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Design and Fabrication of Shaft Drive for two Wheelers

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1. Abstract

1.1 Role Of Automobile In Our Day To Day Life

In modern world the living status were developed and developing more equipped. The automobile takes a great part in the development, since it plays a major key in daily life while automobile is concern two wheeler i.e.(motor cycles and bike) it plays very important role because it saves the time of traveller by reaching the target place very faster. Although it saves the time, it makes lots of noise by the chain drive and also makes greasy over the parts of the bike by the chain drive lubrication. It leads to lot of maintenance cost. So by keeping maintenance as the main concept in our mind we had planned to do this project.

1.2 Proposed Method

A shaft-driven two wheeler is a two wheeler that uses a drive shaft instead of a chain to transmit power from the pedals to the wheel arrangement. Shaft drives were introduced over a century ago, but were mostly supplanted by chain-driven two wheelers due to the gear ranges possible with sprockets and derailleur. Recently, due to advancements in internal gear technology, a small number of modern shaft-driven two wheelers have been introduced. Shaft-driven bikes have a large bevel gear where a conventional bike would have its chain ring. This meshes with another bevel gear mounted on the drive shaft. The use of bevel gears allows the axis of the drive torque from the pedals to be turned through 90 degrees. The drive shaft then 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 a conventional bike, and cancelling out the first drive torque change of axis.

II. Components And Description

2.1components

- **drive shaft**
- **gears**
- **universal joint**
- **bearing**
- **axle**
- **wheel**

2.2description of components

2.2.1 drive shaft A drive shaft, driveshaft, driving shaft, propeller shaft (prop shaft), or Cardan shaft is a mechanical component for transmitting torque and rotation, usually used to connect other components of a drive train that cannot be connected directly because of distance or the need to allow for relative movement between them. As torque carriers, drive shafts are subject to torsion and shear stress, equivalent to the difference between the input torque and the load. They must therefore be strong enough to bear the stress, whilst avoiding too much additional weight as that would in turn increase their inertia.

To allow for variations in the alignment and distance between the driving and driven components, drive shafts frequently incorporate one or more universal joints, jaw couplings, or rag joints, and sometimes a splined joint or prismatic joint.

As an alternative to chain and belt drives, drive shafts offer relatively maintenance-free operation, long life and cleanliness. A disadvantage of shaft drive on a two wheeler is that helical gearing, spiral bevel gearing or similar is needed to turn the power 90° from the shaft to the rear wheel, losing some power in the process. On the other hand, it is easier to protect the shaft linkages and drive gears from dust, sand, and mud.

Two wheeler engines positioned such that the crankshaft is longitudinal and parallel to the frame are often used for shaft-driven two wheelers. This requires only one 90° turn in power transmission, rather than two.

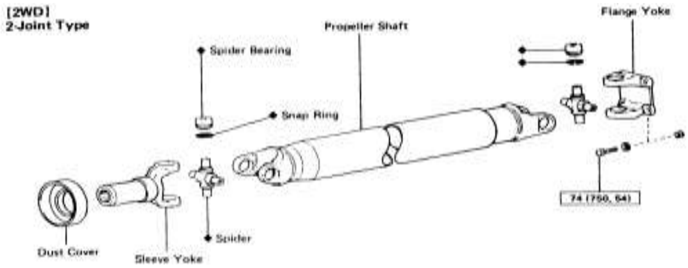


Fig.2.1

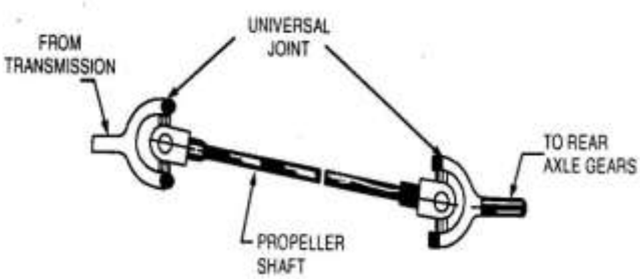


Fig 2.2

2.2.1.1 Shaft Design

The design ofthe shaft involves the following considerations

- Because of the simultaneous occurrence of torsional shear and normal stresses due to bending, the stress analysis of a shaft virtually always involves the use of a combined stress approach.
- The recommended approach for shaft design and analysis is the distortion energy theory of failure.
- Vertical shear stresses and direct normal stresses due to axial loads may also occur.
- On very short shafts or on portions of shafts where no bending or torsion occurs, such stresses may be dominant.
- Cost and qualities needed. The designers use these factors to select a material and specify values for the shaft diameter, bending stress, axial stress, torsional stress, torque transmission.

2.2.1.2 *Design Calculation*

Taking specification from hero splendour plus engine Maximum power from the engine = 6.15 KW at 8000 rpm
Maximum torque from the engine = 8.05 N-m at 5000 rpm

P = $\frac{2\pi NT}{60}$

6.15 x 10^3 = $\frac{2\pi \text{ x } 8000 \text{ x } T}{60}$

T =7.341 N-m = T_{min}

T_{max} = 8.05 N-m

T_{min} = 7.341 N-m

Assuming C_{45} steel,σ_y =380 N/mm^2, n = 2

By using Soderberg equation,

$$\frac{1}{n} = \frac{\sigma_m}{\sigma_y} + k_f \frac{\sigma_a}{\sigma_{-1}}$$

To determine the τ_{max} ,

$\frac{T_{max}}{\frac{\pi}{32} \text{ x } d^4} = \frac{\tau_{max}}{\frac{d}{2}}$

$\frac{T_{max}}{\frac{\pi}{32} \text{ x } d^4} = \frac{\tau_{max}}{\frac{d}{2}}$

$\frac{8.05 \text{ x } 10^3}{\frac{\pi}{32} \text{ x } d^4} = \frac{\tau_{max}}{\frac{d}{2}}$

$\frac{8.05 \text{ x } 10^3}{\frac{\pi}{32} \text{ x } d^4} \text{ x } \frac{d}{2} = \tau_{\text{max}}$

$\frac{8.05 \text{ x } 10^3 \text{x } 16}{\pi \text{ x } d^3} = \tau_{max}$

$\tau_{max} = \frac{40998.39}{d^3}$

To determine the τ_{min},

$\frac{T_{min}}{\frac{\pi}{32} \text{ x } d^4} = \frac{\tau_{min}}{\frac{d}{2}}$

$\frac{T_{min}}{\frac{\pi}{32} \text{ x } d^4} = \frac{\tau_{min}}{\frac{d}{2}}$

$\frac{7.341 \text{ x } 10^3}{\frac{\pi}{32} \text{ x } d^4} = \frac{\tau_{min}}{\frac{d}{2}}$

$\frac{7.341 \text{ x } 10^3}{\frac{\pi}{32} \text{ x } d^4} \text{ x } \frac{d}{2} = \tau_{min}$

$\frac{7.341 \text{ x } 10^3 \text{ x } 16}{\pi \text{ x } d^3} = \tau_{min}$

$\tau_{min} = \frac{37387.4}{d^3}$

To determine τ_m,

$\tau_m = \frac{\tau_{max} + \tau_{min}}{2}$

$\tau_m = \frac{\frac{40998.39}{d^3} + \frac{37387.4}{d^3}}{2}$

$\tau_m = \frac{39192.86}{d^3}$

To determine τ_a,

$\tau_a = \frac{\tau_{max} - \tau_{min}}{2}$

$\tau_a = \frac{\frac{40998.39}{d^3} - \frac{37387.4}{d^3}}{2}$

$\tau_a = \frac{902.725}{d^3}$

Taking k_f = 1.425,

$\frac{1}{n} = \frac{\tau_m}{\tau_y} + k_f \frac{\tau_a}{\tau_{-1}}$

$\frac{1}{2} = \frac{\frac{39192.86}{d^3}}{190} + 1.425 \frac{\frac{902.725}{d^3}}{152}$

$\frac{1}{2} = \frac{206.278}{d^3} + \frac{8.463}{d^3}$

d = 12.42 mm

on standardizing , diameter of the shaft is d = 15 mm = 1.5 cm

2.2.2 Gears

A gear is a rotating machine part having cut teeth, or cogs, which mesh with another toothed part to transmit torque. Geared devices can change the speed, torque, and direction of a power source. Gears almost always produce a change in torque, creating a mechanical advantage, through their gear ratio, and thus may be considered a simple machine. The teeth on the two meshing gears all have the same shape. Two or more meshing gears, working in a sequence, are called a gear train or a transmission. A gear can mesh with a linear toothed part, called a rack, thereby producing translation instead of rotation.

The gears in a transmission are analogous to the wheels in a crossed belt pulley system. An advantage of gears is that the teeth of a gear prevent slippage.

When two gears mesh, if one gear is bigger than the other, a mechanical advantage is produced, with the rotational speeds, and the torques, of the two gears differing in proportion to their diameters.

Types

- Spur
- Helical
- Double helical
- Bevel
- Hypoid
- Crown
- Worm
- Rack and pinion
- Epicyclic
- Cage gear

- Magnetic gear

2.2.2.1 Bevel Gear

A bevel gear is shaped like a right circular cone with most of its tip cut off. When two bevel gears mesh, their imaginary vertices must occupy the same point. Their shaft axes also intersect at this point, forming an arbitrary non-straight angle between the shafts. The angle between the shafts can be anything except zero or 180 degrees. Bevel gears with equal numbers of teeth and shaft axes at 90 degrees are called mitre gears.

2.2.2.1 .1 Spiral Bevel Gear

Spiral bevel gears can be manufactured as Gleason types (circular arc with non-constant tooth depth), Oerlikon and Curvex types (circular arc with constant tooth depth), KlingelnbergCyclo-Palloid (Epicycloide with constant tooth depth) or KlingelnbergPalloid. Spiral bevel gears have the same advantages and disadvantages relative to their straight-cut cousins as helical gears do to spur gears. Straight bevel gears are generally used only at speeds below 5 m/s (1000 ft/min), or, for small gears, 1000 r.p.m.

The cylindrical gear tooth profile corresponds to an involute, but the bevel gear tooth profile to an octoid. All traditional bevel gear generators (like Gleason,Klingelnberg, Heidenreich &Harbeck and WMWModul) manufacture bevel gears with an octoidal tooth profile.

2.2.2.1.2 Crown Wheel

Crown gears are a particular form of bevel gear whose teeth project at right angles to the plane of the wheel; in their orientation the teeth resemble the points on a crown. A crown gear can only mesh accurately with another bevel gear, although crown gears are sometimes seen meshing with spur gears. A crown gear is also sometimes meshed with an escapement such as found in mechanical clocks.

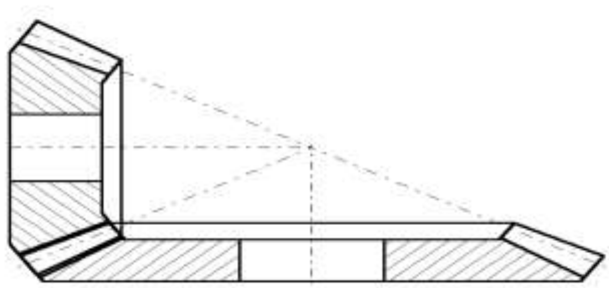


Fig.2.3

Fig.2.4

2.2.2.2.1 Gear Design

The design of the gear involves the following considerations:

The accuracy of the output of a gear depends on the accuracy of its design and manufacturing. The correct manufacturing of a gear requires a number of prerequisite calculations and design considerations.

- Strength of the gear in order to avoid failure at starting torques or under dynamic loading during running conditions.
- Gear teeth must have good wear characteristics.
- Selection of material combination.

- Proper alignment and compactness of drive
- Provision of adequate and proper lubrication arrangement.
- Cost and qualities needed. The designers use these factors to select a material and specify values for the diameter of the gear, pitch, module, clearance of the gear and the gear tooth profile.

2.2.2.2.2 Design Calculations
Crown Wheel Set
Taking C_{45} steel, standard stresses are taken from data book
σ_c =9500 kgf/cm^2
σ_b =3200 kgf/cm^2
Cone distance,
R = $\psi_y \sqrt{i^2+1} \sqrt[3]{(\frac{0.72}{(\psi_y - 0.5)\ X\ [\sigma_c]})^2\ X\ \frac{E\ [M_t]}{i}}$
R = $3\sqrt{0.625^2+1} \sqrt[3]{(\frac{0.72}{(3-0.5)\ X\ 9500})^2\ X\ \frac{(2.15\ X 10^6\ X\ 73.41\ X\ 1.5)}{0.625}}$
R = 4.62 cm

Calculation of average module,
m_{av} =1.28$\sqrt[3]{\frac{[M_t]}{y_v[\sigma_b]\psi_m\ z_1}}$
Taking z_1= 16, ψ_m = 10,
δ_1 + δ_2= 90,
tan δ_1 = i = 0.625
δ_2 =32
$\delta_1 = 58$
z_v= $\frac{z_1}{\cos\ \delta_1}$ = $\frac{16}{\cos\ 58}$
z_v= 30.19
At z_v= 30.19,y_v= 0.402
m_{av} = 1.28$\sqrt[3]{\frac{[M_t]}{y_v[\sigma_b]\psi_m\ z_1}}$
m_{av} = 1.28$\sqrt[3]{\frac{73.41\ X\ 1.5}{0.402\ X\ 3200\ X\ 10\ X\ 16}}$
m_{av} = 0.41 cm
Transverse module,
m_t = m_m $(\frac{\psi_y}{\psi_y - 0.5})$
m_t = 0.41$(\frac{3}{3-0.5})$
m_t = 0.49 cm
Corrected no of teeth of pinion and gear,
R = z_1(0.5)$m_t\sqrt{i^2+1}$
4.62 = z_1 (0.5) x 0.49 $\sqrt{0.625^2+1}$
z_1 = 16
z_2 = iz_1 = 0.625 x 16 = 10
Corrected centre distance,
R = z_1 (0.5)$m_t\sqrt{i^2+1}$
R = 3.92 cm
Face width,
B = 0.3 R = 0.3 x 3.92 =1.386 cm
B = 10 m_t =10 x0.49 =4.9 cm
Pitch diameter,
d_1 = $m_t z_1$ = 8.5 cm
d_2 = $m_t z_2$ =4.5 cm
Root diameter,
d_{01} = 0.49(16+2 cos 58) = 8.36cm
d_{02} = 0.49(10+2 cos 32) = 5.73cm

Bevel Gear Set 2
Taking C_{45} steel, standard stresses are taken from data book
σ_c =9500 kgf/cm^2
σ_b =3200 kgf/cm^2
Cone distance,

$$R = \psi_y \sqrt{i^2+1}\sqrt[3]{\left(\frac{0.72}{(\psi_y - 0.5)\ X\ [\sigma_c]}\right)^2 X\ \frac{E\ [M_t]}{i}}$$

$$R = 3\sqrt{0.692^2+1}\sqrt[3]{\left(\frac{0.72}{(3-0.5)\ X\ 9500}\right)^2 X\ \frac{(2.15\ X 10^6\ X\ 73.41\ X\ 1.5)}{0.692}}$$

R = 3.92 cm

Calculation of average module,

$$m_{av} = 1.28\sqrt[3]{\frac{[M_t]}{y_v[\sigma_b]\psi_m\ z_1}}$$

Taking z_1= 13, ψ_m = 10,
$\delta_1 + \delta_2$= 90,
tan δ_1 = i = 0.692
δ_2 =34.68

$$\delta_1 = 55..31$$

$z_v = \frac{z_1}{\cos\delta_1} = \frac{13}{\cos 55.31}$
z_v= 22.84
At z_v= 22.84,y_v= 0.402

$$m_{av} = 1.28\sqrt[3]{\frac{[M_t]}{y_v[\sigma_b]\psi_m\ z_1}}$$

$$m_{av} = 1.28\sqrt[3]{\frac{73.41\ X\ 1.5}{0.402\ X\ 3200\ X\ 10\ X\ 13}}$$

m_{av} = 0.413 cm
Transverse module,

$$m_t = m_m\left(\frac{\psi_y}{\psi_y - 0.5}\right)$$

$$m_t = 0.413\left(\frac{3}{3-0.5}\right)$$

m_t = 0.496 cm
Corrected no of teeth of pinion and gear,
R = z_1 (0.5)$m_t\sqrt{i^2+1}$
3.92 = z_1 (0.5) x 0.496$\sqrt{0.692^2+1}$
z_1 = 13
z_2 = iz_1 = 0.692 x 13 = 9
Corrected centre distance,
R = z_1 (0.5)$m_t\sqrt{i^2+1}$
R = 3.92 cm
Face width,
B = 0.3 R = 0.3 x 3.92 =1.176 cm
B = 10 m_t =10 x0.496 =4.96 cm
Pitch diameter,
$d_1 = m_t z_1$ = 5.7 cm
$d_2 = m_t z_2$ =5 cm
Root diameter,
d_{01} = 0.496(13+2 cos 55.31) = 7.01cm
d_{02} = 0.496(9+2 cos 34.68) = 5.28cm

2.2.3 Universal Joint

A Universal joint is a connection between two shafts that permits a driving shaft to drive a driven shaft at an angle.Universal joints are needed because the rear end of the propeller shaft is constantly rising and falling due to:
(a) The flexing of the road springs.
(b) The also allow for the rear axle assemble to twist due to the drive and brake torque reaction.

A universal joint is shown in fig. This is also called Hooke's joint. These joints are provided at the ends of the propeller shaft to connect it to the gear box output shaft and the differential pinion's shafts as shown in fig. below. The differential is located at a lower level than the gear box. So these are connected at an angle and the universal joints can serve this purpose. The universal joint not only makes a flexible connection between two rigid shafts at an angle but they permit to continue the transmission of power when this angle is continuously changing. The change in the angle is due to the reason that the differential goes up and down due to uneven road surface.

The universal joint is essentially a double hinged joint consisting of two Y-shaped yokes. One yoke is provided on the driving shaft and second on the driven shaft. A crossed shaped member also known as the spider connects the two yokes. The four arms of the cross are assembled into the bearings in the ends of the two shaft yokes. The arms of the spider are also known as trunnions. The driving shaft makes the spider to rotate and the other two trunnions of the spider make the driven shaft to rotate. When the two shafts are rotating at an angle, the bearing of the yokes permit them to swing around on the trunnions with each revolution. The bearings of the universal joints should be properly lubricated.

2.2.4 Bearings

A bearing is a machine element that constrains relative motion to only the desired motion, and reduces friction between moving parts. 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. Many bearings also facilitate the desired motion as much as possible, such as by minimizing friction. Bearings are classified broadly according to the type of operation, the motions allowed, or to the directions of the loads (forces) applied to the parts.

The term "bearing" is derived from the verb "to bear" ;a bearing being a machine element that allows one part to bear (i.e., to support) another. The simplest bearings are bearing surfaces, cut or formed into a part, with varying degrees of control over the form, size, roughness and location of the surface. Other bearings are separate devices installed into a machine or machine part. The most sophisticated bearings for the most demanding applications are very precise devices; their manufacture requires some of the highest standards of current technology.

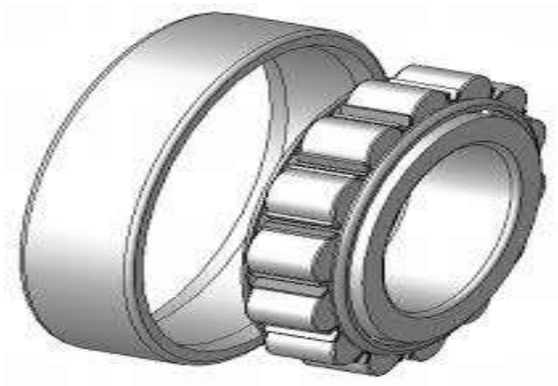


Fig. 2.5

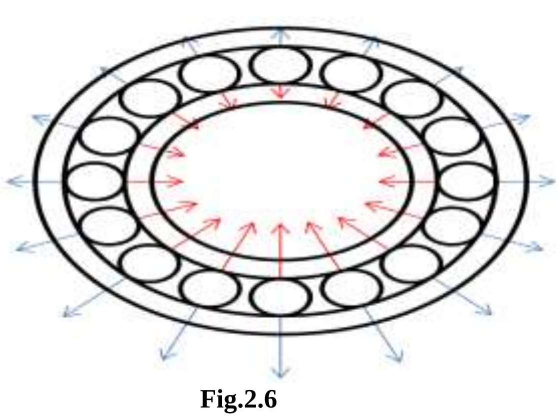


Fig.2.6

2.2.4.1 Design Calculation
Diameter of the shaft d=1.5 cm = 1.5 x 10^{-2} m=0.015 m
Radial load = 1073.5 N
Thrust load =429.32 N
Taking L_h =1000 hrs
$\frac{F_a}{F_r} = \frac{429.32}{1073.3} = 0.4$
Calculating the equivalent static load
P = (X F_r +Y F_a) S
$\frac{F_a}{F_r} = \frac{429.32}{1073.3} = 0.4 = 2$
$\frac{F_a}{F_r} > 2$
0.43>0.4
X=0.65 Y=2.3
Assuming s=1
P = (X F_r +Y F_a) S
P = (0.65 x 1073.3) +(2.3 x 429.32)
P =1685.1 N
Calculating dynamic capacity of the bearing{c}
$C = [\frac{L}{L_{10}}]^{\frac{1}{k}}$ p
L= hours x n x 60 x 10^{-6}
L= 1000 x 8000 x 60 x 10^{-6}
L = 480 millions revolution
$C = [\frac{480}{1}]^2$ x 842.55
C =6596.9 N
Selecting and designating the bearing
Calculated C = 6596.9 N
Standard C = 6550 N
Skf 19 d = 95 mm; D=170 mm; B=43 mm; r = 3.5 mm;
Selction of fit
For d =95 mm
Normal and heavy loads -> ball bearings ->diameter->65-100
->tolerance->m6 N7

2.2.5 Axle

An axle is a central shaft for a rotating wheel or gear. On wheeled vehicles, the axle may be fixed to the wheels, rotating with them, or fixed to the vehicle, with the wheels rotating around the axle. In the former case, bearings or bushings are provided at the mounting points where the axle is supported. In the latter case, a bearing or bushing sits inside a central hole in the wheel to allow the wheel or gear to rotate around the axle. Sometimes, especially on bicycles, the latter type axle is referred to as a spindle.

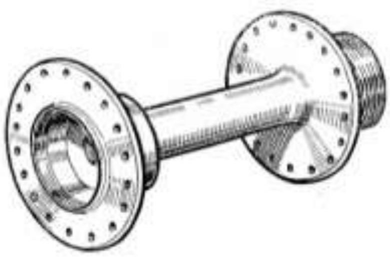


Fig.2.7

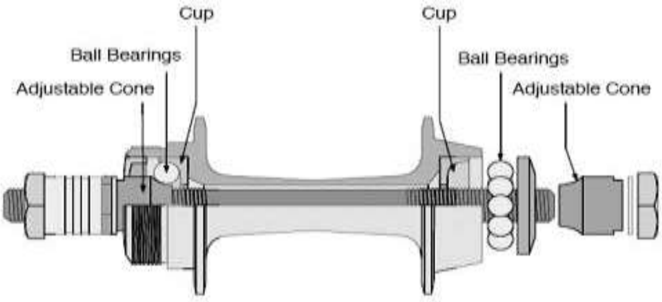


Fig.2.8

2.2.6 Wheel

A wheel is a circular component that is intended to rotate on an axle bearing. The wheel is one of the main components of the wheel and axle which is one of the six simple machines. Wheels, in conjunction with axles, allow heavy objects to be moved easily facilitating movement or transportation while supporting a load, or performing labor in machines. Wheels are also used for other purposes, such as a ship's wheel, steering wheel, potter's wheel and flywheel.

Common examples are found in transport applications. A wheel greatly reduces friction by facilitating motion by rolling together with the use of axles. In order for wheels to rotate, a moment needs to be applied to the wheel about its axis, either by way of gravity, or by the application of another external force or torque.

Construction:

Rim: The rim is the outer edge of a wheel, holding the tire. It makes up the outer circular design of the wheel on which the inside edge of the tire is mounted on vehicles such as automobiles. For example, on a bicycle wheel the rim is a large hoop attached to the outer ends of the spokes of the wheel that holds the tire and tube.

Hub: The hub is the center of the wheel, and typically houses a bearing, and is where the spokes meet. A hub less wheel (also known as a rim-rider or centerless wheel) is a type of wheel with no center hub. More specifically, the hub is actually almost as big as the wheel itself. The axle is hollow, following the wheel at very close tolerances.

Spokes: A spoke is one of some number of rods radiating from the center of a wheel (the hub where the axle connects), connecting the hub with the round traction surface. The term originally referred to portions of a log which had been split lengthwise into four or six sections. The radial members of a wagon wheel were made by carving a spoke (from a log) into their finished shape. A spokeshave is a tool originally developed for this purpose. Eventually, the term spoke was more commonly applied to the finished product of the wheelwright's work, than to the materials used.

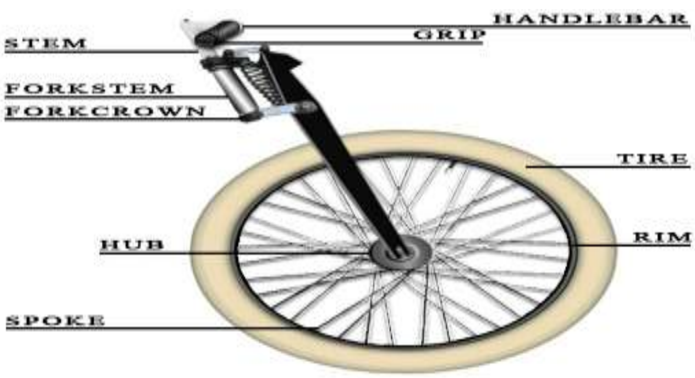


Fig.2.9

III. Specification of Components

3.1 Shaft

Diameter of the shaft = 1.5 cm
Length of the shaft = 750 mm

3.2 bevel gears
gear 1
Diameter of the gear = 5.7 cm
width of the gear = 1.176 cm
Module of the gear = 0.496 cm
Number of teeth = 13

Gear 2
Diameter of the gear = 5 cm
width of the gear = 1.176 cm
Module of the gear = 0.496 cm
Number of teeth = 9

3.3 Crown Wheel

Gear 1
Diameter of the gear = 8.5 cm
width of the gear = 1.386 cm
Module of the gear = 0.49 cm
Number of teeth =16

Gear 2
Diameter of the gear = 4.5 cm
width of the gear = 1.386 cm
Module of the gear =0.49 cm
Number of teeth = 10

IV. CONSTRUCTION

4.1 Block Diagram

The above figure represents the block diagram of the power transmission from engine to the rear wheel using shaft drive mechanism.

4.2 Assembly

- The Engine gear box shaft is connected to a bevel gear which is in turn meshed with a bevel gear attached to main shaft(propeller shaft) and hence provides for perpendicular transmission.
- The other side of the propeller shaft is connected with bevel gears. This in turn meshes with the bevel gear attached to the rear wheel shaft.
- Alignment bearing supports the shaft at the center. The Bearing constrains relative motion to only the desired motion and provides for frictionless motion.
- The bearings case is welded to the frame of twowheeler.
- A universal coupling is fitted at the left end and right of the shaft to accommodate the bends in the shaft due to the suspension action the shocks produced due to uneven path.
- Two bearings are also fitted at the ends of the rear wheel shaft to allowsits smooth rotation without friction.

V. WORKING

5.1 Working Procedure

While using chain drive in two wheeler, there possess some noise and greasy and wear over the chain that leads to high maintenance cost. So this can be prevented by this type of arrangement as output shaft of the gear box is connected to a propeller shaft through a set of bevel gears. The other side of the shaft is connected with another set of bevel gears. These bevel gears are used to rotate the back wheel in parallel to engine shaft. The power from the engine is transmitted to the gear box whenever required. The transmitted power from the engine is made to flow over the output shaft of the gear box which is connected to bevel gear which is meshed with another bevel gear that transmits power from one another. From the bevel gear which is connected to propeller shaft transmits power to the other end of bevel gear that is meshed up with another bevel gear which is connected with the axle, so the power transmitted from gear to axle. The wheel is connected to the axle which rotates the wheel in forward direction. Thus, the power is transmitted from engine to the rear wheel with the help of the bevel gears and shaft.

VI. Advantages

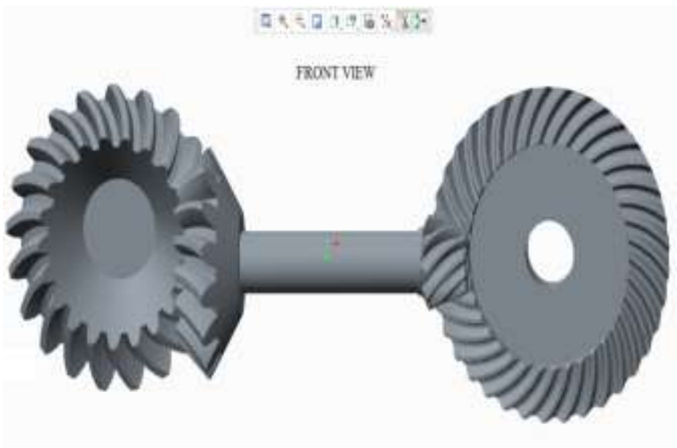
The advantages of using this shaft drive instead of chain drive are as follows

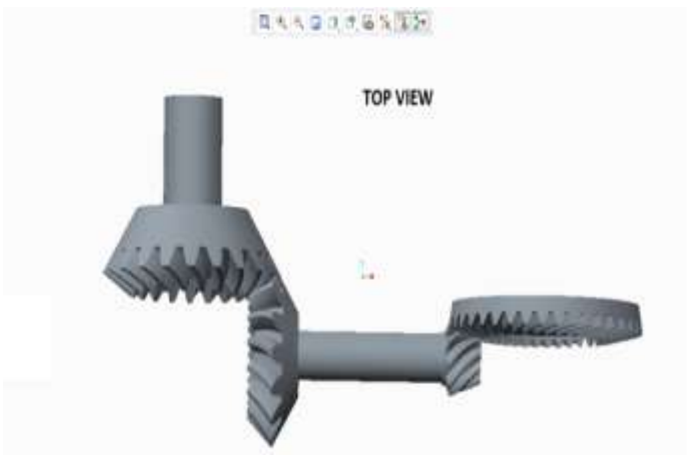
- They have good corrosion resistance and high strength.
- Higher efficiency as compared to the chain drive.
- Greater torque capacity than the chain drive.
- Longer fatigue life than chain drive.
- Shaft drives operate at a very consistent rate of efficiency and performance, without adjustments or maintenance.
- Standard chain drives are noisy, require more frequent maintenance to keep the chain from corroding, wearing, and from frictional wear of the sprockets.
- Provides greater ground clearance

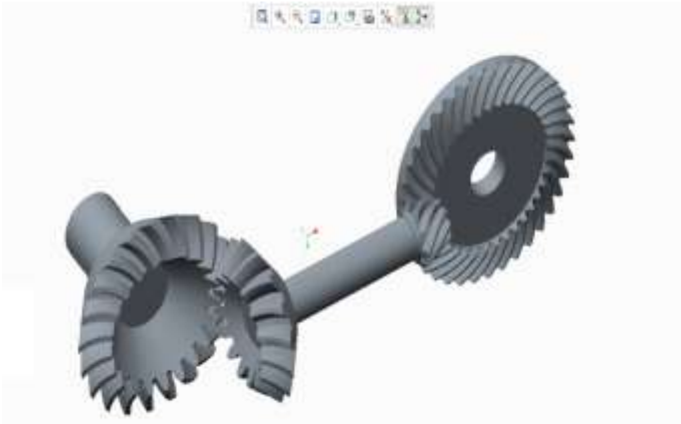
VII. Computer Aided Designed Model

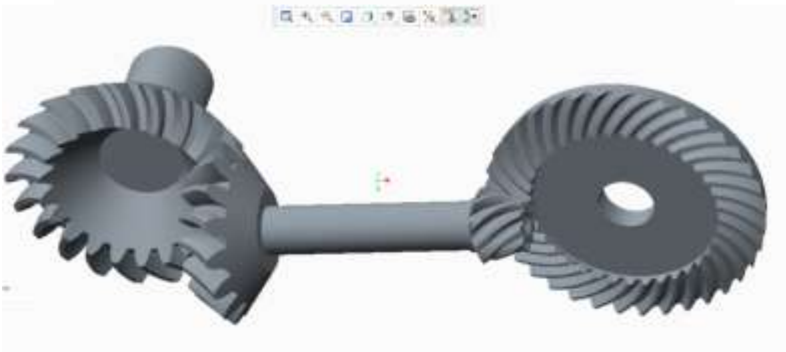
Model Design

The below pictures shows the modelled design of the shaft drive transmission system in two wheeler









VIII. Comparison of Shaft Drive and Chain Drive

Shaft Drive-Hub Bikes vs. Chain-Sprocket-Derailleur Bikes		
Features	**Dynamic Bicycles ShaftDrive Bikes**	**Sprocket-Derailleur Bikes**
Frame construction	Aluminium Alloy	Aluminium Alloy
Gear Components	Shimano internal Gear Hubs; Enclosed Shaft Drive	Sprockets, Derailleur's, Chains
Gear Changes	Single Shifter; Fast and seamless gear changes; shifting independent of pedaling; easy-to-read gear indicator	Multiple Shifters; must pedal to change gears; no gear indicator
Maintenance	No Scheduled Maintenance on Hub; Periodic Grease added to Shaft Drive - fast and easy	Requires adjustment of derailleur's by trained bike mechanic; periodic chain cleaning, lubrication and tensioning
Durability	Hardened cromoly gears, cast aluminium housings, sealed bearings. All moving parts fully enclosed to prevents damage and corrosion	All moving parts fully exposed and susceptible to damage, misalignment and corrosion
Resilience to Elements	Fully internal gearing sealed and protected from rain, salt, dirt, and sand	External gearing fully exposed and adversely affected by rain, salt, sand and debris
Ground Clearance (to drive system parts)	13+ inches to shaft drive	~ 8 inches to derailleur, chain and sprocket
Safety	Gears fully enclosed in shaft-drive, nothing to catch on hands or clothing; no more "chain bite"	Chain, sprockets and derailleurs can tear and soil clothing and cut hands
Efficiency	90%+ efficient (consistently with minimal maintenance)	75% - 95% efficient (varies depending on condition and upkeep)
Gear Range	8-speed = range of 21 gears of chain bike 7-speed = range of 18 gears of chain bike	21-gear or 24-gear
Noise	Low - runs virtually silent	Can vary depending on condition of chain and alignment of derailleur

IX. Conclusion

- ✓ Propeller shaft mechanism is an alternative way for a two wheeler power transmission replacing the conventionally used chain drive.
- ✓ The use of shaft drive overcomes the various drawbacks presented by the chain drive.
- ✓ There can be further modifications made in the proposed design by using composite material for shaft.
- ✓ Also the setup can be further made compact by reducing the number of bevel gears to two by changing the alignment of the engine.

- ✓ The results obtained from this work is an useful approximationto help in the earlier stages of the development, saving development time and helping in the decision making processto optimize a design.

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