Lever Driven Bicycle

Mebin Mathew
B. Tech Student
Department of Mechanical Engineering
Saintgits College of Engineering, Pathamuttom, Kottayam, Kerala

Natheem Nasar
B. Tech Student
Department of Mechanical Engineering
Saintgits College of Engineering, Pathamuttom, Kottayam, Kerala

Rahul Mohan M
B. Tech Student
Department of Mechanical Engineering
Saintgits College of Engineering, Pathamuttom, Kottayam, Kerala

Vijaya Krishnan R
B. Tech Student
Department of Mechanical Engineering
Saintgits College of Engineering, Pathamuttom, Kottayam, Kerala

Er. K C Joseph
Guide & Professor
Department of Mechanical Engineering
Saintgits College of Engineering, Pathamuttom, Kottayam, Kerala

Abstract

The bicycle is only one of the many man-developed lever systems for land transport, but it is the sole remaining type that has a limited propulsive power. Millions of people around the world still rely on their trusty clunkers for cheap and efficient transportation. In fact, the global fleet approaches a billion, with the vast majority circulating in developing countries like Cuba and China where automobiles remain a luxury. Recreational riders continue to take to their wheels for exercise, adventure, and companionship. The Lever Driven Bicycle consists of the following parts: mounting plate, torsion spring and oscillating lever. The lever is pivoted at a point on the mounting plate which is fixed to the bicycle frame and a torsion spring is present in between the mounting plate and the lever. The end of the lever contains a gear sector which is in mesh with the free wheel. This changes the existing conventional driving mechanism by the oscillating motion of a lever into rotatory motion of the wheel. The downward motion of the lever is powered by the human leg and the return or the upward movement of the lever is achieved by the use of torsion spring. The main objectives of this project work is to reduce the effort which is required for cycling and provides a means of transportation to peoples with small disability to his or her legs (i.e. a person with a leg shorter than the other), reduced maintenance which is regularly required for a conventional bicycle (lubrication and tightening of the chain, freewheel and crank set), provides a way of transportation by applying effort only on a single lever and a new way for cycling to the cycling enthusiasts.

Keywords: Bicycle Drives, Bicycle Frame, Freewheel mechanism, Mechanical Advantage, Torsion Spring

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I. INTRODUCTION

A. *History:*

The dandy horse, also called Draisienne or laufmaschine, was the first human means of transport to use only two wheels in tandem and was invented by the German Baron Karl von Drais. It is regarded as the modern bicycle's forerunner; Drais introduced it to the public in Mannheim in summer 1817 and in Paris in 1818. Its rider sat astride a wooden frame supported by two in-line wheels and pushed the vehicle along with his/her feet while steering the front wheel.

The first mechanically-propelled, two-wheeled vehicle may have been built by Kirkpatrick MacMillan, a Scottish blacksmith, in 1839, although the claim is often disputed.

In the early 1860s, Frenchmen Pierre Michaux and Pierre Lallement took bicycle design in a new direction by adding a mechanical crank drive with pedals on an enlarged front wheel (the velocipede). Another French inventor named Douglas Grasso had a failed prototype of Pierre Lallement's bicycle several years earlier. Several inventions followed using rear-wheel drive, the best known being the rod-driven velocipede by Scotsman Thomas McCall in 1869. In that same year, bicycle wheels with wire spokes were patented by Eugène Meyer of Paris. The French vélocipède, made of iron and wood, developed into the "penny-farthing" (historically known as an "ordinary bicycle". In 1868 Rowley Turner, a sales agent of the Coventry Sewing Machine Company (which soon became the Coventry Machinist Company), brought a Michaux cycle to Coventry, England.

Further innovations increased comfort and ushered in a second bicycle craze, the 1890s Golden Age of Bicycles. In 1888, Scotsman John Boyd Dunlop introduced the first practical pneumatic tire, which soon became universal. Soon after, the rear freewheel was developed, enabling the rider to coast. This refinement led to the 1890s invention of coaster brakes. Dérailleur gears and hand-operated Bowden cable-pull brakes were also developed during these years, but were only slowly adopted by casual riders. Bicycles and horse buggies were the two mainstays of private transportation just prior to the automobile, and the grading of smooth roads in the late 19th century was stimulated by the widespread advertising, production, and use of these devices.

B. Problem:

To date there have been three principal drive types used to drive the motorcycle rear wheel. Shaft drive, belt drive and chain drive. All of them date back around 100 years, all have advantages and disadvantages.

Shaft drive is very clean, very reliable and very durable but it is also complex, heavy and much more expensive to produce. On top of that, it has little or no ability to vary the final drive ratios making it almost useless for any type of sports bike. Its use is generally restricted to big and fairly expensive touring bikes.

Belt drive is also very clean, quiet and relatively inexpensive to produce. However, the belts are not nearly as strong as chains. To make them as strong, they would need to make them wider and a belt running on a modern day superbike would need to be many inches wide, making it completely impractical. Changing gearing is also much more difficult and they are completely impractical off road.

Chain drive, on the other hand, is cheap to produce, is fairly durable, is narrow enough to pass the rear wheel easily, is strong enough for all modern day applications, can be used on or off road and can easily vary the gearing ratios. Its only real negatives are that it gradually wears out, is fairly noisy and is relatively messy with chain lubrication. Also regular tightening of the chain is always required for proper traction.

With this project the reduction in the regular maintenance and lubrication of the drive mechanism can be achieved. The main advantage of this project is that it reduces the effort while pedaling in an ordinary/conventional bicycle. A person with small disability can use this bicycle without any problem.

C. Methodology:

To overcome the disadvantages of the existing drive mechanisms used in conventional bicycle, a new drive mechanism was designed. The designed mechanism is known as Lever Drive. Using SOLIDWORKS software, the new mechanism was designed and the analysis was done using ANSYS software. Finally the new drive mechanism was fabricated, implemented and tested on the conventional bicycle.

II. OBJECTIVES

The main objective of this project is to modify the existing drive mechanism of a bicycle so as to reduce the effort which is required for the driving of a conventional bicycle. This can be achieved by modifying the existing drive mechanism of our conventional bicycle by removing the chain drive and attaching an oscillating lever pivoted at a point on the bicycle frame as discussed below and providing a gear sector at the end of the lever. The lever oscillates by an effort on the other end of the lever by human legs. Similarly there is another lever at the other side of the bicycle frame.

The next objective of this project is to provide a means of transportation on the bicycle to a person with a small disability to his or her legs (i.e. a person with a leg shorter than the other). Thus by using the Lever Driven Bicycle the person with the disability will not have to extent his legs for the complete rotation of the crank set for motion. He just only requires oscillating the lever with his legs up to his ability.

The other objective of this project is the reduction of the maintenance which is regularly required for a conventional bicycle (lubrication and tightening of the chain, eliminates lubrication and replacement of the ball bearing in the crank set due to wearing while pedaling). Also it provides a way of transportation by applying effort on only a single lever.

It also provides a new way for cycling to the cycling enthusiasts.

III. DESIGN

A. Mechanical Advantage:

The mechanical advantage of a lever is the ratio of the length of the lever on the applied force side of the fulcrum to the length of the lever on the resistance force side of the fulcrum. It is also defined as the ratio of the resistance force to the applied force.

$$\text{MA} = \frac{\text{Length of the lever on the applied force side of the fulcrum}}{\text{Length of the lever on the resistance force side of the fulcrum}}$$

$$= \frac{\text{Resistance force}}{\text{Applied force}}$$

B. Arc Angle:

Angles are formed when two lines meet at a point. It is defined as the measure of turn between the two lines. The unit of angle is radians or degrees. It can be measured in degrees using the radius and the arc length of the circle. There are also other angles like complementary angles, supplementary angles, interior angles etc.

$$Angle = \frac{Arc\ length\ \times 360^0}{2\pi \times Radius}$$

C. Helical Torsion Spring:

These are wound in a similar manner as helical compression or tension springs but the ends are shaped to transmit torque. The primary stress in helical torsion springs is bending stress whereas in compression or tension springs, the stresses are torsional shear stresses.

$$\text{Bending stress, } \sigma_b = \frac{32 \times T}{\pi \times d^3}$$

where T is the Torque acting on the spring and d is the diameter of the spring wire.

$$\text{Number of coils, } n = \frac{\theta \times E \times d^4}{64 \times T \times D}$$

where ϴ is the angle of twist, E is the modulus of elasticity and D is the mean diameter of the spring.

IV. RESULTS AND DISCUSSIONS

The Lever Driven Bicycle consists of the following parts such as a mounting plate, a torsion spring, an oscillating lever. The parts of the Lever Driven Bicycle are shown in the fig. 1(b) and (c). The lever consists of a gear sector (in mesh with freewheel) at one end and a pedal at the other end. The mounting plate is mounted on the bicycle frame; the lever is mounted and pivoted at a point on the mounting plate and a torsion spring is present in between the mounting plate and the lever. This changes the existing conventional driving mechanism into Lever Drive mechanism, in which the lever oscillates by the effort of the human leg on the pedal. This oscillating motion of the lever is converted into rotatory motion of the free wheel and thus the rear wheel. The return of the lever is achieved by the use torsion spring at the pivoted point.

Fig. 1: (a) Lever Driven Bicycle. (b), (c) Parts of Lever Driven Bicycle.

Static structural analysis was carried out on the bicycle frame and is as shown in the figure 1. The total deformation of the frame was analyzed which is shown in the fig. 2(b). A load of 981 N was applied on the frame and the total deformation distribution was studied. A maximum of 8.7476e-8 m and a minimum of zero deformation were obtained. The equivalent elastic strain distribution on the bicycle frame due to the loading is as shown in the fig. 2(d). It shows that a maximum of 1.094e-5 m/m is the maximum elastic strain acting on the bicycle frame due to the loading. The equivalent stress distribution on the bicycle frame due to the loading is as shown in the fig. 2(c). It shows that a maximum of 2.1879e6 Pa is the maximum stress which is acting on the bicycle frame due to the loading. But the ultimate strength and yield strength of the bicycle frame material are 4.6e8 Pa and 2.5e8 Pa respectively. Therefore we can conclude from the analysis that the design of the bicycle frame is safe.

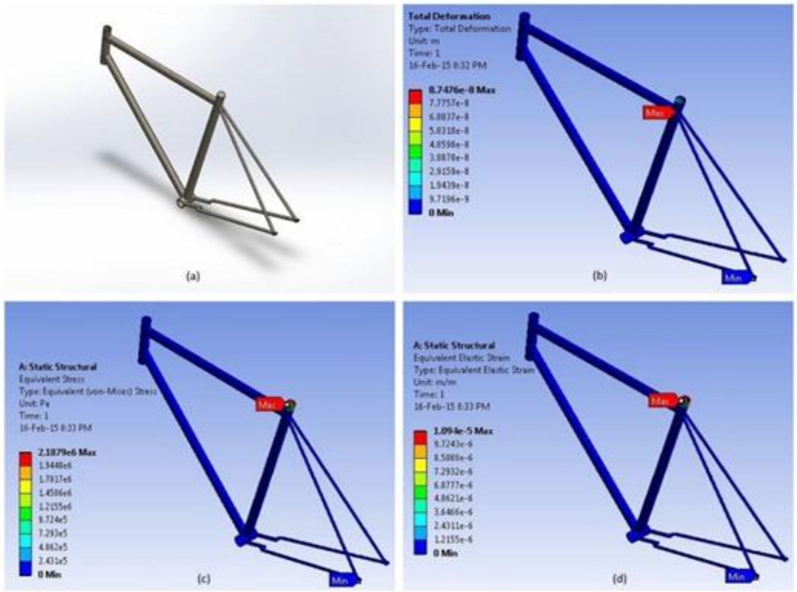

Fig. 2: (a) Bicycle Frame. (b) Total Deformation. (c) Stress Distribution. (d) Strain Distribution.

The static structural analysis of the Lever Driven Bicycle was studied and various distributions were formulated. The fig.3 (a) shows the whole assembled Lever Driven Bicycle with the main parts: oscillating lever, torsion spring, mounting plate and gear sector. The total deformation of the assembly was analyzed which is shown in the fig.3 (b). A load of 441.45 N was applied on the assembly and the total deformation distribution was studied. A maximum of 0.0011187 m and a minimum of zero were obtained. The equivalent elastic strain distribution on the assembly due to the loading is as shown in the fig.3 (d). It shows that a maximum of 0.00070512 m/m is the maximum elastic strain acting on the assembly due to the loading. The equivalent stress distribution on the assembly due to the loading is as shown in the fig.3 (c). It shows that a maximum of 1.3961e8 Pa is the maximum stress which is acting on the assembly due to the loading. But the ultimate strength and yield strength of the material which used are 4.6e8 Pa and 2.5e8 Pa respectively. Therefore we can conclude from the analysis that the design of the Lever Driven Bicycle is safe.

The mechanical advantage of the Lever Driven Bicycle was found to be greater than one. But for conventional bicycle the mechanical advantage was found to be less than one. All that it means is that the conventional bicycle is not designed to amplify force, but the Lever Driven Bicycle is designed for the same. Therefore we can say that the effort for riding a bicycle was reduced and the Lever Driven Bicycle makes riding effortless. It provides a means of transportation on the bicycle to a person with a small disability to his or her legs (i.e. a person with a leg shorter than the other). Thus by using the Lever Driven Bicycle the person with the disability will not have to extent his legs for the complete rotation of the crank set for motion. He just only requires oscillating the lever with his legs up to his ability. The reduction of the maintenance which is regularly required for a conventional bicycle such as lubrication and tightening of the chain, eliminates lubrication of the ball bearing in the crank set and the replacement of the ball bearings in the crank set. It also provides a way of transportation by applying effort only on a single lever. It also provides a new way for cycling to the cycling enthusiasts.

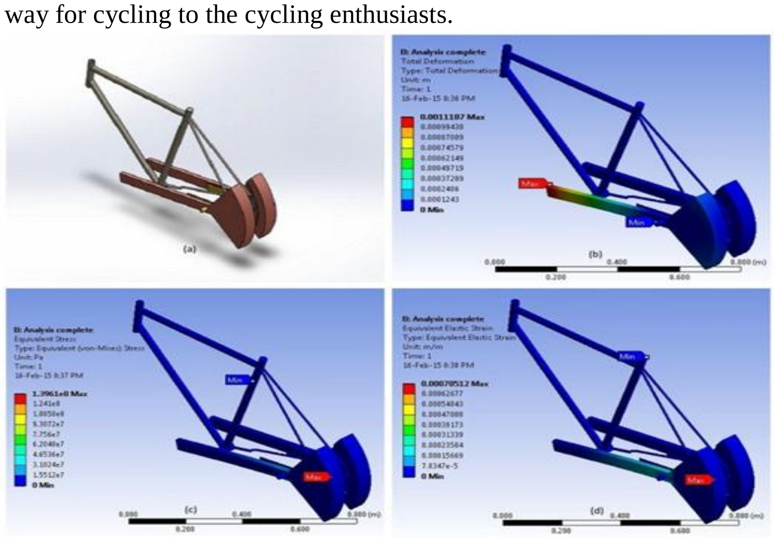

Fig. 3: (a) Lever Driven Bicycle. (b) Total Deformation. (c) Stress Distribution. (d) Strain Distribution.

V. CONCLUSIONS

With the attachment of the mounting plate, the torsion spring, the lever and the gear sector on the bicycle frame we can reduce the effort for powering the bicycle. With successful fabrication we can say that the bicycle has been transformed into Lever Driven Bicycle. With the use of the Lever Driven Bicycle we can conclude the following

1) The mechanical advantage of the Lever Driven Bicycle was found to be greater than one. But for conventional bicycle the mechanical advantage was found to be less than one. All that means is that the conventional bicycle is not designed to amplify force, but the Lever Driven Bicycle is designed for the same. Therefore the effort for riding a conventional bicycle was reduced by modifying it into a Lever Driven Bicycle.
2) The next conclusion of this project is to provide a means of transportation on the bicycle to a person with a small disability to his or her legs (i.e. a person with a leg shorter than the other). Thus by using the Lever Driven Bicycle the person with the disability will not have to extent his legs for the complete rotation of the crank set for motion. He just only requires oscillating the lever with his legs up to his ability.
3) The other conclusion of this project is the reduction of the maintenance which is regularly required for a conventional bicycle such as lubrication and tightening of the chain, eliminates lubrication of the ball bearing in the crank set and completely removes the regular replacement of the ball bearing in the crank set. It also provides a way of transportation by applying effort only on a single lever.
4) It also provides a new way for cycling to the cycling enthusiasts.

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