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DESIGN, ANALYSIS OF SHAFT DRIVEN BICYCLE

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ABSTRACT

The conventional bicycle employs the chain drive to transmit power from pedal arrangement to the wheel and it require to accurate mounting and alignment for proper working. The least misalignment will result in chain dropping. This project is developed for the user to transmit energy from pedal to the rear wheel by using the shaft. Shaft driven bicycle is a bicycle that uses a shaft drive instead of a chain which contain two set of bevel gear at both the ends to make a new kind of transmission system for bicycle for getting high reliability system, and more safe system. There are two spiral bevel gear are used. The use of bevel gears allows the axis of the drive torque from the pedals to be turned through 90 degrees. The rear wheel rotate perpendicular to the shaft. Thus the two wheeler move in the forward direction. According to the direction of motion of the engine, the wheel will be moved forward. This avoid the usage of chain and sprocket method .When initial torque applied on the pedal then shaft rotate then transmit a power from pedal to the rear wheel. It replaces the traditional methods and reduces the accidents to the hill riders.

Keywords: chain and sprocket, bevel gear, shaft , reliability.

I. INTRODUCTION

A shaft drives were introduce over a century ago. The first shaft drive for cycle appear to have been invented independently in 1890 in United State and England. A chainless bicycle is a cycle that uses the shaft to transmit a power from the pedal to the rear wheel and cycle move in forward direction. This method is avoid power transmitted by chain. In this method we are use the two bevel gear which are 90° to the bevel pinion and gear. The gear attached to the rear wheel and the pedal. The drive shaft attached between pedal and rear wheel.The use of bevel gear allow the axis of the drive torque from pedal to be turned through 90°. The drive shaft has another bevel gear near the rear wheel hub which meshes with a bevel gear on the hub where the rear sprocket would be on the conventional bike and canceling out the first drive torque change of axis. The design of bevel gear produces less vibration and less noise than conventional straight cut gear. It is attractive look as compared to chain driven bicycle.

II. Drive Shaft

1. First, it must transmit torque from the transmission to the foot pedal.
2. During the operation, it is necessary to transmit maximum low-gear torque developed by the pedal.
3. The drive shaft must also be capable of rotating at the very fast speeds required by the vehicle.

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4. The drive shaft must also operate through constantly changing angles between the transmission, the differentials and the axle.

III. LITERATURE REVIEW

The first shaft drives for cycles appear to have been invented independently in 1890 in the United States and England. A. Fearnhead, of 354 Caledonian Road, North London developed one in 1890 and received a patent in October 1891. His prototype shaft wasenclosed within a tube running along the top of the chainstay; later models were enclosed within the actual chainstay. In the UnitedStates, Walter Stillman filed for a patent on a shaft-driven bicycle on Dec. 10, 1890 which was granted on July 21, 1891.The shaft drive was not well accepted in England, so in 1894 Fearnhead took it to the USA where Colonel Pope of the Columbiafirm bought the exclusive American rights. Belatedly, the English makers took it up, with Humber in particular plunging heavilyon the deal. Curiously enough, the greatest of all the Victorian cycle engineers, Professor Archibald Sharp, was against shaft drive;in his classic 1896 book "Bicycles and Tricycles", he writes "The Fearnhead Gear.... if bevel-wheels could be accurately andcheaply cut by machinery, it is possible that gears of this description might supplant, to a great extent, the chain-drive gear; but the fact that the teeth of the bevel-wheels cannot be accurately milled is a serious obstacle to their practical success".The shaft has are subject to torsion and shear stress, which represents the difference between the load and input force.

IV. COMPONENT OF BICYCLE

A. 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.

B. Pedal

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 foot rests or is attached, that is free to rotate on bearings with respect to the spindle. Part attached to crank that cyclist rotate to provide the bicycle power.

C. Drive Shaft

It is connected between the pedal and rear wheel. Which are used to developed torque and transmit the power from pedal to the rear wheel.

Merit of Drive Shaft

1. They have high specific modulus and strength.
2. Reduced weight.
3. Due to the weight reduction, energy consumption will be reduced.
4. They have high damping capacity hence they produce less noise and vibration.

5. They have good corrosion resistance.

6. Lower rotating weight transmits more of available power.

D. Brake

Brake are apply on wheel then brake pad must stop the wheel bicycle.

E. Bearing

It is a mechanical element that permit the relative motion between contact surfaces of the member while carrying load. There are two bearing connected to the shaft and holds it correct position.

V Methodology

The selection of the bevel gear which are high strength and transmit exact velocity ratio. It is produced less noise and less vibration. Shaft strength is more and is diameter is less. Both end of the shaft is connected to bevel pinion and pinion engage with crown gear and rear wheel gear. When torque applied on the pedal then shaft rotate and transmit power from the pedal to the rear wheel.

VI. DESIGN METHODOLOGY

A Design assumption

A. The shaft rotates at constant speed about its longitudinal axis.

B. The shaft has a uniform, circular cross section.

C. The shaft is perfectly balanced, i.e. at every cross section, the mass center coincides with the Geometric center.

D. All damping and nonlinear effects are executed.

E. The stress-strain relationship for the composite material is linear & elastic; hence, Hooke's law is applicable for composite materials.

F. Acoustical fluid interactions are neglected, i.e. the shaft is assumed to be acting in a vacuum.

G. Since lamina is thin and no out-of-plane loads are applied, it is considered as under the plane stress.

B. For Drive Shaft

Diameter of shaft (d) = 0.026 m

Length of shaft (L) = 0.35 m

Length of pedal crank (l) = 0.170 m

Speed of pedal gear = 120 rpm

If person does not turn the pedal then he will stand on it and so the maximum torque will be,

1. T = (body mass of the rider) x (g) x (length of pedal crank)

$T = 85 \times 9.81 \times 0.170$

$T = 141.75$ N-m

2. Power (P) = $2\pi NT / 60$

$P = 2\pi \times 115 \times 141.75 / 60 = 1707.86$ watts

3.Design power

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$P_{d=}$ k × P= 1.25 × 1707= 2.133kw

4.Polar moment of inertia

$J = \pi d^4 / 32 = \pi \times (0.026)^4 / 32 = 4.485 \times 10^{-8} m^4$

5. Shear stress (τ) = TR / J

$=141.75 \times 0.013 / 4.485 \times 10^{-8}$

$= 41.32 \times 10^6$ N/ m^2

6.Moment of inertia

$I = \pi d^4 / 64$

$= \pi \times 0.013^4 / 64$

$= 2.243 \times 10^{-8} m^4$

7.Bending moment, M = EI / R

$=2.06 \times 10^{11} \times 2.243 \times 10^{-8} / 0.013$

= 355429.23 N-m

8.Angle of twist

θ = TL /GJ

$= 141.75 \times 0.35 / (0.84 \times 10^{11} \times 4.485 \times 10^{-8})$

= 0.0131 rad

C For bevel gears

Speed of gear (Ng) = 120 rpm

Velocity ratio (i) = 4

Teeth of pinion (Zp) = 10

Diameter of crown = 0.15 m

Diameter of pinion = 0.045 m

9.Select suitable teeth on crown

, i = Zc / Zp = Np / Nc

4 = Zc / 10 = Np / 120 Zc = 40

Np = 480 rpm

10. Pitch angle,

For pinion

tanα = Zp / Zc = 10 / 40

α= 14

For crown

αc = 90- α = 76

11.Module (m) =D/T

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Diameter = module x teeth

45 = m x 10

m=4.5mm

12.Normal module (mn) = 4 mm

M_n = m x cosβ

4 = 4.5 x cosβ

β = 27.3°

13. Cone distance,

L = D_p/2 x sin α

= 93 mm

14 Pitch circle diameter

Pc = π m

= π x 4.5

= 14.137mm

15. Normal pitch

P_n= Pc cos(β)

= 14.137×0.8886

=12.522

16 Virtual number of teeth,

For crown

Zec= Zc /$\cos^3$ β

= 40 / $\cos^3$ (27)

= 56

Zpe= Zp /$\cos^3$(27)

= 10 / $\cos^3$(21)

= 14.186

17 Velocity of gear

V= Π DN/60

= π×0.045×480/60

= 1.1309m/s

18 Velocity factor

Cv= 4.5/(4.5+V)

= 4.5/5.6309

=0.7991

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19 Tangential force (Ft)

$F_t = P_d$ x Cs / V

For medium shock of service factor

Cs = 1.50

Ft = 1000 x 2.133 x 1.50 / 1.1309= 2.829 KN

20. Lewis factor

For ϕ= 20 full depth

y = 0.154 – 0.912/ Zep

= 0.154-0.912/14.186

=0.0897

Ft = σ_d *Cv*b*y* π *m_n /Cw

2829.13=70*0.7980 π *b*4/1.25

=56.16mm

For check the face width of helical gear is

12.5m_n to 20m_n

D. Dynamic load calculation

21 .$F_d = F_t + 21\times v(bc+W_t)/ 21v+\sqrt{(bc+W_t)}$

Where c= Ke/(1/E_g +1/E_p)

For C35 E = 490 to 580 N/ mm^2

C=0.107 x0.055/(2/540)

=1.5889

F_d = 2829.14+(21×1.309×(56.16×1.5889+2829.13)/(21×1.1309+√(56.16×1.5889+2829.13)

= 3720.3 N

E. Wear strength calculation,

Fw = dbQK

Where,

22. Ratio Factor

Q = 2V.R/(V.R+1)

=8/5

=1.6

At BHN 300 the surface endurance limit is 770N/mm^2

23. K = load stress factor

$K=\sigma_{es}^2 \sin(\phi)(1/E_g + 1/E_p)/1.4$

$K= (770)^2 \times \sin(20) \times 2/(540 \times 1.4)$

$=536$

24 .Fw = dbQK

$= 45 \times 56.16 \times 1.6 \times 536$

$=2167326.72N$

Hence Fw>Fd

VII RESULT

Sr. no	Parameter	symbol	units	value
1	Moment of inertia	I	m^4	2.243×10^{-8}
2	Polar moment of inertia	J	m^4	4.485×10^{-8}
3	Shear stress	τ	N/m	41.32×10^6
4	torque	T	N-m	141.75
5	power	P	watt	2133
6	Angle of twist	θ	rad	0.013
7	Bending moment	M	N-m	355429.23

VII. CONCLUSION

The shaft driven bicycle is designed successfully. It is reduced the wastage of the human power on the bicycle. The bicycle transmits the power from pedal to rear wheel smoothly. The initial torque applied on the pedal is very high. It is convert the rotary motion into a linear motion with aid of two bevel gear. The noise and vibration are reduced. The drive shaft with the objective of minimization of the weight of shaft which was subjected to the constraints such as torque transmission, torsion buckling capacity, stress-strain etc.

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