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Design and Fabrication of Chainless Bicycle

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Abstract - *A Shaft Driven Bicycle is a bicycle in which the power from pedals to rear wheel of the bicycle is transmitted by means of gear and shaft arrangement unlike the conventional chain drive. The main aim of the project is to obtain a maximum displacement of bicycle by transmitting the maximum possible torque from pedals to the rear wheel for a minimum applied force, reducing the human effort. This project is estimated to be a more reliable and safe system. Shaft-driven bicycles have bevel gears and a connecting rod system where a conventional bicycle would have its chain ring. The bevel gear meshes with another bevel gear mounted on the drive shaft. The Bevel gears are the most efficient way of turning drives 90 degrees as compared to worm gears or crossed helical gear. This system consists of two set of bevel gears at both the ends. The shaft drive only needs periodic lubrication using a grease gun to keep the gears running quiet and smooth. This "chainless" drive system provides smooth, quiet and efficient transfer of energy from the pedals to the rear wheels. The methodology of the project is to design the chainless transmission system and carryout an analysis of the same using design and analysis tools. A comparison of theoretical and simulated results will be done.*

***Key Words*: A Shaft Driven Bicycle, Chain drive, Torque, of Bevel Gears, Transmission System.**

1. INTRODUCTION

The shaft drive has been developed more recently and only few companies are manufacturing those types. The shaft drive uses a shaft instead of a chain to transmit power from the rider's legs to the wheels. Typically gears are sealed inside a housing that is attached to the main shaft. The number of the shaft drive manufacturers is increasing and public interests are growing as well. It is slowly changing the bike industry. The engineer is constantly conformed to the challenges of bringing ideas and design into reality. New machines and techniques are being developed continuously to manufacture various products at cheaper rates and high quality. So we are going to make a machine for CYCLE industry using bevel gear gives mechanical advantages and make it multipurpose.

2. LITERATURE REVIEW

This project work has done after observing the complications of chained drive mechanism held on the bicycle when bevel gears were used in place of it. The gearing mechanism was applied then to overcome the problems of chain-drive like less load capacity, noisy operation can cause vibrations and require frequent lubrication followed by chain adjustments due to slackness appeared. Gearing system having ability to turn or change torque load 90 degrees in direction provided smooth and noiseless transmission. [1] But this modified system, on working conditions, hampered with various demerits like rusting on gears during prolonged period for which they require frequent adjustments as well as maintenances like frequent lubrication on wear and tear of tooth of gears due to which whole wheel alignment may change or shift. Thereby we took the use of bearing-operated mechanism in place of gearing-setup on the bicycle. [2] Now the focus was on the operations of shaft which was required of low weight and less maintenances. These requirements could have filled with use of composite elements like kevlar or epoxy fibers because of facts like now the conversion would occur from 2 piece shaft into a single piece shaft and also now the shaft would have the high tensile strength, high damping capacity, high torque capacity, long fatigue life and also absorb vibrations. Now the major outcome would be the reduction in weight of shafts but here our problems wouldn't be almost end. Actually we faced unavailability of these kinds of composite elements in the market and if we somehow accessed them they could be available with high purchasing costs ultimately add on the production of bicycles to us. Thereby we used the mild steel as the material for shafts as it provides perfect pros to our shafts like resistance to breakage, high tensile strength followed by the low weight with load carrying capacities. [3] Actually we could have faced with cons of using composite materials like their high UV-resistance (so that they may degrade under sunlight) and ability to absorb moisture (becoming sensitive to environment), so now we were satisfied with the suitability of mild steel over these kinds of materials.

2. EXPERIMENTATIONS AND SPECIFICATIONS

Fig -1: Schematic of Experimental Set-up

Fig -2: Components of bicycle transmission system.

3.1 Components

Paddle: A bicycle pedal is the part of a bicycle that the rider pushes with their foot to propel the bicycle. It provides the connection between the cyclist's foot or shoe and the crank allowing the leg to turn the bottom bracket spindle and propel the bicycle's wheels. Pedals usually consist of a spindle that threads into the end of the crank and a body, on which the footrests or is attached, that is free to rotate on bearings concerning the spindle. Part attached to crank that cyclist rotate to provide the bicycle power; it consists of three segments.

Fender: A piece of curved metal covers a part of the wheel to protect the cyclist from being splashed.

Front Break: Mechanism activated by brake cable compressing a caliper of return springs. It forces a pair of brake pads against the sidewalls to stop the bicycle.

Hub: Center part of the wheel from which spokes radiate, inside the hub is ball bearings enabling to rotate around an axle.

Bevel Gear: A kind of gear in which the two wheels working together lie in different planes and have their teeth cut at right angles to the surfaces of two cones whose apices coincide with the point where the axes of the wheels would meet.

Driven Shaft: A shaft-driven bicycle is a bicycle that uses a 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 derailleurs. Recently, due to advancements in internal gear technology, a small number of modern shaft-driven bicycles have been introduced.

3.2 Construction and Working Principle

The term Driveshaft is used to refer to a shaft, which is used for the transfer of motion from one point to another. Whereas the shafts, which propel referred to as propeller shafts. However, the drive shaft of the automobile is also referred to as the propeller shaft because apart from transmitting the rotary motion from the front end to the rear end of the vehicle, these shafts also propel the vehicle forward. The 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. The design of the drive shaft as shown in fig. Thus the terms Drive Shaft and Propeller Shafts are used interchangeably. In other words, a drive shaft is a longitudinal power transmitting, used in a vehicle where the pedal is situated at the human feet. A drive shaft is an assembly of one or more tubular shafts connected by a universal, constant velocity, or flexible joints. The number of tubular pieces and joints depends on the distance between the two wheels. The job involved the design of a suitable propeller shaft and the replacement of chain drive smoothly to transmit power from the pedal to the wheel without slip. It needs only less maintenance. It is cost-effective. Propeller shaft strength is more and also propeller shaft diameter is less. it absorbs the shock. Because the propeller shaft center is fitted with the universal joint is a flexible joint. It turns into an angular position. Both end of the shaft are fitted with the bevel pinion, the bevel pinion is engaged with the crown, and power is transmitted to the rear wheel through the propeller shaft and gearbox. With our shaft drive bikes; there is no more grease on your hands or your clothes; and no more chain and derailleur maintenance.

3.2 Specification of Drive shaft

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.

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Table -1: Material Properties

Sr 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	250

3.3 Design Assumptions

1. The shaft rotates at a constant speed about its longitudinal axis.
2. The shaft has a uniform, circular cross section.
3. The shaft is perfectly balanced, i.e., at every cross section, the mass center coincides with the Geometric center.
4. All damping and nonlinear effects are excluded.
5. The stress-strain relationship for the composite material is linear & elastic; hence, Hooke's law is applicable to composite materials.
6. Acoustical fluid interactions are neglected, i.e., the shaft is assumed to be acting in a vacuum.
7. Since lamina is thin and no out-of-plane loads are applied, it is considered under the plane Stress.

3.4 Transmission of Torque

If a person does not turn the pedal then he will stand on it and so the maximum torque will =
0.008*16/2
= 0.128/2 =0.064 m
Module (m) = 0.008 m
Mass Moment of Inertia (I) = MR2/2
= 4*0.0142
= 0.0039
Polar Moment of Inertia (J) = π (do4 – di4)/32
= π (0.0284– 0.0264)/32
= (4.953X10-7)/32
= 1.548 X 10-8
Maximum Torque on bicycle is given by
T = (Mass of rider x g) L
Where L = Length of pedal crank in 'm'
g = 9.81 m/sec2
(Assume mass of rider = 60 kgs)

3.5 Design Calculations

Inner Diameter of shaft (di) = 0.026 m
Outer Diameter of shaft (do) = 0.028 m
Length of shaft (L) = 0.335 m
Number of teeth = 16
Gear Pitch (P) = MT/2
= 60 x 9.81 x 0.335 = 197.2 Nm

Power (P) = 2πNT / 60
= (2π x 110 x197.2) / 60
= 2271.5 watts

Shear Stress (r) = Tρ/J
= (197.2)(7209) /1.548 X 10-8
= 9.18 X 1013 N/m4

Max.Shear Stress (rmax) = TRo/J
= (197.2)(0.014) / (1.548 x 10-8)
= 17.83 X 107
Bending moment (M) = EI / R
Where ,
E = Youngs modulus
I = Moment of Inertia
R = Radius (Ro)
M = (105 X 0.0039)/ 0.014 = 29.25
Rate of twist = T/GJ
= 197.2/(36.75)(1.548X10-8)
= 3.46 X 108
Shear Strain = ρ (rate of twist)
= 7209 X 3.46 X108
= 2.49 X 1012
ϴ = TL/GJ
= (197.2)(0.335)/(36.75)(1.548 X 10-8)
= 66.06/(5.68X10-7)
= 1.163X109

Torsion is the twisting of an object due to an applied torque. It is expressed in newton meters (NM), in sections perpendicular to the torque axis, the resultant shear stress in this section is perpendicular to the radius. For shafts of uniform cross-section the torsion is:

T=JT *Shear Stress/r

T is the applied torque Nm.
T is the maximum shear stress at the outer surface.
JT = Jzz for concentric circular tubes.
r is the distance between the rotational axis.
ℓ is the length of the object the torque is being applied to or over.
θ is the angle of twist in radians.
G is the shear modulus or more commonly the modulus of rigidity
ro outer radius.

Torsion (T) = JT.GΘ/L

= (1.548 X 10-8)(36.75)(1.163 X 109) / 0.335

Torsion (T) = 1974.9 Nm

Deflection (Ymax) = ML2 /2EI

= (29.25 X 0.3352) / (2 X 105 X 0.0039)

= 4.008 m

Max. Deflection = [T X do / 2] / I
= [29.25 X 0.014] / 0.0039
= 105 Max. Shear Stress (Γmax)
= (29.25 X 0.014) / (1.548 X 10-8) = 26.45 X 107 Pa

Torque Transmission Capacity (T) is given by
T = Ss x π [(do4– di4)do] / 16

(Assume shear strength (Ss) = 360 to 1200 Mpa)

T = 360 X π [(0.0284 – 0.0264)0.028] / 16 = 3.120 X 10-7 N-m

Tensional buckling capacity= 3.71 X 10-4 m

Bending Vibration Frequency is given by

Fvb = (πp2 / 2L2)√(EIx / mi)
= [(7.73 X 10-3)/(2 X 0.3352)].√(105 X 0.0039)/0.204
= (0.0344).√2.007
=0.0487

4. CONCLUSION

The shaft driven bicycle would replace the existing conventional bicycle which runs by means of chain and sprocket arrangement. As the manual load given by the rider results in increased displacement of the bicycle, the human effort is reduced. It would be very advantageous for off road racing. It also requires less maintenance with a comparatively longer life.

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