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Simulation and Analysis of Shaft Driven Bicycle Mechanism

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Abstract

This paper presents in detail about Design and development of shaft driven bicycle mechanism. Usually in two wheelers, chain and sprocket method is used to drive the back wheel. The shaft of the front bevel gear is connected with a long rod and other side of the long rod is connected with a set of bevel gears. The bevel gears are used to rotate the shaft in 90^0 angles. The back wheel of the vehicle is connected with bevel gear. Thus the back wheel is rotated in perpendicular to the front bevel gear and the bicycle will move forward. According to the direction of motion of the front bevel gear, the wheel will be moving forward or reverse. This avoids the usage of chain and sprocket method.

1. INTRODUCTION

The objective of this work is to reduce the human effort and fulfilling the enthusiasm of riding bicycle by replacing the existing chain drive system with bevel gears. The bevel gears are placed at the rear wheels .The rear wheels will rotate with the help of torque transmitted from the pedals to the drive shaft with 90° rotation of bevel gears. The velocity ratio is three that means for every one rotation of the gear the pinion completes three revolutions. Here the power transmission is in perpendicular direction as pinion and gear axis is perpendicular to each other.

The bicycle riding with the replacement of new materials and the newtechnology gives more comfort and durability.The chain-less drive system gives smooth, highand quick transfer of energy from pedal to rear wheel. Light weight and rugged in construction. The gears do not need any adjustment and are fixed in a position and are heat treated, high precision using a machine cut. The gears are perfectly lubricated and shaft rod is made of solid steel iron rod.

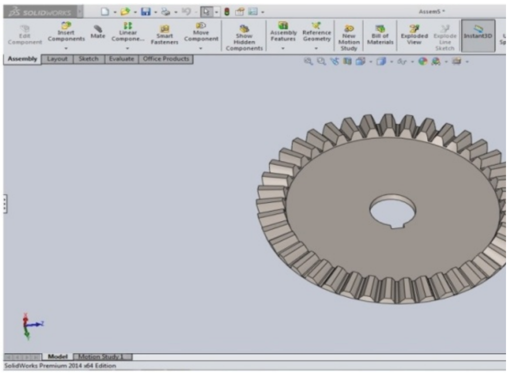
Gear can mesh with another gear; also can mesh with non rotating toothed part rack, produces translation motion. Gears can change the speed, torque and direction of source. The main advantage with gear is it prevents slippage. The multiple gear ratios means, when the gear ratio is continuous rather than discrete. The advantages of drive shaft mechanism are Low maintenance, Cost effective, Ability to absorb shocks, Constant efficiency is maintained, No breakage in the chin drive.

2. LITERATURE REVIEW

The first cycle was developed by the A.Fearnhead of north London in 1890 and received the patent in October 1891**.**The second patent was received by Walterstill man field on July 21, 1891[2].The colonel pope of the Columbia firm bought exclusive American rights belatedly. Professor Archibald Sharp, opposes the shaft drive; and mention the same in his book of "Bicycles and Tricycles" in 1896,he says that "The Fear head Gear...if the bevel wheels are easy to manufacture and easy to cut means it would be supply enormously, but the fact that it is not success in practical as it cannot be accurately milled".

3. DESIGNING OF MECHANISM

Solid works software is used to model the components of the shaft drive bicycle mechanism and assembly. The figure No's:1 to 5 below shows that the designed model of gears and shaft which are used in this project.



Figur-1.*Modelled gear*

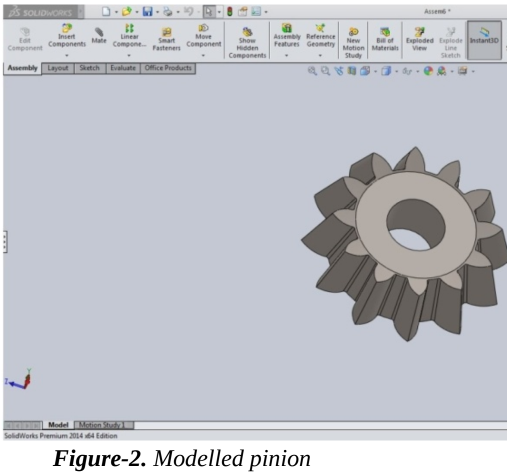


Figure-2. *Modelled pinion*

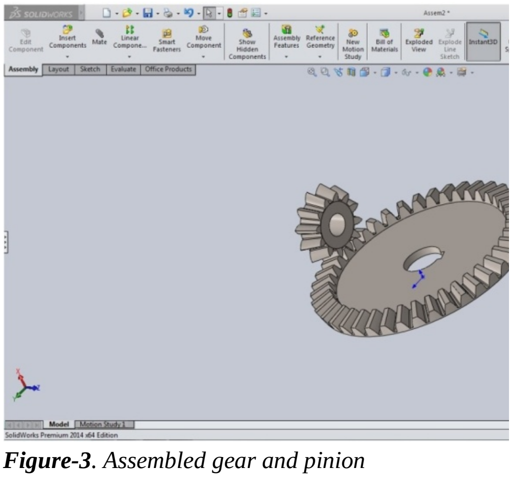


Figure-3. *Assembled gear and pinion*

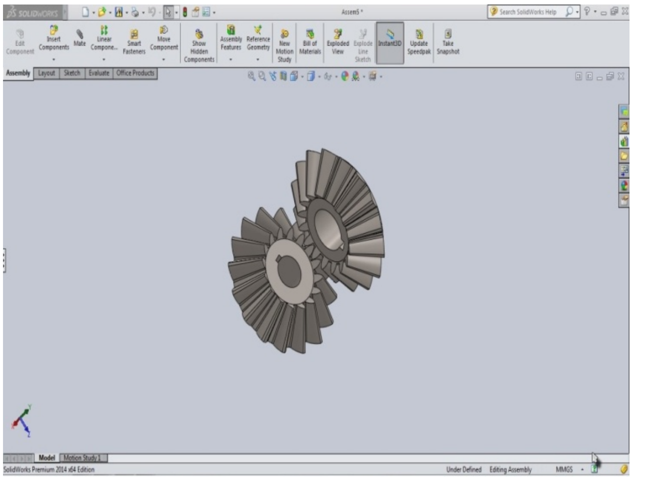


Figure-4.*Assembled rear gear and pinion*

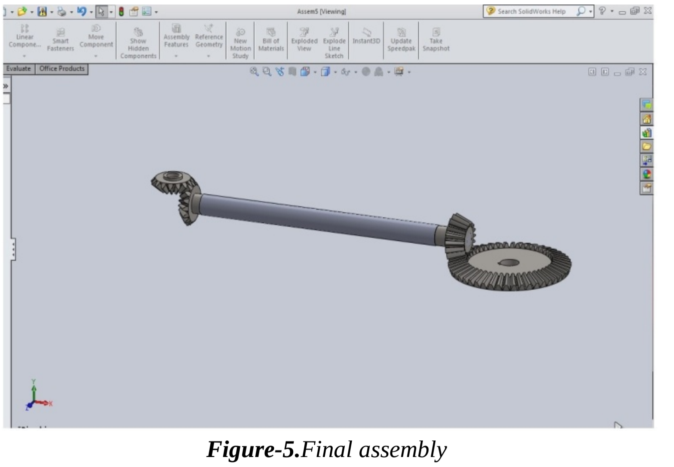


Figure-5.*Final assembly*

3.1. CALCULATIONS

For Gear & Pinion

For satisfactory operation of the bevel gears, the face width should be from 6.3m to 9.5m, where m is module. Also the ratio L/b should not exceed 3. For this, number of teeth's on pinion must not less than $\frac{48}{\sqrt{1+(V.R)^2}}$

Where V.R is required velocity ratio.

Required V.R is 1:3

$$\therefore \text{ Pinion teeth } TP \neq \frac{48}{\sqrt{1+(V.R)^2}}$$

$$\therefore TP > \frac{48}{\sqrt{1+(3)^2}}$$

i.e., $TP > 15.17$

For cycle, Length of pedal (l) = 0.16m

Maximum Torque on bicycle (T) =

(Mass of rider x g) x l

g = 9.81 m/sec^2

Assume mass of rider = 60 kgs.

T = 60x9.81x0.16

= 94,176 N.mm

$$\text{Power} = \frac{2\pi Nt}{60}$$

Considering, the rider will rotate pedal 20 time in 1 Minute ∴ N = 20

$$\text{Power (p)} = \frac{2\pi \times 20 \times 94176}{60}$$

= 197.24 watts.

Tangential load on Pinion (Wt.) = $\frac{2T}{Tp \times m}$

Where T is torque WT = $\frac{T}{Dp/2}$

TP is Pinion teeth $(\therefore Dp = Tp \times m)$

M is module

$$\therefore \text{WT} = \frac{2 \times 94{,}176}{Tp \times m}$$

Assuming, this WT is the maximum tangengential load action on pinion tooth.

WT to be maximum, m should as possible.

We get $TP > 15.17$

$\therefore TP \approx 16 \quad \Rightarrow \quad TG \approx 48$

Pitch angles for bevel gears $(Q_{P1} \,\&\, Q_{P2})$

Pitch angle for pinion $Q_{P1} = Tan^{-1}\left(\frac{1}{V.R}\right)$

$$= Tan^{-1}\left(\frac{1}{3}\right) = 18.43^0$$

Since the shafts are at right angles,

Pitch angle for gear, $Q_{P2} = 90^0 - Q_{P1}$

$$Q_{P2} = 90^0 - 18.43^0 = 71.57^0$$

Formative No. of teeth for Pinion.

$$TEP = TP.\sec Q_{P1}$$

$$= 16 \times Sec(18.43^0) = 16.865$$

Formative No. of teeth for Gear

$$TEG = TG \times SecQ_{P2}$$

$$= 48 \times Sec(71.57^0) = 151.82$$

Since both gears are made of same material, therefore Pinion is weaker. Thus the design should be based up on the Pinion.

The tooth form factor for the Pinion having 20^0 involute teeth

$$Y^1 p = 0.154 - \frac{0.912}{TEP}$$

$$\Rightarrow \; Y^1 p = 0.154 - \frac{0.912}{16.865} = 0.099$$

Pitch line velocity, $V = \frac{\pi D_p N_p}{60}$

$$= \frac{\pi \times T_p \times m \times 60}{60}$$

$$= \pi \times 16 \times M = 50.26m$$

Velocity Factor $C_V = \frac{3}{3+v}$

$$=\frac{3}{3+50.26m}$$

Length of pitch cone element or slant height of pitch cone

$$L=\sqrt{\left(\frac{D_P}{2}\right)^2+\left(\frac{D_G}{2}\right)^2}=\sqrt{\left(\frac{T_P\times m}{2}\right)^2+\left(\frac{T_G\times m}{2}\right)^2}$$

$$=\frac{m}{2}\sqrt{TP^2+T_G{}^2}$$

$$=\frac{m}{2}\sqrt{16^2+48^2}=25.3m$$

For satisfactory operation of bevel gears the ration L/b should not exceed 3

∴ Face width (b) = L/3

Since the material is cast iron the properties are

Allowable static stress = 55 MPa

$$=55N/mm^2$$

Surface Endurance limit (Gees) = 630 Mpa

= 630 N/mm^2

Modulus of elasticity (E) = 84 KN/mm^2

= $84x10^3 N/mm^2$

Tangential load on the Pinion

$$W_T=(Top\times C_V)\times b\times\pi m\times Y^1p\left(\frac{L-b}{L}\right)$$

$$\Rightarrow\ \frac{2\times94176}{T_P\times m}=55\times8.41m\times\pi\,m\times0.099$$

$$\left(\frac{3}{3+50.26m}\right)\times\left(\frac{25.3m-8.41m}{25.3m}\right)$$

$$\Rightarrow\ \frac{2\times94176}{16\times m}=\frac{431.58m^2(0.6676)}{3+50.26m}$$

$$\Rightarrow\ 94176(3+50.26m)=2304.9m^3$$

$$\Rightarrow\ m^3-2.053m-0.722=0$$

By Solving the above equation,

We get $m=2.87\approx3mm$

∴ Pitch diameter of Pinion (D_P) $=TP\times M$

$$=16\times3=48mm$$

Pitch diameter of Gear (D_G) = $T_G\times m$

= 48 x 3 = 144mm

Face width (b) = 8.41m

= 8.41x3=25.23mm

Proportions for Bevel Gear:

1) Addendum a = 1 x m = 1 x 3 = 3 mm
2) Dedendum d = 1.2 m = 1.2 x 3 = 3.6 mm
3) Clearance = 0.2m = 0.2 x 3 = 0.6 mm
4) Working depth = 2 m = 2 x 3 = 6 mm
5) Thickness of tooth = 1.5708 x m =

= 1.5708 x 3 = 4. 7124 mm

Tangential load on pinion $(W_p)=\dfrac{94176X2}{T_pXm}$

4. CONSTRUCTION OF MECHANISM

Welding is a fabrication process for joining materials, usually metals or thermoplastics, by causing coalescence. This is often done by melting the work pieces and adding a filler material to form a pool of molten material (the weld pool) that cools to become a strong joint, with pressure sometimes used in conjunction with heat, or by itself, to produce the weld. This is in contrast with soldering and brazing, which involve melting a lower-melting-point material between the work pieces to form a bond between them, without melting the work pieces. This welding process is used in the project for joining shafts and gears.

Figure-6.Welding

Grinding is a subset of cutting, as grinding is a true metal-cutting process. Each grain of abrasive functions as a microscopic single-point cutting edge (although of high negative rake angle), and shears a tiny chip that is analogous to what would conventionally be called a "cut" chip (turning, milling, drilling, tapping, etc.). However, among people who work in the machining fields, the term cutting is often understood to refer to the macroscopic cutting operations, and grinding is often mentally categorized as a "separate" process. This grinding process is used in the project.

Figure-7.Shaft and gear assembly

Bearing: A bearing is a machine element which supports another moving machine element (known as journal). It permits a relative motion between the contact surfaces of the members, while carrying the load.

The ball bearings that are used for the fabrication is shown in Fig.8. The bearings are fitted to the shaft; this provides support for the shaft for transmission of torque from front bevel gears to the rear bevel gears. The bevel gears are fixed into the c-clamps and the clamps are tightly attached to the bicycle

Figure-8.Ball bearing

Figure-9.Assembly of Shaft drive mechanism to bicycle

5. CONCLUSIONS

1. The presented work was aimed to reduce the wastage of human power (energy) on bicycle riding or any machine, which employs drive shafts; in general it is achieved by using light weight drive shaft with bevel gears on both sides designed on replacing chain transmission.

2. Instead of chain drive one piece drive shaft for rear wheel drive bicycle have been optimally designed and manufactured for easily power transmission.

3. The drive shaft with the objective of minimization of weight of shaft which was subjected to the constraints such as torque transmission , torsion buckling capacity , stress, strain , etc.

4. The results obtained from this work is an useful approximation to help in the earlier stages of the development, saving development time and helping in the decision making process to optimize a design.

6. REFERENCE

[1] Luther H. Porter, Wheels and Wheeling, Wheelman, Boston, 1892; page 162.
[2] Walter Stillman, Bicycle, U.S. Patent 456,387, July 21, 1891.
[3] *Archibald Sharp (1896). Bicycles and Tricycles. Longmans. p. 461. ISBN 0-486-42987-3.*
[4] *Sheldon Brown (2008). "Shaft drive". Retrieved2010-03-02.*
[5] *Tietjen, Alfred (2007). "The Chainless Hill-Climber: A restoration project". Retrieved 2009-08-07.*
[6] *Wilson, David Gordon; Jim Papadopoulos (2004).Bicycling Science (Third ed.). The MIT Press. pp. 331–333. ISBN 0-262-73154-1.*
[7] *Herlihy, David V. (2004). Bicycle, the History. Yale University Press. pp. 286–287*