Design and Fabrication of Chainless Bicycle

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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 are 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 pedals 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 only 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.

Fig -1: Spline Bevel Gear

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.

Fig - 2: Bearing

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.
- Cost of making the machine.
- Numbers of machine or product are manufactured.

4. MATERIAL

Sr. No.	Part Name	Material
1	SHAFT	**EN-8**
2	PEDESTAL BEARING	CAST IRON
3	BEVEL GEAR SET	ALLOY STEEL
4	CYCLE	STD
5	SMALL BEVEL GEAR	ALLOY STEEL
6	RATCHET	STD
7	FRAME	MS
8	MS PLATE	MILD STEEL
9	UNIVERSAL JOINT	ALLOY STEEL
10	ROD	MILD STEEL

Table -1. Material Selection

5. DESIGN OF BEVEL GEAR AND SHAFT

5.1 Gear Specification

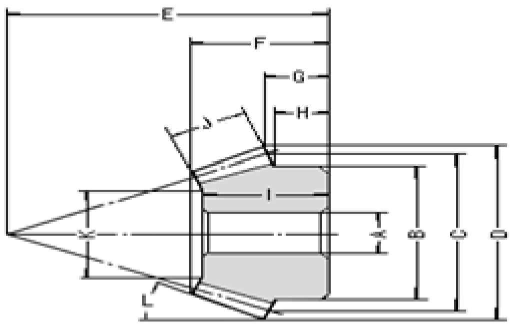


Fig -3: Pinion Gear

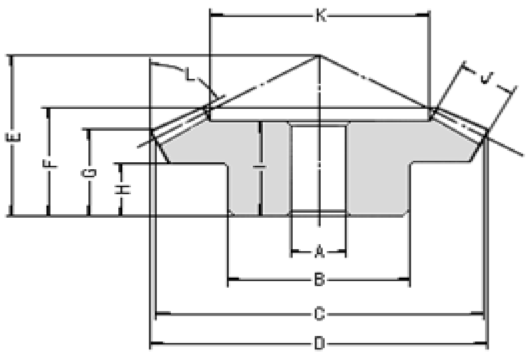


Fig -4: Bevel Gear

Module	No. Of Teeth	Bore	Hub Dia.	Pitch Dia.	Outside Dia.
m	Z	A_{H7}	B	C	D
4	40	20	70	160	162.34
	20	20	60	80	89.62

Total Length	Hub Width	Length of Bore	Face Width	Slant Height	Holding Surface Dia.
F	H	I	b	L	K
53.92	28	45	28	90	102.3
66.92	35	62			42.78

Table – 1: Gear Specification

5.2 Proportion of Bevel Gear-

Addendum = a = 1 x m = 1 x 4 = 4mm

Dedendum = d = 1.2 x m = 1.2 x 4 = 4.8mm

Clearance = c = 0.2 x m = 0.2 x 4 = 0.8 mm

Working depth = w = 1.5708 x m = 1.5708 x 4 =6.28 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:

Wt = (fo x Cv) b x 3.14 x m x y' (L – J / L)

Where,

f_o = Allowable static stress,

Cv = Velocity factor,

$= \frac{3}{3+v}$, for teeth cut by form cutters,

$= \frac{6}{6+v}$, for teeth generated with precision machines

v = Peripheral speed in m / s,

b = Face width = 28mm

m = Module,

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

L = Slant height of pitch cone (or cone distance) = 90mm

$$= \sqrt{\left(\frac{D_G}{2}\right)^2 + \left(\frac{D_P}{2}\right)^2}$$

D_G= Pitch diameter of the gear, and

= Pitch diameter of the pinion.

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

Fog = Fop = Allowable static stress = 85 N /mm^2

v = Peripheral speed in m/sec.

v = 3.14 x D x N / 60

v = 3.14 x m x T x N / 60

v = 3.14 x m x 40 x 8 / 60

v = 16.74 m mm/sec

v = 0.0167 m m/sec

Cv = velocity factor

Cv = 6 / (6 + v)

Cv = 6 / (6 + 0.0167 m)

Determination of Pitch Angle for Bevel Gears

θP1 = Pitch angle for the pinion,

θP2 = Pitch angle for the gear.

θp1 = tan^{-1} (1/V.R) = tan^{-1} (Tp/Tg) = tan^{-1} (20/40)

= 26.56

θp2 = θps- θp1 =90 – 26.56 = 63.44

So formative number of teeth for the gear

Teg = Tg . sec θp2 = 40 x 63.44 = 89.45

y'G = 0.124 – 0.686 / Teg

y'G = 0.124 – 0.686 / 89.45

y'G = 0.116

Fog × y'G = 85 x 0.116 = 9.88

So formative number of teeth for the pinion

Tep = Tp . sec θp1 = 20x 26.56 = 22.35

y'P = 0.124 – 0.686 / Tep

y'P = 0.124 – 0.686 / 22.35

y'P = 0.0933

Fop × y'P = 85 x 0.0933 = 7.93

Since the product of Fog × y'G is greater than Fop × y'P so design should be based on pinion.

Mean Radius (Rm):-

Rm = (L-b/2) Sin θp

$\theta P = 45^0$

L = 90mm

B = 28 mm

Rm = (90-28/2) sin 45

= 53.74 mm.

Induced Tangential Force (W_T)

W_T = T/Rm

= 20280 / 53.74

= 377 N

Considering 20 % frictional load

Then,

$W_{actual} = W_T \times 1.2 = 377 \times 1.2 = 452.4$ N

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

Tangential Force bearing capacity of bevel gear

Wt = (fo x Cv) j x 3.14 x m x y' (L – B / L)

Wt = (85 x 6/(6+0.0167 x 4)) 28 x 3.14 x 4 x 0.12 (90 – 28 / 90)

Wt = 3547(90 – 28 / 90)

Wt = 2445.16 = 2446 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

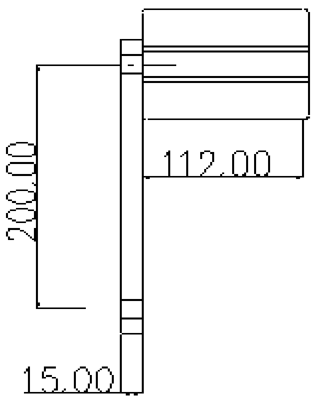
$\sigma_t = \sigma_b = 540/\text{fos} = 270$ N/mm^2

$\sigma_s = 0.5\ \sigma_t$

= 0.5 x 270

= 135 N/mm^2

Pedal Dimension :



We know torque on shaft = force x distance

= 452.4 x 200

= 90000 N -mm

$T = 3.14 / 16 \times fs \times D^3$

$90000 = 3.14 / 16 \times 60 \times D^3$

D = 19.69 = 20 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=spherical ball or deep groove ball bearing

=04=5×4 = 20mm

Bore diameter of bearing.

5.5 DESIGN OF L –SECTION (SUPPORTING MEMBER)

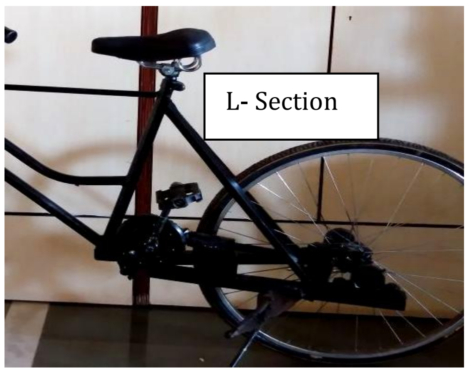


Fig -6: Showing L- Section

Material: - M.S.

The horizontal channel is subjected to bending stress

Stress given by => M/I = fb / 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.

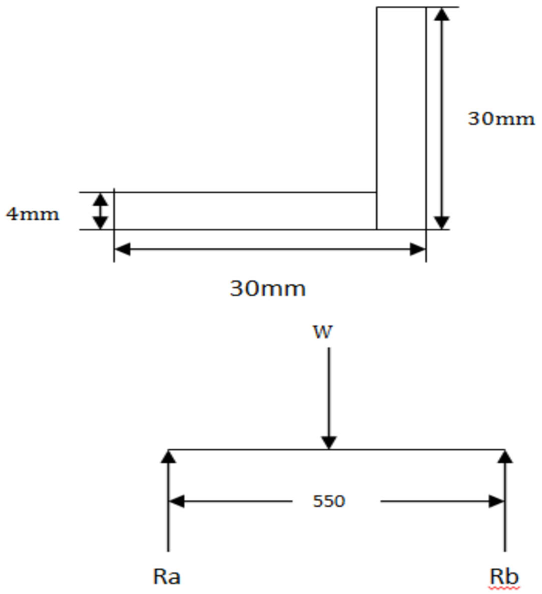


Fig -7: L- Section

We know the channel is subject to axial compressive load In column section the maximum bending moment occurs at channel of section

M = W x L/4   simply supported beam

M = 600 x 550/4

M=82500N-mm

We know

fb = M/Z

$Z = B^3 - b^3/6$

$Z = 30^3 - 26^3/6$

$Z = 1570\ mm^3$

Now check bending stress induced in L section

fb induced = M/Z

fb induced = 82500 /1570 = 52 N / mm^2

As induced stress value is less than allowable 320 N / mm^2 stress value design is safe.

fb = Permissible bending stress = 320 N / mm^2

fb induced < fb 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.

Fig -8: Chainless Bicycle

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.

[2] Wheel removal is complicated.

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

- IJSTE - International Journal of Science Technology & Engineering | Volume 2 | Issue 11 | May. Design & Fabrication of Shaft Driven Bicycle.
- International Journal of Emerging Engineering Research and Technology Volume 2, Issue 2, May 2014, Design & Fabrication of Shaft Drive for Bicycle.
- Machine Design By RS Khurmi & JK Gupta
- PSG Design Data Book
- http://www.wikipedia.org/
- http://www.dynamicbicycles.com/
- http://en.wikipedia.org/wiki/Dynamo