SHAFT DRIVEN BICYCLE

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ABSTRACT

This project is developed for the users to rotate the back wheel of a two-wheeler using propeller shaft. Usually in two wheelers, chain and sprocket method is used to drive the back wheel. But in this project we will use bevel gears with drive shaft. The use of bevel gears allows the axis of the drive torque from the pedals to be turned through 90 degrees. The drive shaft then has another bevel gear near the rear wheel hub which meshes with a bevel gear on the hub of rear wheel, where the rear sprocket would be on conventional bicycles. Thus the back wheel is rotated in perpendicular to the drive shaft. Thus, the two wheeler will move forward. According to the direction of motion of the pedal, the wheel will be moved forward or reverse. This, avoid the usage of chain and sprocket method.

Keyword: - *propeller shaft ,bevel gears, pedals ,sprocket, and chain etc…*

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1. INTRODUCTION

A shaft-driven bicycle that uses drive shaft instead of a chain to transmit power from the pedals to the wheel. Shaft drives were introduced over a century ago, but were mostly supplanted by chain-driven bicycles due to the gear ranges possible with sprockets and derailleur. Recently, due to advancements in internal gear technology, a small number of modern shaft driven bicycles have been introduced. Shaft-driven bicycle have a large bevel gear where a conventional bicycle would have its chain ring. This meshes with another bevel gear mounted on the drive shaft. The use of bevel gears allows the axis of the drive torque from the pedals to be turned through 90 degrees. The drive shaft then has another bevel gear near the rear wheel hub which meshes with a bevel gear on the rear hub. A single piece drive shaft is preferred here and the material of it is considered to be Titanium alloy because of its high strength and low density.

1.1 Purpose of propeller shaft

The torque that is produced from the pedals must be transferred to the rear wheel to push the vehicle forward and reverse. The drive shaft must provide a smooth, uninterrupted flow of power to the axles. The drive shaft and differential are used to transfer this torque.

1.2 Functions of propeller shaft

- It should transmit the torque effectively.
- The drive shafts must also be capable of rotating at the very fast speeds required by the vehicle.
- The length of the drive shaft must also be capable of changing while transmitting torque. Length changes are caused by axle movement due to torque reaction, road deflections, braking loads and so on.

1.3 Merits of propeller shaft

- They have high specific modulus and strength.
- Reduced weight.
- Due to the weight reduction, energy consumption will be reduced.

- They have high damping capacity hence they produce less vibration and noise.
- They have good corrosion resistance.

2. DRIVE MECHANISM

A gear or cogwheel is a rotating machine part having cut, teeth or cogs, which mesh with another toothed part in order to transmit torque, Two or more gears working in tandem are called a transmission and can produce a mechanical advantage through a gear ratio and thus may be considered a simple machine. Geared devices can change the speed, torque, and direction of a power source. The gears in a transmission are analogous to the wheels in a crossed belt pulley system. An advantage of gears is that the teeth of a gear prevent slippage. When two gears mesh, and one gear is bigger than the other (even though the size of the teeth must match), a mechanical advantage is produced, with the rotational speeds and the torques of the two gears differing in an inverse relationship. The definite velocity ratio which results from having teeth gives gears an advantage over other drives (such as traction drives and V-belts) in precision machines such as watches that depend upon an exact velocity ratio. In cases where driver and follower are proximal, gears also have an advantage over other drives in the reduced number of parts required; the downside is that gears are more expensive to manufacture and their lubrication requirements may impose a higher operating cost.

Fig-1 Bevel gear drive mechanism

3. CONSTRUCTION

3.1 Components of bicycle

- **Paddle:** It is a device used to transmit torque from pedal to propeller shaft.
- **Hub:** Centre part of the wheel from which spoke radiate, inside the hub are ball bearings enabling to rotate around in axle.
- **Bearings:** For the smooth operation of Shaft, bearing mechanism is used.
- **Spiral bevels:** Spiral bevel gears can be manufactured as circular arc with non-constant tooth depth and circular arc with constant tooth depth. Spiral bevel gears have the same advantages and disadvantages relative to their straight-cut cousins as helical gears do to spur gears. Straight bevel gears are generally used only at speeds below 5 m/s (1000 ft/min), or, for small gears, 1000 rpm.

In the present work we used set of spiral bevel gears at the rear end of propeller shaft and rear hub of wheel of bicycle.

- **Hypoid gear:** Hypoid gears resemble spiral bevel gears except the shaft axes do not intersect. The pitch surfaces appear conical but, to compensate for the offset shaft, are in fact hyperboloids of revolution. Hypoid gears are almost always designed to operate with shafts at 90 degrees. Depending on which side the shaft is offset to, relative to the angling of the teeth, contact between hypoid gear teeth may be even smoother and more gradual than with spiral bevel gear teeth, but also have a sliding action along the meshing teeth as it rotates and therefore usually require some of the most viscous types of gear oil to avoid it being extruded from the mating tooth faces, the oil is normally designated HP (for hypoid) followed by a number denoting the viscosity.

  In the present work we used these type of gears at the front part of the bicycle.

3.2 Backlash

Backlash is the error in motion that occurs when gears change direction. It exists because there is always some gap between the trailing face of the driving tooth and the leading face of the tooth behind it on the driven gear, and that gap must be closed before force can be transferred in the new direction. The term "backlash" can also be used to refer to the size of the gap, not just the phenomenon it causes; thus, one could speak of a pair of gears as having, for example, "0.1 mm of backlash." A pair of gears could be designed to have zero backlash, but this would presuppose perfection in manufacturing, uniform thermal expansion characteristics throughout the system, and no lubricant. Therefore, gear pairs are designed to have some backlash.

3.3 Tooth profile

A profile is one side of a tooth in a cross section between the outside circle and the root circle. Usually a profile is the curve of intersection of a tooth surface and a plane or surface normal to the pitch surface, such as the transverse, normal, or axial plane. The fillet curve (root fillet) is the concave portion of the tooth profile where it joins the bottom of the tooth space. The velocity ratio is dependent on the profile of the teeth. Friction and wear between two gears is also dependent on the tooth profile. There are a great many tooth profiles that will give a constant velocity ratio, and in many cases, given an arbitrary tooth shape, it is possible to develop a tooth profile for the mating gear that will give a constant velocity ratio. However, two constant velocity tooth profiles have been by far the most commonly used in modern times.

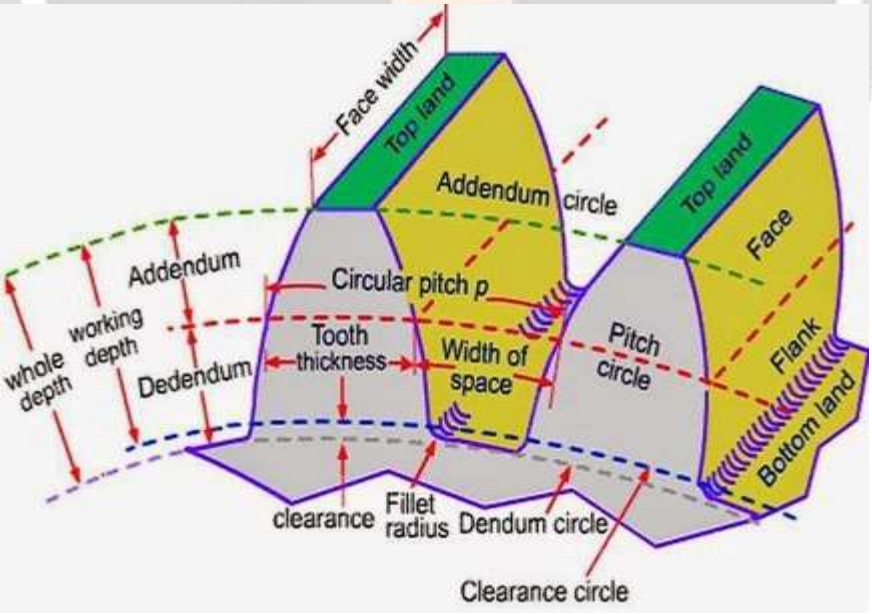

Fig-2 Gear tooth profile

3.4 Gear materials

Numerous nonferrous alloys, cast irons, powder-metallurgy and plastics are used in the manufacture of gears. However, steels are most commonly used because of their high strength to weight ratio and low cost. Plastic is commonly used where cost or weight is a concern.

3.5 Selection of Materials

Based on the advantages discussed earlier, the E-Glass/Epoxy, High Strength Carbon/Epoxy and High Modulus Carbon/Epoxy materials are selected for composite drive shaft.The E-Glass/Epoxy, High Strength Carbon/Epoxy and High Modulus Carbon/Epoxy materials used for composite drive shafts

4. WORKING PRINCIPLE

The propeller shaft is the primary connection between the front and the rear end , which performs both the jobs of transmitting the motion and propelling the front end. Thus the terms Drive Shaft and Propeller Shafts are used interchangeably. In other words, a driveshaft is a longitudinal power transmitting, used in vehicle where the pedal is situated at the human feet.

The job involved is the design for suitable propeller shaft and replacement of chain drive smoothly to transmit power from the engine to the wheel without slip. It needs only a less maintenance. It is cost effective. Propeller shaft strength is more and also propeller shaft diameter is less. it absorbs the shock. The both end of the shaft are fitted with the bevel pinion, the bevel pinion engaged with the crown and power is transmitted to the rear wheel through the propeller shaft . The use of bevel gears allows the axis of the drive torque from the pedals to be turned through 90 degrees.

4.1 Design requirements and specifications

Table-1 Design requirements and specifications

S. NO	Name	Notation	Unit	Value
1.	Ultimate Torque	T_{max}	Nm	3500
2.	Max. Speed of shaft	N_{max}	Rpm	6500
3.	Length of Shaft	L	Mm	1250

Steel (SM45C) used for automotive drive shaft applications. The material properties of the steel (SM45C) are given in Table. The steel drive shaft should satisfy three design specifications such as torque transmission capability, buckling torque capability and bending natural frequency.

Table-2 Mechanical properties of Cast iron (SM45C)

S.NO	Mech. Properties	Symbol	Units	Cast Iron
1.	Young's Modulus	E	GPa	105.0
2.	Shear Modulus	G	GPa	36.75
3.	Poisson Ratio	v	------	0.23
4.	Density	ρ	Kg/m^3	7209
5.	Yield Strength	Sy	MPa	130
6.	Shear Strength	Ss	MPa	169

4.2 Design Assumptions

- The shaft rotates at a constant speed about its longitudinal axis.
- The shaft has a uniform, circular cross section.

- The shaft is perfectly balanced.
- All damping and nonlinear effects are excluded.
- Acoustical fluid interactions are neglected,
- Since lamina is thin and no out-of-plane loads are applied, it is considered as under the plane Stress.

4.3 Selection of Cross-Section

The drive shaft can be solid circular or hollow circular. Here hollow circular cross-section was chosen because: The hollow circular shafts are stronger in per kg weight than solid Circular. The stress distribution in case of solid shaft is zero at the centre and maximum at the outer surface while in hollow shaft stress variation is smaller. In solid shafts the material close to the centre are not fully utilized.

4.4 Factor of Safety

The designer must take into account the factor of safety when designing a structure. Since, composites are highly orthotropic and their fractures were not fully studied the factor of safety was taken as 2.

4.5 Transmission of Torque

If a person does not turn the pedal, then he will stand on it and so the maximum torque will = (body mass of the rider x g) x the length of the pedal lever.Remember to consider the gearing of the bike though.The average, fit, adult rider can produce only 75 watts or 1/10hp when cycling at a continuous 12mph (19.3kph)." This usually happens with a pedalling speed of 60-80 rpm though many rider pedal faster.

4.6 Design Optimization

Optimization of an engineering design is an improvement of a proposed design that results in the best properties for minimum cost. Most of the methods used for design optimization assume that the design variables are continuous. In structural optimization, almost all design variables are discrete. A simple Genetic Algorithm (GA) is used to obtain the optimal number of layers, thickness of ply and fibre orientation of each layer. All the design variables are discrete in nature and easily handled by GA. With reference to the middle plane, symmetrical fiber orientations are adopted.

4.7 Objective Function

The objective for the optimum design of the composite drive shaft is the minimization of weight, so the objective function of the problem is given as

Weight of the shaft,

$m = \rho a l$

$m = \rho\pi/4(d_o^2 - d_i^2)$

Where,

d_i =Inner diameter of the shaft

d_o =Outer diameter of the shaft

a =cross sectional area of the shaft

5. REMEDIES

When abnormal vibrations or noises are detected in the driveshaft area, this chart can be used to help diagnose possible causes.

Problem	**Caused by**	**What to do**
As bicycle is accelerated from stop	torque is required	Apply more torque at starting
when gears are not shifting	Rusting	Clean with fluids
Vibration at speed	High speed	Maintain low speed
Noise at low speed	Universal joint	Apply grease
Gears pitch circle is not coinciding	Vibrations	Adjust the position of gears
Gear backlash	Noise, Overloading ,Overheating	Follow, design characteristics

6. ADVANTAGES AND APPLICATIONS

6.1 Advantages

- Drive system is less likely to become jammed.
- The use of a gear system creates a smoother and more consistent pedaling motion.
- Lower maintenance.
- Efficiency is more as compared to conventional bicycle design.
- High durability.
- Low cost of ownership when manufactured in large scale.
- More flexibility.
- Comfortable riding.
- The torque required for pedaling is less after Initiation.

6.2 Applications

- It is used for racing purpose.
- It used for Off-road riding.
- It is used For Cycling.
- It is used for public activities.
- It is used for rental purpose.
- It is used for riding in hilly areas.
- It used for riding longer distances.

Fig-3 Basic bicycle model

7. CONCLUSION

The work was aimed to reduce the wastage of human power (energy) on bicycle riding which employs drive shafts; in generally it is achieved by using light weight drive shaft with bevel gears on both sides designed on replacing chain transmission.one-piece drive shaft for rear wheel drive bicycle have been optimally designed and manufactured for easily power transmission. The drive shaft with objective of minimization of weight of shaft which was subjected to the constraints such as torque transmission, torsion buckling capacity, stress, strain, etc. The torque transmission capacity of the bicycle drive shaft has been calculated by neglecting and considering the effect of centrifugal forces and it has been observed that centrifugal force will reduce the torque transmission capacity of the shaft.

8. REFERENCES

8.1 Book reference

[1].US PATENT DOCUMENTS Kenneth S. Keyes 5,078,416 1/1992 280/260.
[2].J.C. Martin, W.W. Spirduso "Determinants of Maximal Cycling power: Crank length, Pedaling rate and Pedal speed", Springer-Verlag, 84, 2001, 413-418.
[3].Engineering materials by r.k.rajput, schand publications.
[4].Rahul U. Urunkar, Prof. P.P. Deshpande "Study of Drive Mechanisms of Bicycle, Tricycle or Like Vehicles to Optimize Operating Performance - A Review",
[5].Int. Journal of Engineering Research and Applications ISSN : 2248-9622, Vol. 4, Issue 1(Version 2), January 2014, pp.214-219.
[6].Rastogi, N. (2004) "Design of composite drive shafts for automotive applications", Visteon Corporation, SAE technical paper series.
[7].A.K. Singh, A.S. Bobade, A.K. Ghodmare, B.C. Bisen, H.H. Walmik, P.C. Padole, V.U. Gaikwad, C.K. Tembhurkar, N.K. Mandavgade "Concept of User
[8].Friendly Modified Folding Bicycle", European Journal of Applied Engineering and Scientific Research 2014, 3 (1):16-20.
[9].R.S. Khurmi, J.K. Gupta "A Text Book of Machine Design", S CHAND, 2005.
[10].B.D. Shiwalkar "Design Data for Machine Elements", Denett, 2013.
[11]."Design Data"- Data book of engineering.
[12].Machine design – Design data book.
[13].Strength of material by R.S Kurmi.

8.2 Website references

[1].www.wikipedia.com
[2].www.Dynamic bicycles.com
[3].www.engineeringtoolbox.com
[4].www.Makeitform.com
[5].www.Convertunits.com
[6].www.Webbicycle.netpaths.net/technology.php
[7].www.driveshats.com
[8].www.design tools.com