Design and Fabrication of Chainless Bicycle

Khan Hassan Zakariya¹, Kolkar Abhimanyu Dashrath², Quazi Azhar Husain Farrukhzama³, Assistant Prof. Shivraj Kavhale⁴

¹,²,³ UG Student, Department of Mechanical Engineering, Dilkap Research Institute Of Engineering And Management Studies, Neral, Maharashtra, India
⁴Assistant Professor Department of Mechanical Engineering, Dilkap Research Institute Of Engineering And Management Studies, Neral, Maharashtra, India

Abstract - The development of the chain drive helped make the bicycle that we know today possible. The chain drive eliminated the need to have the cyclist directly above the wheel. Instead the cyclist could be positioned between the two wheels for better balance. More recently, bicycles with a shaft drive have been developed and it is slowly changing the bike industry. They both have unique advantages and can produce nearly the same efficiency. This paper illustrates the characteristics of the two alternate drive mechanisms, chain drive and shaft drive. After carefully examining the two alternatives, the conventional shaft drive was selected for the project since its cost and flexibility were determined to be better suited for the project.

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.

Key Words: Introduction, Components, Design of Bevel Gear & Shaft

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 with 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. COMPONENTS

2.1 Drive shaft

A shaft is a rotating machine element which is used to transmit power from one place to another. The power is delivered to the shaft by some tangential force and the resultant torque (or twisting moment) set up within the shaft permits the power to be transferred to various machines linked up to the shaft.

In a chainless cycle, a drive shaft takes over the role of the chain. The pedals are connected to the drive shaft by gears, allowing the drive shaft to transfer power from the pedal to the rear wheel. The power from the drive shaft then spins a shaft rod that propels the rear wheel, providing the cycle with power. The drive shaft connects to a hub transmission that replaces the stacked gears found on a conventional bicycle. This transmission is factory-lubricated and sealed permanently.

2.2 Bevel Gear

Bevel gears are gears where the axes of the two shafts intersect and the tooth-bearing faces of the gears themselves are conically shaped. Bevel gears are most often mounted on shafts that are 90 degrees apart, but can be designed to work at other angles as well. The pitch surface of bevel gears is a cone.

The elements of the cones intersect at the point of intersection of the axis of rotation. Since the radii of both the gears are proportional to their distances from the apex, therefore the cones may roll together without sliding. The elements of both cones do not intersect at the point of shaft intersection. Consequently, there may be pure rolling at one point of contact and there must be tangential sliding at all other points of contact. Therefore, these cones, cannot be used as pitch surfaces because it is impossible to have positive driving and sliding in the same direction at the same time. We, thus, conclude that the elements of bevel gear pitch cones and shaft axes must intersect at the same point.
2.3 Bearings

A bearing is a machine element that constrains relative motion and reduces friction between moving parts to only the desired motion. The design of the bearing may, for example, provide for free linear movement of the moving part or for free rotation around a fixed axis; or, it may prevent a motion by controlling the vectors of normal forces that bear on the moving parts. Bearings are required for the front and rear axles.

3. CONCEPT IN MACHINE DESIGN

Consideration in Machine Design

When a machine is to be designed the following points to be considered:

- Types of load and stresses caused by the load.
- Motion of the parts and kinematics of machine. This deals with the type of motion i.e. reciprocating, rotary and oscillatory.
- Selection of material & factors like strength, durability, weight.
- Corrosion resistant, weld ability, machine ability is considered.
- Form and size of the components.
- Frictional resistances and ease of lubrication.
- Convince and economical in operation.
- Use of standard parts.
- Facilities available for manufacturing.

4. MATERIAL

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Part Name</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SHAFT</td>
<td>EN-8</td>
</tr>
<tr>
<td>2</td>
<td>PED ESTAL BEARING</td>
<td>CAST IRON</td>
</tr>
<tr>
<td>3</td>
<td>BEVEL GEAR SET</td>
<td>ALLOY STEEL</td>
</tr>
<tr>
<td>4</td>
<td>CYCLE</td>
<td>STD</td>
</tr>
<tr>
<td>5</td>
<td>SMALL BEVEL GEAR</td>
<td>ALLOY STEEL</td>
</tr>
<tr>
<td>6</td>
<td>RATCHET</td>
<td>STD</td>
</tr>
<tr>
<td>7</td>
<td>FRAME</td>
<td>MS</td>
</tr>
<tr>
<td>8</td>
<td>MS PLATE</td>
<td>MILD STEEL</td>
</tr>
<tr>
<td>9</td>
<td>UNIVERSAL JOINT</td>
<td>ALLOY STEEL</td>
</tr>
<tr>
<td>10</td>
<td>ROD</td>
<td>MILD STEEL</td>
</tr>
</tbody>
</table>

Table -1. Material Selection

5. DESIGN OF BEVEL GEAR AND SHAFT

5.1 Gear Specification
5.2 Proportion of Bevel Gear-

Addendum = \( a = 1 \times m = 1 \times 4 = 4 \text{mm} \)

Dedendum = \( d = 1.2 \times m = 1.2 \times 4 = 4.8 \text{mm} \)

Clearance = \( c = 0.2 \times m = 0.2 \times 4 = 0.8 \text{mm} \)

Working depth = \( w = 1.5708 \times m = 1.5708 \times 4 = 6.28 \text{mm} \)

5.3 Design of Bevel Gears

A pair of teeth of bevel gears mounted, which are interesting at right angles, consists of 20 teeth on both the pinion and 40 teeth on gears.

The strength of a bevel gear tooth is obtained in a similar way as discussed in the previous articles. The modified form of the Lewis equation for the tangential tooth load is given as follows:

\[
W_t = (f_o \times C_v) \times b \times 3.14 \times m \times y' \left( L - \frac{J}{L} \right)
\]

Where,

\( f_o \) = Allowable static stress,

\( C_v \) = Velocity factor,

\( y' \) = Tooth form factor (or Lewis factor) for the equivalent number of teeth,

\[ L = \text{Slant height of pitch cone (or cone distance)} = 90 \text{mm} \]

\[ D_g = \text{Pitch diameter of the gear, and} \]

\[ D_p = \text{Pitch diameter of the pinion.} \]

(REFER MACHINE DESIGN BY R.S. KHURMI & J.K.GUPTA pg.no 1080)

\[ v = \text{Peripheral speed in m/sec}. \]

\[ v = 3.14 \times D \times N / 60 \]

\[ v = 3.14 \times m \times T \times N / 60 \]

\[ v = 3.14 \times m \times 40 \times 8 / 60 \]

\[ v = 16.74 \text{ mm/sec} \]

\[ v = 0.0167 m / \text{sec} \]

\( C_v = \text{velocity factor} \)

\( C_v = 6 / (6 + v) \)

\( C_v = 6 / (6 + 0.0167 m) \)

Determination of Pitch Angle for Bevel Gears

\( \theta P_1 = \text{Pitch angle for the pinion,} \)

\( \theta P_2 = \text{Pitch angle for the gear.} \)

\[ \theta p_1 = \tan^{-1} \left( \frac{1}{V.R} \right) = \tan^{-1} \left( \frac{T_p}{T_g} \right) = \tan^{-1} \left( \frac{20}{40} \right) = 26.56 \]

\[ \theta p_2 = \theta p_1 = 90 - 26.56 = 63.44 \]

So formative number of teeth for the gear

\[ T_{eg} = T_g \times \sec \theta p_2 = 40 \times 63.44 = 89.45 \]

\[ y'G = 0.124 - 0.686 / T_{eg} \]

\[ y'G = 0.124 - 0.686 / 89.45 \]

\[ y'G = 0.116 \]

\[ F_{og} \times y'G = 85 \times 0.116 = 9.88 \]

So formative number of teeth for the pinion

\[ T_{ep} = T_p \times \sec \theta p_1 = 20 \times 26.56 = 22.35 \]

\[ y'P = 0.124 - 0.686 / T_{ep} \]

\[ y'P = 0.124 - 0.686 / 22.35 \]

\[ y'P = 0.0933 \]

\[ F_{op} \times y'P = 85 \times 0.0933 = 7.93 \]

Since the product of \( F_{og} \times y'G \) is greater than \( F_{op} \times y'P \) so design should be based on pinion.

Mean Radius (Rm):

\[ R_m = \left( L - \frac{b}{2} \right) \sin \theta p \]
\[ \theta_P = 45^\circ \]

\[ L = 90 \text{mm} \]

\[ B = 28 \text{mm} \]

\[ R_m = \frac{(90-28/2) \sin 45}{2} = 53.74 \text{mm}. \]

**Induced Tangential Force (W_t)**

\[ W_t = \frac{T}{R_m} = \frac{20280}{53.74} = 377 \text{N} \]

Considering 20% frictional load

Then,

\[ W_{\text{actual}} = W_t \times 1.2 = 377 \times 1.2 = 452.4 \text{N} \]

The force applied by the pedal system on bevel gear unit is 452.4 N

**Tangential Force bearing capacity of bevel gear**

\[ W_t = \left( \frac{f_o \times C_v}{j} \right) \times 3.14 \times m \times y' \left( L - \frac{B}{L} \right) \]

\[ W_t = \left( \frac{85 \times 6}{(6+0.0167 \times 4)} \right) 28 \times 3.14 \times 4 \times 0.12 \left( \frac{90-28}{90} \right) \]

\[ W_t = 3547(90-28/90) \]

\[ W_t = 2445.16 = 2446 \text{N} \]

As Tangential Force bearing capacity of bevel gear is more than applied force thus design of pinion gear is safe.

### 5.4 Design of Gear Shaft

Material = C 45 (mild steel)

Take fos 2

\[ \sigma_t = \sigma_b = \frac{540}{f_o} = 270 \text{ N/mm}^2 \]

\[ \sigma_s = 0.5 \sigma_t \]

\[ = 0.5 \times 270 = 135 \text{ N/mm}^2 \]

**Pedal Dimension:**

We know torque on shaft = force x distance

\[ = \frac{452.4 \times 200}{90000} = 90000 \text{ N-mm} \]

\[ T = \frac{3.14}{16 \times f_s \times D^3} \]

\[ 90000 = \frac{3.14}{16 \times 60 \times D^3} \]

\[ D = 19.69 = 20 \text{ mm} \]

For 20 mm Shaft Diameter. We Select Standard Pedestal Bearing Of P204 From Design Data Book

**Fig -5: Pedestal Bearing**

Where,

P=pedestal bearing

\[ 2=\text{spherical ball or deep groove ball bearing} \]

\[ = 04 = 5 \times 4 = 20 \text{mm} \]

Bore diameter of bearing.

### 5.5 DESIGN OF L-SECTION (SUPPORTING MEMBER)

**Fig -6: Showing L- Section**

Material: - M.S.

The horizontal channel is subjected to bending stress

Stress given by => \( M/I = f_b/y \)

In above equation first we will find the moment of inertia about \( x \) and \( y \)

Axis and take the minimum moment of inertia considering the angle of 30 x 30 x 4 mm size.
We know the channel is subject to axial compressive load
In column section the maximum bending moment occurs at channel of section

\[ M = W \times \frac{L}{4} \]  

simply supported beam

\[ M = 600 \times 550/4 \]
\[ M = 82500 \text{N-mm} \]

We know

\[ f_b = \frac{M}{Z} \]

\[ Z = B^3 - b^3/6 \]
\[ Z = 30^3 - 26^3/6 \]
\[ Z = 1570 \text{ mm}^3 \]

Now check bending stress induced in L section

\[ f_b \text{ induced} = \frac{M}{Z} \]
\[ f_b \text{ induced} = \frac{82500}{1570} = 52 \text{ N/mm}^2 \]

As induced stress value is less than allowable 320 N/mm² stress value design is safe.

\[ f_b = \text{Permissible bending stress} = 320 \text{ N/mm}^2 \]
\[ f_b \text{ induced} < f_b \text{ allowable} \]

Hence our design is safe.

6. WORKING PRINCIPLE

In above figure the input revolution is given by simple paddling to input of bevel gear shaft. The transmission is completed by two bevel gear in paddling unit then offset transmission free wheel arrangement it makes paddling free in reveres paddling, shaft is attach with rear wheel by means of two bevel gear and thus transmission is completed.

7. ADVANTAGES AND DISADVANTAGES

7.1 Advantages

[1] Less jammed as compared to chain drive.

[2] The rider cannot become dirtied from chain grease or injured by the chain from "Chain", which occurs when clothing or even a body part catches between the chain and a sprocket.

[3] Lower maintenance than a chain system when the drive shaft is enclosed in a tube More consistent performance. Efficiency may increase if we are using aluminium material.

7.2 Disadvantages

[1] A drive shaft system weighs more than a chain system, usually 1-2 pounds heavier.


8. CONCLUSION

[1] Instead of chain drive shaft and bevel gear for rear wheel drive bicycle have been optimally designed and manufactured for easily power transmission.

[2] 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.

[3] 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.
9. REFERENCES


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- http://www.wikipedia.org/

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