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Proposed Theory for I-Bicycle

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Abstract: ***"I-Bicycle" refers to a bicycle with the hub-less rear wheel. The main idea behind this project is to develop a hub-less or spoke-less wheel. This bicycle overcomes some drawbacks of the bicycle being used nowadays such as heavy design due to the presence of spokes, power consumption issues, space issues. The advantages associated with this bicycle are light weight due to the absence of hubs or spokes, additional space in the wheel due to the absence of spokes, aesthetic look to the design and lowered center of gravity. The bicycle runs with a "rack and pinion system" connected to the rear-wheel. The paddle gear is connected to the pinion whereas the pinion meshes with the internal teeth of the rear-wheel rim. This bicycle can be used to overcome the above mentioned issues and it's a great innovation in the design of the conventional bicycle which gives the operator a fresh feel while using it and it's awesome and very aesthetic when it comes to the appearance of the bicycle.***

Keywords: Bicycle, Hub-less wheel, I-Bicycle, Spoke-less Bicycle, Gear Drive.

I. INTRODUCTION

Nowadays, the majority of the vehicles are dependent on non-renewable fuels such as petroleum or diesel. Such problems result in an increase in toxicity in the atmosphere, traffic issues, global warming and other environmental hazards. In this era of mass-fuel consumption, a bicycle can be a relief to the environment and can reduce the load and burden on petroleum and diesel reserves.

In order to overcome the drawbacks of the bicycle being used nowadays, we, a group of Mechanical Engineers have come up with an ideology of a spoke-less bicycle, which we have named as "I-bicycle". Modification in the design of the conventionally used bicycle is possible. The basic idea is to design a bicycle with a spoke-less rear wheel, using a "pinion and rack mechanism". Idea is that the constraints that occur on a wheel are at ground level, on the outer periphery. A wheel without x axis enables to support the vehicle at the lowest point. The center of gravity is lowered for better grip. This design reduces the weight as well as it reduces human effort. The concept is to develop a spoke-less or hub-less wheeled bicycle. The benefits desired of this bicycle is to reduce the material used in the bicycle, to reduce the weight of the bicycle as there is absence of hubs or spokes, to provide increased safety while riding and to provide some space to the user so that he can accompany a storage box or can even install an electric motor if required. In addition to this, the development of a hub-less wheeled bicycle results in a reduction in effort applied by the driver while riding the bicycle.

II. LITERATURE REVIEW

S. Mohindar, M. Vinoth Kumar, A. Tamil Arasu, S. Tamizhmaran, R. Tarun, B. Tilak [2017] [1], explained in journal "design and fabrication of lunartic hubless wheel bicycle" states that "Lunartic is a compact urban bicycle concept exploring the combination of different tyre sizes a toothed belt drive and hub less rear wheel as a unique working prototype. The design aims to combine the benefit of both wheel sizes for a balance of speed, size and ride quality. Larger wheels travel faster and are more stable and give comfortable ride while small wheels are light compact and more maneuverable. But small wheeled bikes take up less space and are very manoeuvrable. Belt drives are clean quiet and maintenance free and hub less wheel creates extra space. Big wheels are very stable due to gyroscopic effect of the larger wheel. By using belt drive it replaces the drawbacks made by using a chain drive for transmission of power from driver to driven. By using toothed belt pulley it increases the efficiency of power transmission which intently reduces the work and gains energy."

Andrew J. Horst [2013] [2], in the paper "Hubless wheel and related stroller" states that "A seat is disposed on the frame. The Hub fewer Wheels are disposed on the frame. The Hub less Wheel includes a rim, an internal sliding structure, and at least one bridging component. A tire is disposed on the Hub less Wheel. The rim has an external sliding structure on an inner surface of the rim. The internal sliding structure is disposed inside the external sliding structure. The bridging component is disposed between the external sliding structure and the internal sliding structure. The bridging component revolves on its own axis."

Bennett Ross [2001] [3], in the paper "Spokeless bicycle system" states that "A spoke less bicycle system for providing a bicycle that does not have spokes within the wheels- The inventive device includes a frame having a seat structure and handle bars, a rear bracket having rear bearings within that rotatably engages a rear wheel, a front bracket having front bearings within that rotatably engages a front wheel and a drive train that engages the rear Wheel for driving the rear wheel. The rear rim of the rear wheel includes a rear groove that receives the plurality of rear bearings. The rear rim of the rear Wheel includes a rear gear that is engaged by a drive sprocket from the drive train. The front rim of the front wheel includes a front groove that receives the plurality of front bearings."

Paul E. Lew [1995] [4], in the paper "Hubless wheel" states that "A Hub less wheel for a vehicle which provides advantageous weight and aerodynamic properties. The wheel includes a rotationally stationary inner hoop, coupled to the vehicle, and a rotatable outer hoop, concentric with the inner hoop. The inner hoop and outer hoop are both fabricated with a woven fiber composite shell. A ground engaging tread is disposed on the radial periphery of the outer hoop. Bearings, preferably three rotating bearings spaced circumferentially around the inner hoop at approximately 120° intervals, are mounted on the inner hoop to be rotationally stationary therewith and each includes a support surface on their respective radial peripheries. The support surface is particularly contoured to operatively engage a bearing engaging surface located on the inner periphery of the outer hoop. The outer hoop is axially and radially supported relative to the inner hoop through this engagement to allow rotation there between."

III. PROBLEM DEFINATION

The main aim of our project is to design a drive-system of a bicycle consisting of a spoke-less wheel. This spoke-less wheel consists of a "rack and pinion" arrangement, wherein the pinion (sprocket) acts as the driving element and the rack (rear wheel rim with internal gears) acts as the driven element.

Objectives:
- To design a drive-system with a spoke-less/hub-less wheel.
- To reduce the effort of the driver.
- To reduce the total weight of the bicycle by eliminating spokes from the rear wheel.
- To increase the gear-ratio of the bicycle.

IV. PROPOSED METHODOLODGY

A. Concept Design

This project mainly aims at designing a drive-system of a bicycle with a spoke-less rear wheel by introducing a rack and pinion arrangement in the rear wheel. The basic idea is to transmit power by connecting the peddle gear to the pinion which meshes with the rear wheel-rim having internal gears. The back wheel has internal gears that are attached to the inside of the wheel, and in order to rotate, you had a sprocket attached to it that was attached to a chain. You look at a picture of the bike and see we have this big wheel at the back and a tiny little sprocket working with the pedals. Gear reduction was also necessary because of the design.

B. Market Survey

According to our concept of the project we studied many spoke-less and hub-less bicycle design from various journal papers as discussed above and compared the design of sprocket and chain with normal road bicycles to find out the limitations in the designs normal road bicycle and changes to be made in earlier spoke-less bicycle design. We have been trying to avoid all the limitations of the earlier bicycle. It is important to find out the material suitable to make the bicycle much more efficient and light weight. On the basis of our survey, we selected the data which is further discussed in material selection.

C. Material Selection

1) **Design of Sprocket:** For the given bicycle to be more efficient, sprockets should be as large due to which the working load will be less for a given amount of transmitted power, allowing the use of a smaller pitch chain.
Calculation of dimensions of sprockets are as follows

Where P = pitch of the chain,
N = number of teeth on the sprocket;

Pitch Diameter = $\frac{p}{\sin(\frac{180^\circ}{N})}$

Outside Diameter = $p \times [0.6 + \cot(\frac{180^\circ}{N})]$

Sprocket Thickness = $0.93 \times Roller\ Width - 0.006"$

2) **Design of Chain:** Identification of chai is done with the help of numbers; i.e. a number 40 chain. The digit to the right is 0 for a chain of the standard dimensions; 1 for the lightweight chain; and 5 for rollerless bushing chain. The digits to the left indicate the pitch of the chain in eighths of an inch. For example, a number 40 chain would have a pitch of four-eighths of an inch, or 1/2", and would be of the standard dimensions in width, roller diameter, etc.

The roller diameter is "nearest binary fraction" (32nd of an inch) to 5/8ths of the pitch; pin diameter is half of the roller diameter. The width of the chain, for "standard" (0 series) chain, is the nearest binary fraction to 5/8ths of the pitch; for narrow chains (1 series) width is 41% of the pitch. Sprocket thickness is approximately 85-90% of the roller width.
Plate thickness is 1/8th of the pitch, except "extra-heavy" chain, which is designated by the suffix H and is 1/32" thicker.

TABLE I
ANSI STANDARD CHAIN DIMENSIONS

Chain No.	Pitch	Roller Diameter	Roller Width	Sprocket Thickness	Working Load
25	1/4”	0.130”	1/8”	0.110”	140 lbs
35	3/8”	0.200”	3/16”	0.168”	480 lbs
40	½”	5/16”	5/16”	0.284”	810 lbs
41	½”	0.306”	¼”	0.227”	500 lbs
50	5/8”	0.400”	3/8”	0.343”	1400 lbs
60	¾”	15/32”	½”	0.459”	1950 lbs

3) **Design of Rear Wheel:** The spoke-less wheel is the main drive that is to be rotated by the pinion. For this, purpose teeth were made on the inner circumference of the wheel. The spacing between the holes made is the same as the pitch of the pinion gear. The perfect meshing is made so that the gears move smoothly and helps in driving so that the drive is smooth.

For this, purpose mild steel was used density being 7850kg/m3 and Young’s modulus E = 210GPA

Outer Diameter (OD) =0.4064m
Inner Diameter (ID) =0.36836m
Thickness =0.0254m
Weight =4.62kgs
Here we use 200 full depth involute for weight bearing and less friction.
Minimum number of teeth to avoid interference on the pinion is 18.
Assuming, minimum number of teeth =32
D1 = Inner diameter of Rack = 0.3683m
D2 = Diameter of Pinion = 0.1016m

As we know,

$$\frac{D1}{D2} = \frac{T1}{T2}$$

$$\frac{0.3683}{0.1016} = \frac{T1}{32}$$

Module (m) = $\frac{D}{T} = \frac{0.4064}{116} = 3.175 \times 10^{-3}$

TABLE II
REAR WHEEL PINION DIMENSIONS

Addendum	1 m	3.175×10^{-3}
Dedendum	1.25 m	3.968×10^{-3}
Working Depth	2 m	6.35×10^{-3}
Min. Total Depth	2.25 m	7.143×10^{-3}
Tooth thickness	1.5708 m	4.98×10^{-3}
Min. Clearance	0.25 m	0.79×10^{-3}
Filter radius at root	0.4 m	1.27×10^{-3}

V. CONCLUSIONS

The hubless wheel is a futuristic wheel which eliminates the limitations of any conventional hub motored vehicle. In the present situation, where safety, quality, and accessibility are a major concern, it provides a solution to each of them. The current wheel design exhibits its uniqueness in terms of the mode by which the power is getting transmitted. The removal of hub and spokes introduces safety in the device and ride experience enhances as the use of hubless wheel provides better vehicle stability. The presence of non-complex components in the design makes it more serviceable and accessible. A hubless bicycle can be commercialized in order to replace Hub wheel into the Hubless wheel. The hubless bicycle is innovative design, which required less effort and speed will increase compared to traditional bicycle as per customer satisfaction. The maximum speed limit of the drive mechanism is improved. Storage space is also available. It can save the energy and also free pollution.

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