels. While riding on loop-wheel rider does not experience the usual feeling of vibration up your arms, because Loop-wheels absorb and isolate you from the "noise" of the road. So rider get less wrist and shoulder ache on long rides.Pedalling is much smoother and not as jerky, because the springs release energy more evenly. This makes for a very comfortable, easy ride.

Loop-wheels : because sometimes it's good to reinvent the wheel.

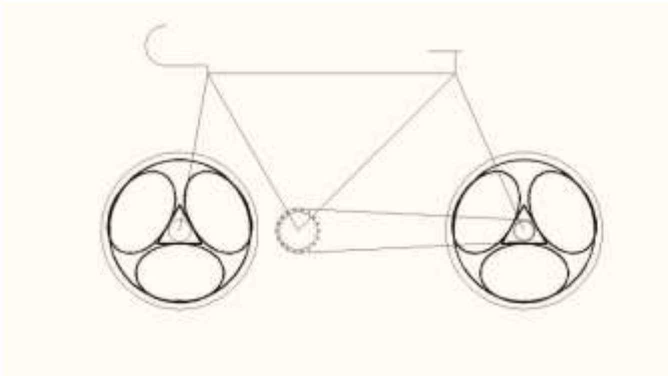
Loop-wheels are a new type of bicycle wheel that have been designed to make cycling more comfortable. Loop-wheels feature a spring system between the hub and the rim of the wheel which provides suspension – cushioning the rider from bumps and potholes in the road. They also have a conventional hub with a hub brake and hub gears. Because of the suspension within the wheel, user can use high-pressure or puncture-resist tyres. So you don't need to rely on fat (and sluggish) tyres to cushion your ride. Loop-wheel springs are made from a carbon composite, carefully developed and tested to give optimum compression and lateral stability as well as strength and durability. Speciallydesigned connectors attach the springs to the hub and rim. There are three springs in each wheel, which work together as a self-correcting system. 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. Unlike suspension forks, 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. Most riders have said they don't experience the usual vibration up their arms, because Loop-wheels absorb and isolate you from the "noise" of the road.

The British engineer who really HASreinvented the wheel: Loop-wheels systemabandons spokes for springs to give asmoother ride.

The Loop-wheel system uses springs instead of spokes, giving the wheel built in suspension. Mr Pearce, who usually designs parts for pushchairs and other vehicles, has spent four years perfecting the idea. The current version is constructed from carbon composite strips developed in conjunction with an archery bow manufacturer. He first made a mountain bike wheel, and itwas incredibly noisy and wouldn't steer - but it worked. The first wheels are designed around the 20- inch wheels commonly used on fold-up bicycle, 'When rider first sit on the bike, it feels normal. 'But as soon as rider rides, on a gravel road, it feels like velvet - there is no noise from the road, and it is exactly like riding a normal bike.

Loop-wheels

Loop-wheels fit the vast majority of manual wheelchairs. They make 24″ and 25″ Loop-wheels for wheelchairs. Their wheels have ½ inch bearings to fit standard ½ inch quick release axle pins. Some wheelchairs take 12mm axles, and they can make Loop-wheels with this size axle bearing too. When you first put the Loop-wheels on the chair, you just need to check that there aren't any bolts sticking out from the side of your chair that could rub against the wheels. This is not usually the case, but it does happen with some chairs and is not a unique problem to Loop-wheels. You should be able to prevent any rubbing by adding some washers to your axle, which will move the wheels out just enough to ensure there is clearance. There are 3 important factors as to whether Loop-wheels are suitable for your bike. 1: Wheelsize. 2: Width of the Drop-out centre The "drop out centre" : on a bike is the distance between the forks where the hub fits. 3: Clearance space above the wheel. This is to allow space for the loop-wheel's suspension to function. As the wheel hits a bump, the wheel moves up towards the frame. You need a minimum of 35mm from the top of the tyre to the underside of the fork (or any other part of the bike frame). If there is less than this 35mm space, your wheel could hit the frame causing it to brake. This is important, If you decide the fit thicker tyres to your Loop-wheels, reduce this clearance gap, If your bike already matches these criteria, you're good to go.



2D Model

Components Used

Bicycle

Tyre

Wheel Rim

Loop Spring

Triangular Wheel Hub

Bicycle

Tyre

Wheel Rim

Loop Spring

Triangular Wheel Hub

SAFETY PRECAUTIONS

The following points should be considered for the safe operation of machine and to avoid accidents:-All the parts of the machine should be checked to be in perfect alignment. All the nuts and bolts should be perfectly tightened. The operating switch should be located at convenient distance from the operator so as to control the machine easily. The inspection and maintenance of the machine should be done from time to time.

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