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CHAINLESS BICYCLE SYSTEM

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ABSTRACT

Chainless Bicycle System (CBS) is a setup which makes bicycles run on the road without chains. CBS uses a shaft-driven concept; it uses a drive-shaft for the transmission of power from the pedals to the wheels in place of chains. In the present era, development in internal gear technology produces various advantages. So, I decided to construct a bicycle using the shaft-driven system rather than using chain-driven. In this system, I use bevel gears, shaft rod, and another two bevel gears and the hub assembly. The rider pushes the pedal which rotates the shaft rod using bevel gears at the front end. This rotating shaft has a bevel gear at the rear end also which meshes with another bevel gear on the rear hub along with the rear wheel and drive the rear wheel of bicycle. CBS is fully enclosed, requires less maintenance, and periodic lubrication through grease gun. Chainless Bicycle System is very comfortable and produces efficient transmission of power from the rider's foot to the rear wheel. The rider's footwear, pants do not get accidental damage. Cyclist of this chainless bicycle system does not get injured because of chain bite as in this system chain are not present.

KEYWORDS: Chainless Bicycle System, Shaft Drive Bicycle, Bicycle with bevel gears, Components of shaft drive bicycles, Design of Chainless Bicycle.

I. INTRODUCTION

Chainless Bicycle System (CBS) is a setup which makes bicycles run on the road without chains. CBS uses the shaft-driven concept; it uses a drive-shaft for the transmission of power from the pedals to the wheels in place of chains. Shaft Driven Bicycle was introduced over the period almost 100 years ago. In the present era, development in internal gear technology produces various advantages. So, I decided to construct a bicycle using a shaft-driven system rather than using chain-driven. In this system, I use bevel gear in place of chain-ring, also shaft rod in place of chains, and another two bevel gears which mounted on the front and rear end of the shaft and the hub assembly. For the maintenance of Gears to keep their running smooth, quiet and efficient, the shaft-driven bicycle requires periodic lubrication only which can be done by grease gun. Chainless Bicycle System is very comfortable and produces efficient transmission of power from the rider's foot to the rear wheel hug along with the rear wheel.

CBS is capable of maintaining the following details:-

- Frame: Chainless Bicycle frame is very durable and life lasting. Capable of carrying 80 kg weight and look very decent and attractive.
- Tyres: Normal size road tyre of 700mm.
- Brakes: We can use either Rim Brake or Disc brake.
- **Drive Train**:

a. Chainless bicycle run using shaft rod, hub and bevel gear. This shaft-drive bicycle uses a large bevel gear in place of a chain-ring also called sprocket that can commonly see in traditional bicycles. This bevel gear meshes with another bevel gear which mounted on a drive shaft.

b. At the rear end of the bicycle's drive-shaft has another bevel gear, this gear meshes with the bevel gear of rear wheel hub, where traditional bikes would have rear sprocket.

c. At the front end, the meshing of the bevel gears allows the axis of drive torque from the pedal to be turned by 90 degrees. That cancelling out the axis change of drive torque produces through bevel gears set on the rear end.

➢ **Use of drive shaft: -**

Drive-shaft has gears on its both ends. The Drive-shaft is an intermediate axle which used to connect the gears on rear wheel hub to the front bevel gear through meshing up with bevel gears on both sides of shaft respectively. For pushing the bicycle forward and reverse it is necessary to transfer the generated torque to the rear wheel, this work has done by drive shaft assembly. It has to provide a secure and smooth pass of power to the axles.

Purpose of the Drive Shaft (Propeller Shaft):

Drive-shaft is the heart of this Chainless Bicycle System. Employing drive-shaft power is transmitted to the rear wheels. It has bevel gears on it's both ends.

The bevel gear in place of chain-ring has mashed with the bevel gear of the shaft at the front end. At the rear end, Gear mounted on the rear hub is meshing up with the bevel gears on the shaft. For pushing the bicycle forward and reverse the torque which has produced through paddling the bicycle crank has to transfer to the rear wheels. The Drive-Shaft is used to transmit torque to the rear wheel from the front.

Functions of the Drive Shaft

- It has to transfer torque from the foot pedal to the rear wheel for the motion of the bicycle.
- It is needed to transfers the highest torque through paddling during the operation.
- Drive-Shaft must have the ability to rotate at high speed as per the requirement of the vehicle.
- Drive-Shaft has to work correctly through persistently changing angles between the shaft, transmission and the axles.

Comparison of Shaft Drive vs Chain Drive: -

- This Shaft-Driven System is packed and has not affected by weather and only needs periodic lubrication whereas, Chain-Drive System needs lubrication frequently, mainly in poor weather condition that may be dirty and troublesome.
- Shaft Drive System is the most robust, soft and requires less maintenance, costs and cleanliness. Whereas, Chain Drive System is generally open to the elements and generates a lot of dust and dirt also needs their chains adjusting time to time as chain length tends to increase over time. And they can be expensive to restore when they wore out.
- Shaft-Drive System consists of an axle connected to the output of the gearbox through a universal joint, which is a coupling that transmits the torque at a selected angle. At the other end, the axle has connected to the rear wheel hub through a spiral bevel gear. The bevel gear rotates the wheels by turning this axle 90 degrees. Whereas, Chain-Drive System consists of a simple connection chain that connects the sprockets.
- Shaft-Drive System is very smooth and generates no noise while Chain-Drive System is noisy, especially when the chain is loose.

Reasons to Make Chainless Bicycle System

In school life, children go to school by using a bicycle and face some issues like:-

➢ The grease, oil of chain makes their school dress, clothes dirty.
➢ When they are going to school and coming back to home, the chain gets losses. And they have to stand the bicycle, fix the loose chain to the sprocket by using their hands.

These issues can be resolve by using Chainless Bicycle. This bicycle is very durable and comfortable.

Objectives of the Chainless Bicycle System

➢ To increase the durability of a bicycle.
➢ To reduce the overall maintenance cost of a cycle.
➢ To make cycle better, comfortable and admirable.
➢ To increase the overall strength and power.
➢ To increase the efficiency of the bicycle system.
➢ To reduce the dirty clothes problem caused by grease.

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II. LITERATURE REVIEW

2.1 Introduction

The shaft is usually circular in cross-section and a long piece of metal which are used to turn and transmits power from one part of the machine to the other parts. Generally, they are used to transfer torque and rotational motion from one point to another point. Due to the input force and load on Chainless Bicycle, this system has subjected to torsional and shear stress. That is why this system needs to have enough strength to bear these stresses, without imposing additional inertia by the weight of the shaft. In the present scenario, bicycles use chain drive system or rigid driveshaft system for transmitting power to the rear wheel from the pedals.

2.2 History of Chainless Bicycle (Shaft Drive Bicycle):-

- First time 'Thomas Moore' use driven shaft concept and make Orbicycle:- a tricycle in 1880.
- After 1897, League Cycle Company of Columbia started to produce shaft-driven bicycle and market them.
- Between 1898 and 1899, the chainless bicycle gets the attention of people. But because of their high cost, sales of the regular-bicycle are more that chainless bicycle.
- Due to the limited manufacturing technology at that time, these bicycles are less efficient as compared to regular-bicycles.
- Shaft drive bicycle is complex to dismantle when repairing the rear tyre.
- In 1902, the three-speed shaft-driven bicycle had manufactured by Hill-Climber Bicycle Manufacturing Company. This company use three sets of bevel gear for the shifting of the shaft.
- At the starting of the 20th century, shaft-driven bicycle disappears because of their less marketing and high cost.

2.3 Different Types of Shaft

a) **Transmission shaft**: These kinds of shaft receive and transmit power to the wheels and output source. They generally made up of stainless steel. The common types of transmission shafts are overhead shaft, line shaft, and the countershaft. These shafts are subjected to the bending moments and torque, axial force as they carry machine parts like gears, pulleys etc.

b) **Machine Shaft:** They are the integral parts of a machine and usually are of short rotating type shafts. The common types of machine shafts are crankshafts and spindle. These shafts are also subjected to axial force, bending moments and torque. Crankshafts have used to convert reciprocating motion into rotational motion.

c) **Axle:** They are the shaft which used to transmit the bending movement from one part of a machine to another. It is a stationary machine element of the system. We can say that these shafts used to support the rotating object.

d) **Spindle:** They are the shafts that transmit motion either to a work-piece or to the cutting tool. These spindles are very short shafts. For example; lathe spindle and tinny shaft use in a drilling operation.

Shafts are used frequently in too many places. In the present time approximately in all place as a machine element, where the transmission of power is required. Such as:

1) Shafts which have used to transfer power to the differential gearbox from the main gearbox; are generally called drive-shaft frequently used in automobiles.
2) Shafts which play a role to transmit power from the gearbox to the propeller which attached on it; are called ship propeller shaft.
3) A Shaft which has used to transfer power from the source to the rail rotor fan; is generally called tail rotor shafts used in the helicopter.

2.4 Demerits of Traditional Drive Shaft Bicycle

1. It has less strength and durability.
2. They are very heavy in weight.
3. The corrosive resistance property of the traditional drive-shaft is low as compare to EN 8 material.
4. The cyclist has to apply high power for the motion of a bicycle.
5. They produce more noise and vibrations.

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2.5 Benefits of EN 8 Drive Shaft Bicycle

1. The use of EN 8 material makes this bicycle system strong and durable.
2. It is less in weight as compared to traditional shafts.
3. EN 8 provides moderate wear resistance and reasonable tensile strength.
4. The cyclist can run bicycle smoothly and efficiently.
5. They produce little noise and vibrations.
6. Components that require greater strength than that of steel are generally made up of EN 8 because it is suitable for all engineering purposes.
7. In this system, drive-shaft has made up of small diameter. Because of the use of EN8 material, this system can endure a high level of stress.

2.6 Drive Shaft Vibration

Drive Shaft vibration is the phenomenal problem that can be caused by many conditions in the drive shaft. Vibration is generally caused by worn-out U-Joint, out of balance components, out of misaligned angles etc. It has difficult to find out where the vibration occurs in the vehicle either from the drive-shaft or something else.

As per the conditions, vibrations may be torsional or transverse. The torsional vibrations occur from the improper arrangement of joint angles in this chainless bicycle system. It creates a sound disturbance which can be noticeable. Transverse Vibrations has generally occurred by the dust and foreign material present on the shaft. Vibration can be notice and the result of an unbalanced condition on the shaft. These vibrations can damage the universal joint and bearing if they are very high.

III. COMPONENTS OF CHAINLESS BICYCLE SYSTEM

3.1 Pedal

A bicycle pedal has used to propel the bicycle by pushing pedal through the rider's foot. It is the main parts of the bicycle system.

Pedals have connected to the crank. It acts as a medium that connects the rider's shoe or foot and crank. Another end of the pedal has connected to the bevel gear. That makes the connection with the bevel gear on the shaft at the front end. Pedals allow the leg to move and turn the bevel gear.

In this project, I am using Simple Platform Bicycle Pedal because it has a large flat area on which foot can easily take rest. It gives the user more comfort and more control over the movement of pedals.

3.2 Brakes Arrangement

Bicycle Brake is used to stop the movement of wheels or slows down the bicycle when the rider applies it on the system. Following are the main types of brakes:

1) Disc brakes
2) Rim brakes
3) Drum brakes

This Chainless Bicycle Brake system is consists of three main elements:-

a. This system consists of brake pedal or the brake levers mechanism to apply brakes on bicycle by pushing that through cyclist.
b. This system consists of cables, rods, hydraulic hoses for the purpose to create a mechanism that transmits the brake signal.

c. This system may consist of drum or calliper for the purpose of converting the kinetic energy of the bicycle into thermal energy through pressing two or more surface together; it dissipates as a form of heat. It can also say that the third element is the brake mechanism itself.

I am using a Disc Brake in Chainless Bicycle. It consists of a metallic disc which rotates with the wheel as it attached to the wheel hub. I joint the calliper to the chainless bicycle's frame along with the pads that are used to pushes the rotors for braking purpose. Because of the pads that drag against the disc then to the wheel, the kinetic energy (motion) of the bicycle is dissipated in the form of heat and slows down the bicycle. Disc brake mainly applied through hydraulically or mechanically by cables. The main reason for choosing disc brake is they tend to perform great in every weather conditions including mud, snow and water.

3.3 HUB

Hub is itself used to connect the axle to the bicycle's wheel. It is a central element of bicycle's wheel from which the spokes radiate, and it consists of bearing, axle and a hub shell. The hub shell is attached to the spokes employing its two machined metal flanges. In older designs, flanges are attached to the separated hub shell. Within the hub, bearings provide rotation around in the axle.

3.4 Bearings

A bearing has used to reduce friction between moving parts to the desired motion. It is the element of the machine. In this project, a bearing used in both front & rear axles. The function of the bearing is to supplying moving parts a free linear and rotational movement around the fixed axis. The bearing allows wheel along with the hub shell to rotate freely around the axles. We can commonly see that bicycle hub generally used ceramic or steel ball bearing.

3.5 Drive-Shaft

The function of the shaft is to transmit power from a machine part to another part. It is a rotating machine element.

- Shaft drive consists of two bevel gears, shaft rod and fully enclosed.
- The cyclist wants the motion and delivered power to the shaft employing pedalling. That power is delivered by some inertia force, tangential force, torque and twisting moment which set up within the shaft. And shaft allows that power to be transferred further to other machine elements which connected to the shaft.

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- In this chainless bicycle system, drive-shaft is the major part which plays the major role that is played by chains in chainless bicycle system. Simply say, drive-shaft plays the role of a chain.
- Drive-shaft and pedal have connected through the bevel gears; this connection allows transferring of power to the drive-shaft from the pedals which further goes to the rear wheel and drives the wheels.
- That power which comes through the rider's foot to the pedal and transfer to the drive shaft then revolves the shaft rod that drives the rear hub and the rear wheel for the motion of cycle.

3.6 Bevel- Gear

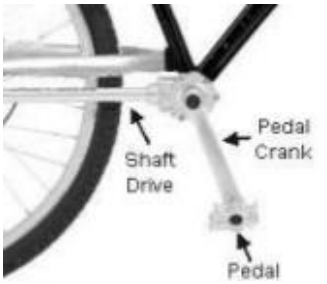
These gears have conically shaped tooth-bearing faces. It is the type of gear which used to intersect the axis of two shafts.

- On the shaft, bevel gears have usually mounted 90 degrees apart. I also can work on the other angles as per the requirements.
- Bevel gear's pitch surface is conical in shape.

Generally, bevel gear's tip is cut and this gear has a shape of a right circular cone. The imaginary vertices of bevel gears must have to inhabit a similar point during the meshing of the bevel gears. At the same point, their shaft axis also intersects and has to form an arbitrary non- straight angle between the shafts. That angle can't be zero or 180 degrees. Miter gear is a form of bevel gear which as equal numbers of tooth and shaft axes at 90 degrees.

3.7 Crankset

It is an element of chainless bicycle system which is used to converts the reciprocation generate through rider's leg into the rotatory motion. Rider's legs generate reciprocating motion through pedalling and transfer that motion into drive shaft as a form of rotational motion which drives the shaft rod. Crankset front end is attached to the pedal which rider used to push and other end is attached to the shaft rod by means of bevel gear.



IV. DRIVE MECHANISM

4.1 Introduction

- Gears have come in the vast range of tooth, shape and sizes. For driving the shaft, meshing gears have to transmit rotational motion. As compared to the large gear, small gears rotate much faster. But the torque of large gear is proportionally more than the small gears. To achieve, a particular arrangement of the drive mechanism, both meshing gears have the same linear speed at the pitch diameter.

- Gears can produce both translational and rotational motion as per the arrangements of the gear system. Gears have cut teeth; they are machine elements which rotate and mesh with other toothed or cut parts to perform a function of transmitting torque. When gear meshes with stationary toothed machine part, it produces translation motion. These gear devices have used to transmit power, change the torque and speed and also to change the direction of power. Gear can transmit high torques values. Employing different gear ratios, they provide various mechanical advantages.
- We can make a gear system according to the need where two, three or more gears mesh with each other to transmit power. When gear of different sizes with similar tooth size is meshes, they produce a mechanical advantage such as high torque. The meshing of teeth of gears prevents slippage. The efficiency of gear is very high.

4.2 Types of gears

4.2.1 External gear:- These are the types of gear framing up teeth on the outer surfaces are called the external gear. Surfaces are usually cylindrical or conical

4.2.2 Internal gear:- These are the types of gear framing up teeth on the inner surfaces are called internal gear. Surfaces are usually cylindrical or conical. When the pitch angle is more than 90 degree then this type of internal gear is named as bevel gears.

4.3 BACKLASH

During the meshing of gears, the backlash is the amount by which tooth space exceeds the thickness of gear. For smooth rotation of messed gears, a little backlash is necessary & for the high precision gear application, zero-backlash or low backlash has required. In simple words, backlash refers to the size of the gap between the trailing face of the meshing tooth. If the amount of backlash is high then it can damage teeth and other components. Backlash should be less than 1/10 of the module.

4.4 Gears Shifting

It is the marvellous phenomena of the meshing of gears provide various advantages and have several outcomes. As per the requirement of the vehicle and task, we have to change the gear ratio.

4.5 Gear material

Generally, gears have made up of steel. As per the requirements, Gears may have made up of other materials like cast iron, aluminium, plastic and nonferrous alloys. It has also made up of iron-based material. Generally, gears are made up of steel material because steel is available easily in the market, cheap in price, come with a lightweight and have high strength. The strength of gear is different and depending upon the type of material, heat treatment & quenching applied. Plastics have various properties including low-speed meshing, dirt tolerance. Plastics do not need extra lubrication. That is why; a well manufactured plastic gear can take the place steel gears in a few ways.

V. CONCEPT OF MACHINE DESIGN

Machine Design Consideration

Following points has to consider while designing a machine: -

- ✓ Applied forces that cause many types of stress and load on the system
- ✓ Material selection should have based on factors like strength, weight and durability.
- ✓ Consider the material with moderate weldability, machinability, and corrosion resistance properties.
- ✓ Cost of making the machine, etc.
- ✓ Consider the kinematics to deal with rotational motion, oscillation and reciprocating motion.
- ✓ Components size, design and form.
- ✓ Frictional resistance and ease of lubrication.
- ✓ Use of standard parts.
- ✓ Select the material with high weldability.
- ✓ Optimize part handling.
- ✓ Assemble in the open area.
- ✓ Manufacturing facilities available.

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VI. MATERIAL SELECTION

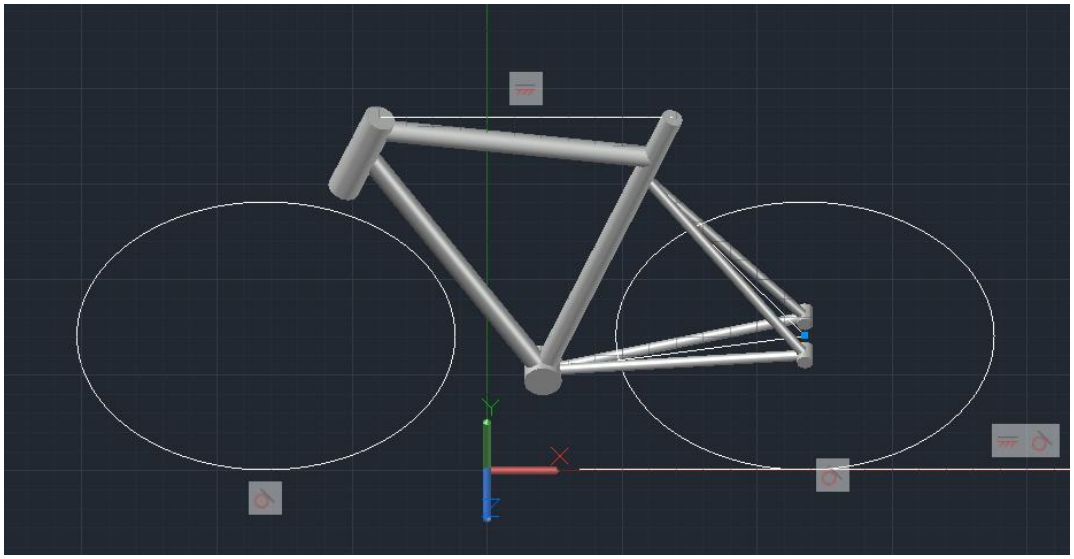
Based on the availability, cost and mechanical properties, I decided to make the Chainless Bicycle System as per the material I mention below.

Sr. No.	Element Name	Use Material
1	Shaft	EN-8
2	Bearing	Cast Iron
3	Bevel gear set	Alloy Steel
4	Frame	Mild Steel
5	Universal Joint	Alloy Steel
6	Rod	Mild Steel

VII. CHAINLESS BICYCLE SYSTEM DESIGN

7.1 Introduction

Chainless bicycle system has used drive shaft in place of chains to transfer power to the rear wheel by means of pedalling the bicycle through pedals. This system use shaft rod and gears as the main parts to deliver power to the wheel. Chainless Bicycle is very smooth and efficient. The shaft-driven bicycles were introduced 100 years ago but have not got popularity because chain drive bicycles system comes with the possibility of various gear ranges with the sprockets assembly. In the present scenario, few modern shaft-driven bicycles have introduced due to the advantages of internal gear technology.



I design a suitable drive shaft which can take the place of chain drive easily and transfer power to the rear wheel from the pedals through pedalling without creating any issue. For keeping running of gears smooth and quiet, this chainless-bicycle system needs periodic lubrication. This setup of bicycle provides the transfer of energy efficiently to the rear wheel from the pedals.

7.2 Construction and Working Principle

- The shaft may be of two types that are propeller shaft and drive-shaft. The propeller shaft has used to propel the vehicle and drive-shafts are one which we use to transferring motion from one point to another. In this chainless bicycle system, the drive shaft has used to transfer rotational motion from the front end of the bicycle to the rear wheel to propel the bicycle forward so in this project drive-shaft also referred as the propeller shaft.

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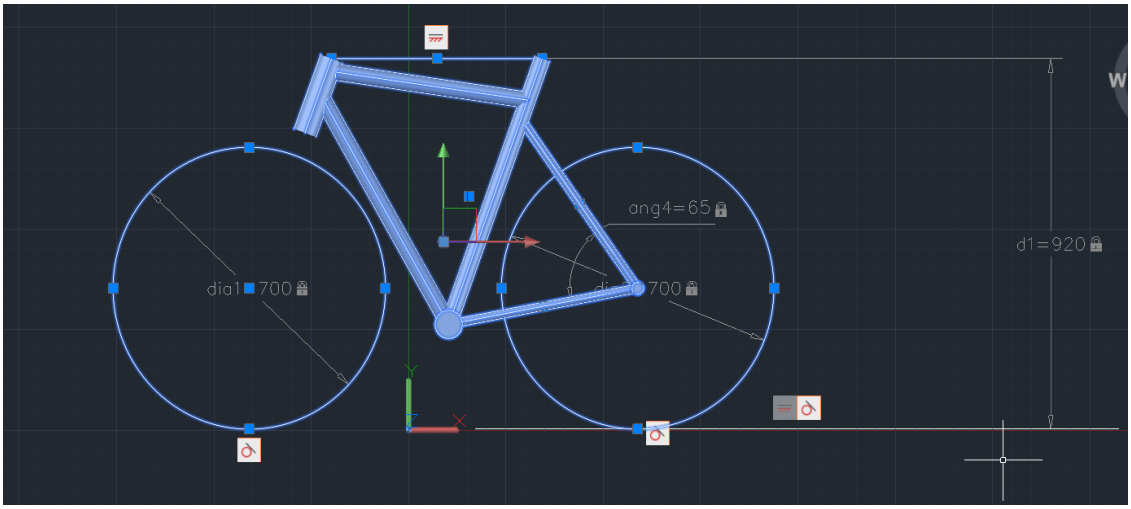
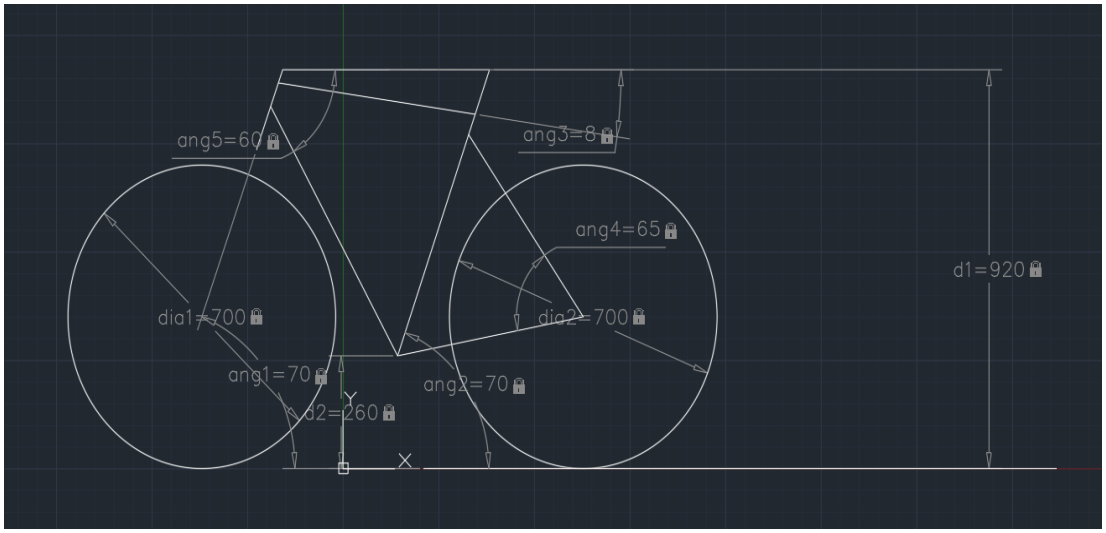
- The drive-shaft is the chief connection of bicycle which has used to connect the front end that is pedal and crank to the rear hub along with the wheel. Drive-shaft performs the job of propelling the front end and transmitting motion.
- The pedal has connected to the crankset which is further connected to the drive-shaft by mean of bevel gear.
- Drive-shaft consists of shaft rod, two bevel gears and universal joint. Bevel gears are present at both ends of the drive-shaft.
- On the bicycle's rear end, drive-shaft bevel gear is connected to the gear on the rear hub assembly along with the rear wheel.



- The strength of this system is high and takes small maintenance.
- Drive shaft's centre has fitted with a flexible universal joint. Thus, absorbs shock
- Use of drive shaft provides protection to clothes and safety of cyclist as there is no more chain bite, also no more grease on hand to maintain the chain.
- Rider of the chainless bicycle system has not to apply extra power to push the vehicle forward.



- This chainless bicycle system has a bevel gear in place of the chain-ring. This large bevel gear is attached to the crankset and mashes with the bevel gear which attached to the drive shaft at the front end.
- The cyclist pushes the pedal which turns the bevel gear of the crankset and bevel gear of the shaft allow the axis of drive torque to turns by 90 degrees.
- At the rear end of the drive shaft, another bevel gear is mounted and mesh with the bevel gear on the rear hub assembly along with the rear wheel and cancel out the change of axis of first drive torque.
- The rider pushes the pedal which rotates the shaft rod by means of bevel gear at the front end. This rotating shaft has a bevel gear at the rear end which meshes with another bevel gear on the hub along with the rear wheels and drives the rear wheel.

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7.3 Drive Shaft Specifications

- Drive-shaft has subjected to various forces. It has the torque transmission capacity of more than or equal to 3500Nm. For optimal design, the specifications EN 8 drive shaft is almost similar to that of a steel shaft.
- The outer and inner diameter of the drive-shaft should not exceed 70mm and 60mm approximately due to the limitation of space.
- Following specific design, requirements are used for optimally design of drive shaft transmission system.

Table 7.1: Design requirement

S. No.	Name	Notation	Unit	Value
1	Length of shaft	L	mm	410
2	Ultimate torque	Tmax	Nm	3500
3	Max. speed of shaft	Nmax	Rpm	6500

EN-8 has used for automotive drive shaft applications. EN 8 which is an unalloyed medium carbon grade steel with moderate wear resistance and reasonable tensile strength. It has also called as Engineering Steel. It is also a freely machineable material.

Applications of EN 8 are:-

- Used in making general engineering components.
- Used in making various automotive parts.
- Used to make a connecting rod.
- Used to make bolts and studs sometimes.
- Used to make spindle or axles also.

Table 7.2: Mechanical properties of EN-8 Carbon Steel

S. No	Mech. Properties	Symbol	Units	EN-8 Carbon Steel
1	Density	ρ	Kg/m3	7800
2	Young's modulus	E	GPa	190
3	Poisson ratio	v	--	0.3

7.4 Design Assumptions

a. This Drive-shaft rotates at a constant speed about its longitudinal axis.
b. This drive-shaft is made up uniformly with a circular cross-sectional area.
c. The mass centre coincides with the geometric centre at every cross-section. Because of that drive shaft is flawlessly balanced.
d. It has assumed that the shaft is acting in a vacuum.
e. We consider that the nonlinear and damping effects of all types have excluded.

7.5 Factor of Safety

It is the supreme aspects to design a Bicycle. It has used to express the safety of the system. It shows that for an intended load, the system needs to be that much stronger to perform well. It has calculated as the ratio of the structure's absolute strength that is, in other words, the capability of a structure to the actual applied load. For a particular design, we calculate the factor of safety to find out the reliability of the structure.

VIII. CALCULATIONS TO MAKE CHAINLESS BICYCLE SYSTEM

8.1 Calculation of Drive-Shaft

Let us assume, the mass of rider= 75 kg

1. Shaft's Inner Diameter(di) = 22mm = 0.022m
2. Shaft's Outer Diameter (do) = 24mm = 0.024m
3. Length of Shaft (L) = 410mm = 0.410m
4. Transmitted Torque (T) = Cyclist's Mass *g* Length of Shaft
   = 75 * 9.81 * 0.410

= 301.657 Nm
= 301657 Nmm

5. Polar moment of inertia (J) = π (do4 – di4)/32
= π [(0.024)^4 – (0.022)^4]/32
= π (9.752*10^-8)/32
= (3.063681156*10^-7)/32
= 9.574*10^-9 m^4
6. Power (P) = 2πNT /60
= 2π*100*301.657/60
= 3158.945 W
7. Shear Stress (τ) = Tρ/J = (301.657)(7800)/ 9.574*10^-9
= 2.457*10^14 N/ m^2
8. Maximum Shear Stress (τmax) = TRo/J
= (301.657)(0.012)/ 9.574*10^-9
= 37.812*10^7 N/ m^2

8.2 Front Gear Set Calculation

Module is the term or says unit used to show the size of gears. It is equal to the ratio of the reference diameter of the gear to the total number of teeth. It is shown by 'm' & the unit of size.

Module (m) = Gear reference diameter/ no. of teeth present on the gear

Or, m=d/z

Let, Module (m) = 4

Pressure Angle (α) = 20 degree

On Pinion, no. of Teeth (Zp) = 24

On Gear, no. of Teeth (Zg) = 44

Pitch Circle Diameter (D) = m*Z

Pinion pitch circle diameter (Dp) = 4*24 = 96mm

Gear Pitch Circle Diameter (Dg) = 4*44 = 176 mm

Addendum (ha) = module (m) = 4mm

Dedendum (hd) = 1.25m = 1.25*4 = 5 mm

Clearance (c) = 0.25m = 0.25*4= 1 mm

Working depth (hw) = 2m = 2*4 = 8 mm

Whole depth (h) = 2.25m = 2.25*4 = 9 mm

Thickness of Tooth (s) = 1.5708m = 1.5708*4 = 6.28mm

Tooth Space = 1.5708m = 1.5708*4 = 6.28mm

Fillet Radius = 0.4m = 0.4*4 = 1.6mm

8.3 Rear Gear Set Calculation

Module (m) = 4

Pressure angle (α) = 20Degree

On Pinion, no. of Teeth (Zp) = 24

On Gear, no. of Teeth (Zg) = 24

Pitch Circle Diameter (D) = m*Z

Pinion pitch circle diameter (Dp) = 4*24 = 96 mm

Gear pitch circle diameter (Dg) = 4*24 = 96 mm

Addendum (ha) = m = 4 mm

Dedendum (hd) = 1.25m = 1.25*4 = 5 mm

Clearance (c) = 0.25m = 0.25*4 = 1 mm

Working depth (hw) = 2m = 2*4 = 8 mm

Whole depth (h) = 2.25m = 2.25*4 = 9 mm

Thickness of Tooth (s) = 1.5708m = 1.5708*4 = 6.28 mm

Tooth space = 1.5708m = 1.5708*4 = 6.28 mm

Fillet radius = 0.4m = 0.4*4 = 1.6 mm

8.4 Design Optimization

Design optimization is a principle part of engineering design. By design optimization, we can improve our designs to a very considerable extends. It shows us where the improvement is needed & according to the result; we can improve our product at minimum cost. We can choose the best property materials for our design. Various methods have applied for the design optimization process includes the mathematical optimization to design and calculation problem formulations, physics law. Design optimization also performs engineering optimization.

IX. ADVANTAGES AND DISADVANTAGES

9.1 Advantages of Chainless Bicycle System

1) This chainless Bicycle system does not jam.
2) Cyclist of this chainless bicycle system does not get injured because of chain bite as in this system chain is not present.
3) The rider's clothes not any more affected by the chain grease. Rider's footwear, pants do not get accidental damage.
4) This chainless bicycle system is fully enclosed and requires less maintenance, and periodic lubrication through a grease gun.
5) This system can deliver more efficiency as compared to the chain drive system.
6) This bicycle has a greater clearance compared to the traditional bicycle.

9.2 Disadvantages of Chainless Bicycle System

1) The weight of the chainless bicycle system is a little bit more as compared to the chain drive system.
2) Hub Assembly has used; is complex.
3) This system can't use derailleur gears; these gears are light in weight and come in a variety of the gears ratio.
4) This chainless bicycle system is complex to dismantle when repairing the rear tyre.

X. RESULT AND DISCUSSION

- ✓ The design of the Chainless Bicycle System based on design calculation is done.
- ✓ Design of this chainless bicycle system found to be safe according to the theoretical analysis.
- ✓ The Chainless Bicycle System which has used the shaft-drive mechanism is secure when subjected to various loads.
- ✓ The Chainless Bicycle System use drive shaft which is light in weight and have bevel gear on its both end and reduce the wastage of energy.
- ✓ The chainless bicycle system with shaft drive mechanism is design and manufacture for trouble-free and better transfer of power.

These results that are the outcome of this work are a useful way to increase the awareness, generate the interest in Chainless Bicycle System. It also helps in the early stage of development.

XI. CONCLUSION AND FUTURE SCOPE

11.1 Conclusion

- ➢ This Chainless Bicycle System would be able to replace the existing traditional bicycle system of chain and sprocket arrangement.
- ➢ This Chainless Bicycle is run successfully with the use of drive-shaft in place of chain-ring.
- ➢ This chainless bicycle system has manufactured for quiet, smooth and easy power transmission.

- This chainless bicycle system has optimally designed and use drive shaft which consists shaft rod, bevel gears, bearing in place of chain drive that consists of chains, sprocket.
- This Chainless Bicycle System would be very comfortable for off-road racing.
- This Chainless Bicycle System requires little maintenance with comparatively a longer life.

11.2 Future Scope

- This Chainless Bicycle System generates efficient and reliable output as compared to the traditional system.
- In Future, this system can implement on bikes and also become a better transmission system.
- This can also be implemented on the vehicles run by engines such as truck or other high-powered vehicles.

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