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Stage-II

Project Report

On

**“Design and Fabrication of shaft driven bicycle”**

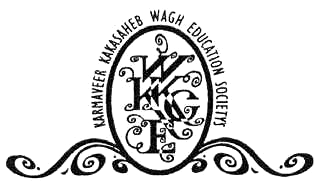
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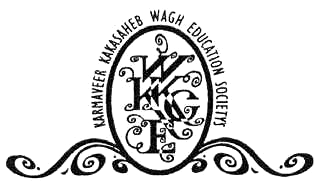
**K.K. Wagh Education Society’s**

**K.K. Wagh Institute of Engineering Education and Research, Nashik-3**

**Department of Mechanical Engineering**

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**Sem-VII**



# C E R T I F I C A T E

This is to certify that the project report entitled

**“DESIGN AND FABRICATON OF SHAFT DRIVEN BICYCLE”**

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is a bonafide work carried out by them under the supervision of Prof. **Amit** **Bhagure**

and it is approved for the partial fulfillment of the requirement of Savitribai Phule Pune University for the award of the Degree of Bachelor of Engineering (Name of Programme)

This project report has not been earlier submitted to any other Institute or University for the award of any degree or diploma*.*

Internal Guide Head of Department

External Examiner

Date:

Place: Nashik

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|  |  |
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**ABSTRACT**

This project is developed for the users to rotate the back wheel of a two wheeler using propeller shaft.

Power transmission through chain drive is the oldest and widest used method in case of bicycle. In this paper we implemented the chainless transmission to the bicycle to overcome the various disadvantages of chain drive. Shaft drives were introduced over a century ago, but were mostly supplanted by chain-driven bicycles 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 bicycles have been introduced. Usually in two wheelers, chain and sprocket method is used to drive the back wheel.

The shaft drive only needs periodic lubrication using a grease gun to keep the gears running quiet and smooth.

A 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 safesystem.Shaft-driven bikes have a large bevel gear where aconventional bike would have its chain ring. This meshes with another bevel gear mounted on the driveshaft.The use of bevel gears allows the axis of the drive torque from the pedals to be turned through 90degrees.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 ofaxis.

According tothe direction of motion of pedal, the wheel will be moved forwardorreverse. This avoids the usage of chain and sprocket method.This “chainless” drive system providessmooth, quiteand efficienttransferofenergy from the pedals to the rearwheel.It is attractive in look compare with chain driven bicycle. It replacesthe traditional method.

Keyword: - Shaft, Bevel gear

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**CHAPTER- 1**

**INTRODUCTION**

## GENERAL INTRODUCTION

* A shaft-driven bicycle is a bicycle that uses adrive shaft instead of a chain to transmit power from the pedals to the rear wheel. Shaft driveswere introduced over a century ago, but were mostly supplanted by chain-driven bicycles due to the gear ranges possible with sprockets and derailleur. If bevel-gear could be accurately and cheaply cut by machinery, it is possible that gears of this description might supplant, to a greatextent.

Shaft-driven bikes have a large bevel gear wherea conventional bike would have its chain ring. This meshes with another bevel gear mountedon the drive shaft. The useof bevel gears allows the axis of the drive torque from the pedals to be turned through 90 degrees.The drive shaft thenhas anotherbevel 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 ofaxis.

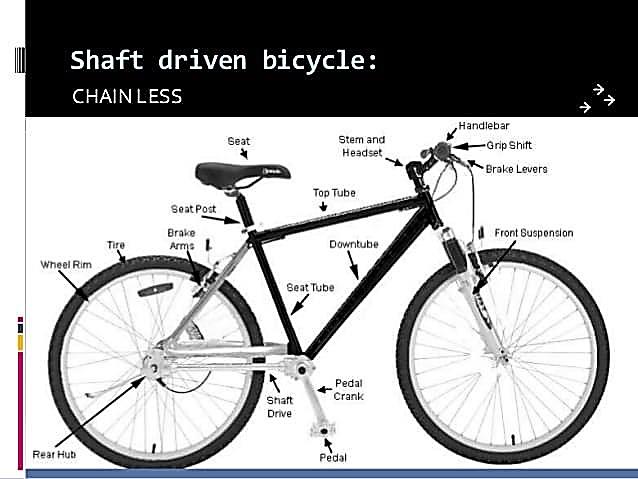


Figure 1.1- Replacement of chain drive bicycle with driveshaft

The design of bevelgear produceslessvibrationandlessnoisethan conventional straight-cut or spur-cut gear with the straight teeth. The shaft drives only needs periodic lubrications using a grease gun to keep the gears running quite, smooth and efficient transfer of energy from the pedals to the rear wheel. It isattractive in look compared with chain drivenbicycle.

An automotive drive shaft transmits power from the engine to the differential gear of a rear wheel drive vehicle. The drive shaft is usually manufactured in two pieces toincrease the fundamental bendingnaturalfrequency because the bending natural frequency of a shaft is inversely proportional to the square of beam length and proportional to the square root of specific modulus which increases the total weightof an automotive vehicle and decreases fuel efficiency. So, a single piecedrive shaft is preferred here and the material of it is considered to be Titanium alloy because of its high strength and low density. Drive shafts are carriers of torque and are subject to torsion and shear stress, equivalent to the difference between the input torque and the load. They must therefore be strongenough tobear the stress, whilst avoiding too much additional weight as that would in turn increase theirinertia.

* 1. **Purpose of the Drive Shaft (Or PropellerShaft)**

The torque that is produced fromthe engine and transmission must be transferred to the rear wheels to push the vehicle forward and reverse. The drive shaft must provide a smooth, uninterrupted flow of power to the axles. The drive shaft and differential are used to transfer thistorque.

## Functions of the DriveShaft

* + 1. First, it must transmit torque from the transmission to the differential gearbox.
    2. During the operation,it isnecessary to transmit maximum low-gear torque developed by theengine.
    3. The drive shafts must also be capableof rotatingat the very fast speeds required by thevehicle.
    4. The drive shaft must also operate through constantly changing angles between the transmission, the differential and the axles. As the rearwheels roll over bumps in the road, the differential and axles move up and down. This movement changes the angle between the transmission and thedifferential.
    5. The length of the drive shaft must also be capable of changingwhiletransmitting torque. Length changes are caused by axle movement due to torque reaction, road deflections, braking loads and so on. A slip joint is used to compensate forthis



Figure 1.2- 3D model of a drive shaft

motion. The slip jointisusuallymadeof aninternal and external spline. It is locatedon the front end of the drive shaft and is connected to thetransmission.

Now days all automobiles (which arehaving front engine rear wheel drive) have the transmission shaft as shown in figure. A pair of short drive shafts is commonly used to send power from a central differential, transmission, or transaxle to the wheels. Two piece drive shaft increases the weight ofdrive shaft which is not desirable in today’s market. Many methods are available at present for the design optimization of structural systems and these methodsbased on mathematicalprogramming techniques involving gradient search and direct search. The reductionin weight of the drive system is advantageous in overall weight reductionof automobiles which is a highly desirable goal of designengineer.



Figure 1.3- Position of Drive Shaft

## Objectives of dynamicbicycle

* + 1. Increase durability of bicycle with the help of shaftdrive.
    2. Reduce maintenance cost ofbicycle.
    3. Increase power transmission efficiency of thebicycle.
    4. Making system morereliable.
    5. Reduce noise pollution using shaft drive transmissionsystem.

**CHAPTER- 2**

**LITERATURE REVIEW**

## INTRODUCTION

* + - Drive shafts are carriers of torque; they are subject to torsion and shear stress, which represents the difference between the input force and the load. They thus need to be strong enough tobear the stress, without imposing too great an additional inertia by virtue of the weight of the shaft. Most automobiles today use rigid driveshaft to deliver power from a transmission to the wheels. A pair of short driveshaft is commonly used to send power from a central differential, transmission, or transaxle to the wheels. There are different types of drive shafts in AutomotiveIndustry:

1. 1 piecedriveshaft
2. 2 piecedriveshaft
3. Slip in Tubedriveshaft

The Slip in Tube Driveshaft is the new type which also helps in Crash Energy Management. It can be compressed in case of crash. It is alsoknown as a collapsible drive shaft. Front-wheel drive is the most commonform of engine/transmission layout used in modern passenger cars, where the engine drivesthefrontwheels.Mostfront wheel drive vehicles today feature transverse engine mounting, where as in past decades engines were mostly positioned longitudinally instead. Rear-wheel drivewas the traditional standard and is still widely used in luxury cars and most sportcars.

## History

* + - The first shaft drives for cyclesappear 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 was enclosed within a tube running along the top of the chain stay; later models were enclosed within the actual chain stay .In the United States, Walter Still man 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 theUSA where Colonel Pope of the Columbia firm bought the exclusive American rights. Belatedly, the English makers took it up, with Humber in particular plunging heavily on 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 and cheaply cut by machinery, it is possible thatgears of thisdescription 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 practicalsuccess".

* + - In the USA, they had been made by the League Cycle Company as early as 1893. Soon after,the Frenchcompany Metro pole marketed their Acatane.By1897 Columbia began aggressively tomarket the chainless bicycle it had acquired fromthe League Cycle Company. Chainless bicycles were moderately popular in 1898 and 1899, although sales were still much smaller than regular bicycles, primarily due to the high cost. The bikes were also somewhat less efficient than regular bicycles: there wasroughly an 8 percentloss in the gearing, in part due to limited manufacturingtechnology at the time. The rear wheel was also more difficult to remove to change flats. Many of these deficiencies have been overcome in the pastcentury.
    - In 1902, The Hill-Climber Bicycle Mfg. Company solda three-speed shaft-drivenbicycle in which the shifting was implemented with three sets of bevel gears. While asmall number of chainless bicycles were available, forthe most part, shaft-driven bicycles disappeared from view for most of the 20th century. There is, however, still a niche market for *chainless* bikes, especially for commuters, and there are a number of manufacturers who offer them either as part of a larger range or as a primary specialization. A notable example is [Bio mega](http://en.wikipedia.org/wiki/Biomega_(bicycles)) inDenmark.

## Different Types ofShafts

1. **Transmissionshaft:** These shaftstransmitpowerbetween thesourceandthe machines absorbing power. The countershafts, line shafts, overhead shafts and all factory shafts are transmission shafts. Since these shafts carry machinepartssuchas pulleys, gears etc., therefore they are subjected to bendingmoments in addition to twisting.
2. **Machine Shaft:** These shafts form an integralpart of the machine itself. For example, the crankshaft is an integral part of I.C engines slider-crankmechanism.
3. **Axle:** A shaft is ca**l**ed“an axle”, if it is a stationary machine element and is used for the transmission of bending moment only. It simplyacts as a support for rotating bodies.

**Application:** To support hoisting drum, a car wheel or a rope sheave.

1. **Spindle:** A shaft is called “a spindle”, if it is a short shaft that imparts motion either to a cutting tool or to awork-piece.

**Applications:**

* 1. Drill press spindles-impart motion to cutting tool (i.e.)drill.
  2. Lathe spindles- impart motion towork-piece.

Apartfrom, an axle and a spindle, shaftsareusedatsomanyplacesandalmost everywhere wherever power transmission is required. Few of themare:

1. **Automobile Drive Shaft:** Transmits power from main gearbox to differential gearbox.
2. **Ship Propeller Shaft:** Transmits power fromgearbox topropellerattachedonit.
3. **Helicopter Tail Rotor Shaft:** Transmits power to rail rotorfan.

**Part of Drive Shaft**



Figure 2.1- Parts of Drive Shaft

* 1. **Demerits of a Conventional DriveShaft**

1. They have less specific modulus andstrength.
2. Increasedweight.
3. Conventional steel drive shafts are usually manufactured in two pieces to increase the fundamental bending natural frequency because the bending natural frequency of a shaft is inversely proportional to the square of beam length and proportional to the square root of specific modulus. Ther1efore the steel drive shaft is made in two sections connected by a support structure, bearings andU-joints and hence over all weight of assembly will bemore.
4. Its corrosion resistance is less as compared with compositematerials.
5. Steel drive shafts have less dampingcapacity.

## Merits of Composite DriveShaft

1. They have high specific modulus andstrength.
2. Reducedweight.
3. The fundamental natural frequency of the carbon fiber composite drive shaft can be twice as high as that of steel or alluminiumbecause the carbon fiber composite material has more than4 times the specific stiffness of steel or alluminium, which makes it possible to manufacture the drive shaft of passenger cars in one piece. A one- piece composite shaft can be manufactured so as tosatisfy the vibration requirements. This eliminates all the assembly, connecting the two piece steel shafts and thus minimizes the overall weight, vibrations and the totalcost
4. Due to the weight reduction, fuel consumption will bereduced.
5. They have high damping capacity hence they produce less vibration andnoise.
6. They have good corrosionresistance.
7. Greater torque capacity than steel or alluminiumshaft.
8. Longer fatigue life than steel or alluminiumshaft.
9. Lower rotating weight transmits more of availablepower.
   1. **Drive ShaftVibration**
      * Vibration is the most commondrive shaft problem. Small cars and short vans and trucks (LMV) are able to use a single drive shaft with a slipjointatthefrontend without experiencing any undue vibration. However, with vehicles of longer wheel base, the longer drive shaft required would tend to sag and under certain operatingconditions would tend to whirl and then setup resonant vibrations in the body of the vehicle, which will cause the body to vibrate as the shaftwhirls.
      * Vibration can be either transverse or torsional. Transverse vibration is the result of unbalanced condition acting on the shaft. This condition is usually bydirt or foreign material on the shaft, and it can cause a rather noticeable vibration in the vehicle. Torsional vibration occurs from the power impulses of the engine or from improper universal join angles. It causes a noticeable sounddisturbance and can cause a mechanical shaking. In excess, both types of vibrationcan cause damage to the universal joints and bearings. Whirling of a rotating shaft happens when the centreof gravity of the shaft mass is eccentric and so is acted upon by a centrifugal force which tends to bend or bow the shaft so that it orbits about the shaft longitudinal axis like a rotating skipping rope. As the speed rises, the eccentric deflection of the shaft increases, with the result that the centrifugal force also will increase. The effectis thereforecumulative and will continue until the whirling become critical, at which point the shaft will vibrateviolently.
      * From the theory of whirling, it has been found that the critical whirling speed of the shaft is inversely proportional to the square of the shaft length. If, therefore, a shaft having, for example, a critical whirling speed of 6000 rev/min is doubled in length, the critical whirling of the new shaft will be reduced to a quarter of this, i.e. the shaftwill now begin to rotate at 1500 rev/min. Thevibrationproblemcouldsolveby increasing the diameter of the shaft, but this would increase its strength beyond its torque carrying requirements and at the same time increase its inertia, which would oppose the vehicle’s acceleration and deceleration. Another alternative solution frequently adopted by car, van, and commercial vehicle manufacturers is the use of two-piecedrive shafts supportedby intermediateorcentrebearings.Butthiswill increase the costconsiderably.

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**CHAPTER- 3**

**DRIVE MECHANISM**

## INTRODUCTION

* + - For the gear-like device used to drive a roller chain, see [Sprocke](http://en.wikipedia.org/wiki/Sprocket)t. This article is about mechanical gears. For other uses, se[e Gear (disambiguation)](http://en.wikipedia.org/wiki/Gear_(disambiguation))Two meshinggears transmitting rotational motion. Note thatthe smaller gear is rotating faster. Although the larger gear is rotating less quickly, its torque is proportionally greater. One subtlety of this particulararrangementisthatthelinearspeedatthepitchdiameteris the same on bothgears.
    - A **gear** or **cogwheel** is a [rotating](http://en.wikipedia.org/wiki/Rotating) [machine](http://en.wikipedia.org/wiki/Machine_(mechanical)) part having cut *teeth*,or *cogs*,which*mesh* with another toothed part in order to transmit [torque](http://en.wikipedia.org/wiki/Torque), in most cases with teeth on the one gear being of identical shape, and often also with that shape on the other gear. Twoor more gears working in tandem are called [a transmission](http://en.wikipedia.org/wiki/Transmission_(mechanics)) and can produce a mechanical advantage through a gear ratio and thus may be considered a simple machine. Geareddevices can change thespeed,torque,anddirectionof apower source. The most common situation is for a gear to mesh with another gear; however, a gear can also mesh withanon-rotatingtoothedpart,calledarack,therebyproducing translation instead ofrotation.
    - 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 preventslippage. When two gears mesh, and one gear is bigger than the other (even though the size of the teeth must match), a mechanical advantage is produced, with the rotational speeds and the torques of the two gears differing in an inverserelationship.
    - In transmissions which offer multiple gear ratios, such as bicycles, motorcycles, and cars, the term **gear**, as in *first gear*, refers to a gear ratio rather than an actual physical gear. The term is used to describe similar devices even when the gear ratio is continuous rather than discrete, or when the device does not actually contain any gears, as in a continuously variable transmission. The earliestknown reference to gears was circa A.D. 50 by Hero of Alexandria, but they can be traced back to the Greek mechanics of the Alexandrian school in the 3rd century B.C. and were greatly developed by the Greek polymath Archimedes (287–212 B.C).The Antikythera mechanism is an example of a very early and intricate geareddevice,

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designed to calculate astronomical positions. Its time of construction is now estimated between 150 and 100 BC.

* + - The definite velocity ratio which results from having teeth gives gears anadvantage

over other drives (such as traction drives and V-belts) in precision machines such as watches that depend upon an exact velocity ratio. In cases wheredriver and follower are proximal, gears also have an advantage over other drives in the reduced number of parts required; the downside is that gears are more expensive to manufacture and their lubrication requirements may impose a higher operating cost.

## Types ofgears

An external gear is one with the teethformed on the outer surface of a cylinder or cone.Conversely,

An internal gear is one with the teethformed on the inner surface of a cylinder or cone. For bevel gears, an internal gearis one with the pitch angle exceeding 90 degrees. Internal gears do not cause output shaft directionreversal.

## List ofgears

**1) Spur gear**

Spur gears or straight-cut gears are the simplest type of gear. They consist of a cylinder or disk with the teeth projecting radials, and although they are not straight- sided in form (theyare usually of special formto achieve constant drive ratio, mainly involute), the edge of each tooth is straight and aligned parallel to the axis of rotation. These gearscan bemeshed together correctly only if theyare fitted to parallelshafts.

* + - **Helicalgears**

Helical or "dry fixed" gears offera refinement over spur gears. The leadingedges of the teeth are not parallel to the axis of rotation, but are set at an angle. Since the gear is curved, this angling causes the tooth shape to be a segment of a helix. Helical gears can be meshed unparallel or crossed orientations. The formerrefers to when the shafts are parallel to each other; this is the most common orientation. In the latter, the shafts are non-parallel, and in this configuration the gears are sometimes known as "skewgears".

The angled teeth engage more gradually than do spur gear teeth, causing them

to run more smoothly and quietly. With parallel helical gears, each pair of teeth first make contact at a single point at one side of the gear wheel; a moving curve of contact then grows gradually across the tooth face to a maximum then recedes until the teeth break contact at a single point on the opposite side. In skewgears, teeth suddenly meet at a line contact across their entire width causing stress and noise. Skew gears make a characteristic whine at high speeds. Whereas spur gears are used for low speed applications and those situations where noise control is not a problem, the use of helical gears is indicated when the application involves high speeds, large power transmission, or where noise abatement is important. The speedis considered to be high when the pitch line velocity exceeds 25m/s.

A disadvantage of helical gears is a resultant thrust along the axis of the gear, which needs to be accommodated by appropriate thrust bearings, and a greater degree of sliding friction between the meshing teeth, often addressed with additives in the lubricant.

* + - **Skewgears**

For a 'crossed' or 'skew' configuration, the gears must have the same pressure angleand normal pitch; however, the helix angle and handedness can be different. The relationship between the two shafts isactually defined by the helix angle(s) of the two shafts and the handedness, asdefined:

Where is the helix angle for the gear? The crossed configuration is less mechanically sound because there is only a point contact between the gears, whereas in the parallel configuration there is a linecontact.

Quite commonly, helical gears are used with the helix angle of one havingthe negative of the helix angle of the other; such a pair might also be referred to as having a right-handed helix and a left-handed helix of equal angles. The two equal but opposite angles add to zero: the angle between shafts is zero – that is, the shafts are parallel. Where the sum or the difference (as described in the equations above) is not zero the shafts are crossed. For shaftscrossed at rightangles,thehelixanglesare of the same hand because they must add to 90degrees.

* + - **Double helicalgears**

Double helical gears, or herringbone gears, overcome the problem of axial thrust presented by "single" helical gears, by having two sets of teeth that are set in a V shape. A double helical gear can be thought of as two mirrored helical gears joined together. This arrangement cancels out the net axial thrust, since each half of thegear thrusts inthe opposite direction resulting in a net axial force of zero. This arrangement can remove the need for thrust bearings. However, doublehelical gears are more difficult to manufacture due to their more complicatedshape.

For both possible rotational directions, there exist two possible arrangements for the oppositely-oriented helical gears or gear faces. One arrangementis stable, and the other is unstable. In a stable orientation, the helical gear facesare oriented so that each axial force is directed toward the center of the gear. In anunstable orientation, both axial forces are directed away from the center of the gear. In both arrangements, the total (or net) axial force on each gear is zero when the gears are aligned correctly. If the gears become misaligned in the axial direction, the unstable arrangement will generate a net force that may lead to disassembly of the gear train, while the stable arrangement generates a net correctiveforce. If thedirection of rotation is reversed, the direction of the axial thrusts is also reversed, so a stable configuration becomes unstable, and viceversa.

Stable doublehelical gears can be directly interchanged with spur gears without any need for differentbearings.

* + - **Bevelgear**

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

Figure 3.1- Bevel gears

* + - **Spiral bevelgear**

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

**Note:** The cylindrical gear tooth profile corresponds to an involute, butthe bevel gear tooth profile to an octoid. All traditional bevel gear generators(like Gleason, Klingelnberg, Heidenreich&Harbeck,and WMWModule) manufacture bevel gears with an octoidaltooth profile. IMPORTANT: For 5-axis milled bevel gear sets it is important to choose the same calculation / layout like the conventionalmanufacturing method.Simplified calculated bevel gears on the basis of an equivalent cylindrical gear in normal section with an involute tooth form show a deviant tooth form with reduced tooth strength by 10-28% without offset and 45% with offset [Diss. Hünecke, TU Dresden]. Furthermore those "involute bevel gear sets" causes morenoise.

* + - **Hypoidgear**

Hypoid gears resemble spiral bevel gears exceptthe shaft axes do not intersect. The pitch surfaces appear conical but, to compensate for the offset shaft, are in fact hyperboloids of revolution. Hypoid gearsare almost always designed to operate with shafts at 90 degrees.Dependingonwhichsidetheshaftisoffsetto, relative to the angling of the teeth, contact between hypoid gear teeth may be even smoother and more gradual than with spiral bevel gear teeth, but also have a sliding action along the meshing teeth as it rotates and therefore usually require some of the most viscous types of gear oil to avoid it being extruded from the mating tooth faces, the oil is normally designated HP (for hypoid) followed by a number denoting the viscosity.

Also, the pinion can be designed with fewer teeth than a spiral bevel pinion, with the result that gear ratios of60:1 and higher are feasible using a single set of hypoid gears. This style of gear is most commonly found drivingmechanical differentials; which are normally straight cut bevel gears; in motor vehicleaxles.

## Backlash

* + - [Backlash](http://en.wikipedia.org/wiki/Backlash_(gear))is the error in motion that occurs when gears change direction. Itexists

ecausethere isalwayssomegapbetweenthetrailingfaceofthedrivingtoothand the leading face of the tooth behind it on the driven gear, and that gap must be closed before force can be transferred in the new direction. The term"backlash" can alsobe used to refer to the size of the gap, not just the phenomenon it causes; thus, one could speak of a pair of gears as having, for example, "0.1 mm of backlash." A pair of gears could be designed to have zero backlashes, but this would presuppose perfection in manufacturing,uniformthermalexpansioncharacteristics throughoutthe system, and no lubricant. Therefore, gear pairs are designed to have some backlash. It isusually provided by reducing the tooth thickness of each gear by half thedesiredgapdistance. In the case of a large gear and a small pinion, however, the backlash is usuallytaken entirely off the gear and the pinion is given full sized teeth. Backlash canalso be provided by moving the gears further apart. The backlashof a [gear train](http://en.wikipedia.org/wiki/Gear_train)equals the sum of the backlash of each pair of gears, so in long trains backlash can become a problem. For situations in which precision is important, suchas instrumentationand control, backlashcanbeminimizedthroughoneofseveraltechniques.Forinstance, the gear can be split along a plane perpendicular to theaxis,onehalf fixedto theshaft in the usual manner, the other half placed alongside it, free to rotate about the shaft, but with springs between the two halves providing relative torque between them, so that one achieves, in effect, a single gear with expanding teeth. Another methodinvolves taperingtheteethintheaxialdirectionandprovidingforthegeartobeslid in the axial direction to take upslack.

## Shifting ofgears

* + - In some machines (automobiles) it is necessary to alter the gear ratio to suit the task, a process known as gear shifting or changing gear. There are several outcomes of gearshifting in motor vehicles. In the case of [vehicle noise emissions,](http://en.wikipedia.org/wiki/Roadway_noise)there are higher[sound levels](http://en.wikipedia.org/wiki/Sound_level)emitted when the vehicleisengagedinlowergears. The design life of the lower ratio gears is shorter, so cheaper gears may be used (i.e. spur for 1st and reverse) which tends to generate more noise due to smaller overlap ratio and a lower mesh stiffness etc. than the helical gears used for the high ratios. This fact has been utilized in analyzing vehicle generated sound since the late 1960s, and has been incorporated into the simulation of urban roadway noise and corresponding design of urban [noise barriers](http://en.wikipedia.org/wiki/Noise_barrier)alongroadways.

## Toothprofile

* + - A profile is one side of a tooth in a cross section between the outside circle andthe

root circle. Usually a profileis the curve of intersectionof atooth surfaceanda plane or surface normal to the pitch surface, such as the transverse, normal, or axialplane.

The fillet curve (root fillet) is the concave portion of the tooth profile where it joins the bottom of the tooth space. The velocity ratiois dependent on the profile of the teeth. [Friction](http://en.wikipedia.org/wiki/Friction)and wear between two gears is also dependent on the tooth profile. There are a great many tooth profiles that will give a constant velocity ratio, and in many cases, given an arbitrary tooth shape, it is possible to develop a tooth profile for the mating gear that will give a constant velocity ratio. However, two constant velocity tooth profiles have been by far the most commonly used in modern times. They are the [cycloid](http://en.wikipedia.org/wiki/Cycloid_gear)and the [involute](http://en.wikipedia.org/wiki/Involute_gear). The cycloidwas more common until the late 1800s; since then the involute has largely superseded it, particularly in drive train applications. The cycloid is in some ways the more interesting and flexible shape; howeverthe involute has two advantages: it is easier to manufacture, and it permits the center to center spacing of the gears to vary over some range without ruining the constancy of the velocity ratio. Cycloidal gearsonly work properly if the center spacing is exactlyright.

## Gearmaterials

* + - Numerousnonferrous alloys, cast irons, powder-metallurgy and plastics are used in the manufacture of gears. However, steels aremost commonly used because of their high strength-to-weight ratio and low cost. Plastic is commonly used where cost or weight is a concern. A properly designed plastic gear can replace steel in many cases because it has many desirable properties, including dirt tolerance, low speed meshing, the ability to "skip" quite well and the ability to be made with materials not needing additional lubrication. Manufacturers have employed plastic gears to reduce costs in consumer items including copy machines, optical storage devices, cheapdynamos, consumer audio equipment, servo motors, andprinters.

## The modulesystem

* + - As a result, the term module is usually understood to meanthe pitch diameter in millimeters divided by the number of teeth. When the module is based upon inch measurements, it is known as the English module to avoid confusionwith the metric module. Moduleis adirect dimension, whereas diametral pitch is an inverse dimension (like "threads perinch").

**CHAPTER- 4**

**DESIGN OF CAST IRON DRIVESHAFT**

* + - A **shaft-drivenbicycle** isa bicycle thatusesa [drive shaft](http://en.wikipedia.org/wiki/Drive_shaft) instead of a [chain](http://en.wikipedia.org/wiki/Bicycle_chain) totransmit power from the pedals to the wheel through contact of gears and a shaft rod to smoothly and efficient. Shaft drives were introduced over a century ago, but were mostly supplanted by chain-driven bicycles due to the gear ranges possible with sprockets and derailleurs. Recently, due to advancementsin internal gear technology, a small number of modern shaft-driven bicycles have beenintroduced.

Figure 4.1- Assembling of bearing cover

The torque that is produced fromthe engine and transmission must be transferred totherearwheelstopushthevehicleforwardmoment.Thedriveshaft must provide a smooth, uninterrupted flow of power to the axles. The drive shaft and differential are used to transfer thistorque.

**Functions of the DriveShaftare :**

* + - 1. It must transmit torque from the transmission to thepedal
      2. During the operation, it is necessary to transmit maximum low-geartorque
      3. The drive shafts must also becapable of rotating at the very fast speeds required by thevehicle.
      4. The drive shaft must also operate through constantly changing gear velocity ratio.
      5. The length of the drive shaft must also be capable ofchanging while transmitting torque. Length changes are caused by axle movement due to torque reaction, road deflections, braking loads and so on. A slip joint isused tocompensate for this motion.
      6. The slip joint is usually made of an internal and external spline. It is located onthe

front end of the drive shaft and is connected to the transmission.

## Construction and workingprinciple of the shafts are :

* + - The term Drive shaft is used to refer to a shaft, which is used for the transfer of motion from one point to another. Whereas the shafts, which propel (push theobject ahead)are referred to as the propeller shafts. However the drive shaft of the automobile is also referred to as the propeller shaft because apart from transmitting the rotary motion from the front end to the rear end of the vehicle, these shafts also propel the vehicle forward. Theshaftistheprimaryconnectionbetweenthefrontand the rear end (engine and differential), which performs both the jobs of transmittingthe motion and propelling thefront end. Thus the terms Drive Shaft and Propeller Shafts are used interchangeably. In other words, a drive shaft is a longitudinal power transmitting, usedin vehiclewherethe pedal is situated at the human feet. A drive shaft is an assembly of one or more tubular shafts connected by universal, constant velocity or flexible joints. The number of tubular piecesand joints depends on the distance between the twowheels.
    - The job involved isthe design for suitable propeller shaft and replacement of chain drive smoothly to transmit power from the enginetothewheelwithoutslip.Itneeds only a less maintenance. It is cost effective. Propeller shaft strength is more and alsopropeller shaft diameter is less. it absorbsthe shock. Because the propeller shaft center is fitted with the universal joint is a flexible joint. It turnsinto any angular position. The both end of the shaft are fitted with the bevel pinion, the bevel pinion engaged with the crown and power is transmitted to the rear wheel through the propeller shaft and gear box.. With our shaft drive bikes; there is no more grease on your hands or your clothes; and no more chain and derailleurmaintenance.
    - Shaft-drivenbikes have a large [bevel gear](http://en.wikipedia.org/wiki/Bevel_gear) where a conventional bike would have its [chain ring.](http://en.wikipedia.org/wiki/Chainring)This meshes with another bevel [gear](http://en.wikipedia.org/wiki/Gear)mounted on the drive shaft. The use of bevel gears allows the axis of the drive torquefromthepedalstobeturned 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 canceling out the first drive torque change ofaxis.

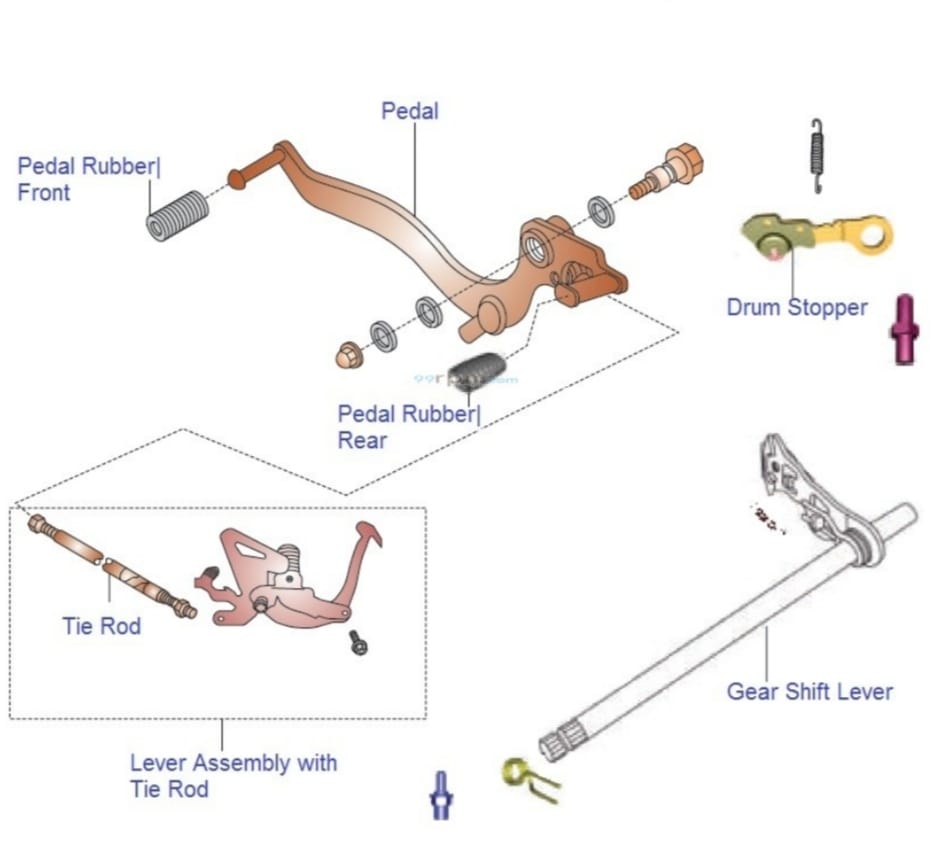


Figure 4.3- Assembling of pedal with gear

* + - The 90-degree change of the drive plane that occurs at the [bottom bracket](http://en.wikipedia.org/wiki/Bottom_bracket) and again at the [rear hub](http://en.wikipedia.org/wiki/Bicycle_wheel) uses bevel gears for the most efficient performance,though other mechanisms could be used, e.g. [Hobson’s joints](http://en.wikipedia.org/w/index.php?title=Hobson%27s_joint&action=edit&redlink=1), [worm gears](http://en.wikipedia.org/wiki/Worm_gear) or [crossed helical gears](http://en.wikipedia.org/wiki/Gear). The drive shaft is often mated to a hub gear which is aninternal gear system housed inside the rearhub.

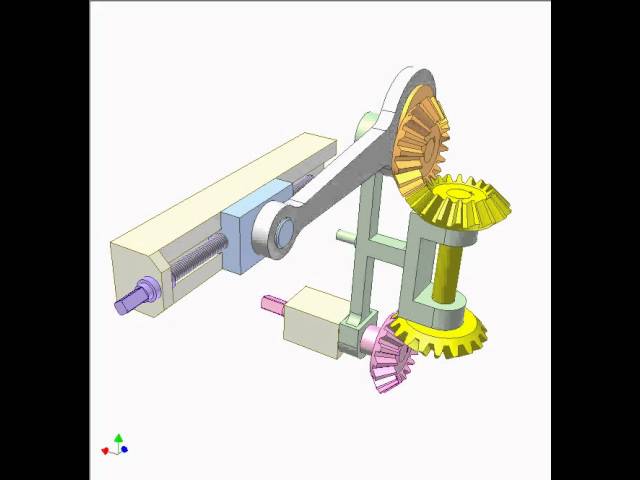


Figure 4.4- Bevel Gear Mechanism

## Specification of driveshaft :

* + - The specifications of the composite drive shaft of an automotive transmission are same as that of the steel drive shaft for optimaldesign.
    - The fundamental natural bending frequency for passenger cars, small trucks, and vans of the propeller shaft should be higher than 6,500 rpm to avoid whirling vibration and the torque transmission capability of the drive shaft should be larger than 3,500 Nm. The drive shaft outer diametershould notexceed 100 mm due to space limitations. Here outer diameter of the shaft is taken as 90 mm. The drive shaft of transmission system is to be designed optimally for following specified design requirements as shown inTable

Table 4.1: Design requirements and specifications

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sr.No.** | **Name** | **Notation** | **Unit** | **Value** |
| 1. | Ultimate Torque | Tmax | Nm | 3500 |
| 2. | Max. Speed of shaft | Nmax | Rpm | 6500 |
| 3. | Length of Shaft | L | Mm | 1250 |

Steel (SM45C) used for automotive drive shaft applications. The materialproperties of the steel (SM45C) are given in Table. The steel drive shaftshould satisfy three design specifications such as torque transmission capability, buckling torque capability and bending naturalfrequency.

Table 4.2: Mechanical properties of Cast iron (SM45C)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sr.No** | **Mech. Properties** | **Symbol** | **Units** | **Cast Iron** |
| **1.** | Young’s Modulus | E | GPa | 105.0 |
| **2.** | Shear Modulus | G | GPa | 36.75 |
| **3.** | Poisson Ratio | v | **------** | 0.23 |
| **4.** | Density | ρ | Kg/m3 | 7209 |
| **5.** | Yield Strength | Sy | MPa | 130 |
| **6.** | Shear Strength | Ss | MPa | 169 |

## 4.1 DesignAssumptions

1. The shaft rotates at a constant speed about its longitudinalaxis.
2. The shaft has a uniform, circular crosssection.
3. The shaftis perfectlybalanced, i.e., at every cross section, the mass center coincides with the Geometriccenter.
4. All damping and nonlinear effects areexcluded.
5. The stress-strain relationship forcompositematerial is linear &elastic; hence, Hooke’s law is Applicable for composite materials.
6. Acoustical fluid interactions are neglected, i.e., the shaft is assumed to be acting ina vacuum.
7. Since lamina is thin and no out-of-plane loads are applied, it is considered as under the planeStress.

**Selection ofCross-Section:**

The drive shaft can be solid circular or hollow circular. Here hollow circular cross-section waschosen because: The hollow circular shafts are strongerin per kg weight than solid Circular. The stress distribution in case of solid shaft is zero at the center and maximum at the outer surface while in hollow shaft stress variation is smaller. In solid shafts the material close to the center are not fullyutilized.

**Selection ofMaterials :**

Based on the advantages discussed earlier, the E-Glass/Epoxy, High Strength Carbon/Epoxy and High Modulus Carbon/Epoxy materials are selectedfor composite drive shaft. The Table shows the properties of the E-Glass/Epoxy, High Strength Carbon/Epoxy and High Modulus Carbon/Epoxy materials usedfor composite drive shafts.

**Factor ofSafety:**

The designer must take into account the factor of safetywhen designing a structure. Since, composites are highly orthotropic and theirfractureswere not fully studied the factor of safety was taken as2.

**Designcalculation:**

1. Inner Diameter of shaft (di) = 0.026m
2. Outer Diameter of shaft (do) = 0.028m
3. Length of shaft (L) = 0.335m
4. Number of teeth =16
5. Gear Pitch (P) =MT/2

**Transmission ofTorque :**

Action and reaction my friend.If a person does not turn the pedalthen hewill stand on it and so the maximum torque will = (body mass of the rider x g) x the length of the pedal lever. Remember to consider the gearing of the bikethough.

The average, fit, adult ridercan produce only 75 watts or 1/10hp when cycling at a continuous 12mph (19.3kph)." This usually happenswith a pedaling speed of 60- 80 rpm though many rider pedals faster. When I cycle, I usually spin at between 100- 120 rpm, but I have been riding for years and have found that the higher speed works better for me. Typically a shaft has acircular cross section. However, theshaft with other cross-sections finds special application.in the design concept of a [drive shaft](http://www.brighthub.com/engineering/mechanical/articles/27709.aspx)

subjected to a fixed load. A driveshaftissupportedbygears(bearings)atboththe ends (and at regularinterval in the centrefor longer shafts). The footpedal arrangement usually placed over the shaft in between the[gears.](http://www.brighthubengineering.com/machine-design/26455-types-of-bearing-ball-bearings/)

If a device is rotating at a steady rate or is stationary, the torques appliedto it must add up to zero -- any torque applied at one point must be taken off at another.So, with a bicycle crank set, the torque applied at the pedals is equal and opposite thattaken off by the chain, neglecting the small amount lost in friction. Let's lookat a bicycle drive train starting with the cyclist's feet. Torque isconveyedfroma pedal through the crank -- and from the left crank, then also through the bottom-bracket spindle -- tothe chain wheel. Generally, the cyclist's rising leg appliesa lighttorque opposite that of the descending leg. The chain, at the chain wheel, produces a torque equal and opposite the sum of the torques applied at the pedals. Let's put some numbers to this weassume that the left leg is descending in mid-stroke, applying a force of 100 pounds directly downward on the left pedal, while the rising right leg is applying a reverse force of 10 pounds to the right pedal. Crank length is usually given in millimeters, but we're using English measurement here, as it's more familiar to most English-speaking readers. We'll assume0.56 foot (170 mm) cranks. The torqueon the bottom-bracket spindle is 56 pound-feet: the 100-pound force at the pedal, times the 0.56 foot length of the crank. The torque at the chain wheel is slightlyless,

50.4 pound feet, after we subtract the -5.6 pound-foot torque from the right pedal.

In these calculations, we neglect forces which would not contributeto torque: pedal force not in the direction of rotation, and the weight on the rear wheel. We also neglect friction, which reduces the drive force by a few percent. Numbers arerounded

-- close, but not exact.

The ratio of the force at the pedals to drive force at the road is the [gainratio,](http://sheldonbrown.com/gloss_g.html#gain)which can be calculated more simply as the ratio of road speed to pedal speed, like this:

16 teeth/10 teeth = 1.6

* + - Action and reaction my friend. If a person does not turn the pedal thenhe will standon it and so the maximum torque will be“Tmax”,

Tmax = {body mass of the rider **x** g} **x** the length of the pedal lever

= 0.008\*16/2 = 0.128/2 = 0.064 m

* + - Module (m) = 0.008m
    - Mass Moment of Inertia (I) =MR2/2

= 4\*0.0142 = 0.0039

* + - Polar Moment of Inertia (J) = π (do4 –di4)/32

= π (0.0284 – 0.0264)/32 = (4.953X10-7)/32

= 1.548 X 10-8

* + - Maximum Torque on bicycle is given by T = (Mass of rider x g) L Where, L = Length of pedal crank inm

‟ g = 9.81 m/sec2 (Assume mass of rider = 60 kgs) T = 60 x 9.81 x 0.335 = 197.2 Nm

* + - Power(P)=2πNT/60=(2πx110x197.2)/60=2271.5watts
    - Shear Stress (***τ***) = Tρ/J = (197.2)(7209) /1.548 X 10-8 = 9.18 X 1013N/m4
    - Maximum Shear Stress (𝜏max) = TRo/J = (197.2)(0.014) / (1.548 x10-8)

= 17.83 X 107

* + - Bending moment (M)=E/R

Where, E = Young’s modulus I = Moment of Inertia R = Radius (Ro)

M = (105 X 0.0039)/ 0.014 = 29.25

* + - ϴ= TL/GJ=(197.2)(0.335)/(36.75)(1.548 X10-8)

= 66.06/(5.68X10-7) = 1.163X109

* + - Torsion is the twisting of an object due to an applied torque. It is expressed in newton metres(N-m), In sections perpendicular to the torque axis, the resultant shear stress in this section is perpendicular to the radius

Where,

o ***T*** is the applied torque Nm.

* ***τ*** is the maximum shear stress at the outersurface
* ***r*** is the distance between the rotationalaxis
* ***ℓ*** is the length of the object the torque is being applied to orover.
* ***θ*** is the angle of twist inradians.
* ***G*** is the shear modulus or more commonly the modulus of rigidity(GPa),
* ***ro*** outerradius

oTorsion (**T**) = (1.548 X 10-8)(36.75)(1.163 X 109) / 0.335

Torsion (**T**) = 1974.9 Nm

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**Limits to torque and drive force**

1. Now, let's look at the limits to torque and to driveforce.
2. The limit to drive force is set by front-wheel lifting, which occurs when the drive force is about 1/2 the weight of the cyclist andbicycle.
3. Let'sassume that theweightis200pounds.Then thedrive force cannot exceed 100 pounds, or the front wheel willlift.
4. Let's also assume that the cyclist can push down on a pedal with a force of 200 pounds -- somewhat morethanthe cyclist'sown weight, by standing on a pedal and pulling up on thehandlebar.
5. Then at gain ratios below 2, the cyclist's pedaling force is capable of generating over 100 pounds of drive force, and lifting the front wheel. The cyclist must avoid pedaling as hard as possible.
6. In our example with the 0.56 foot crank length and 1.11 foot wheel radius, this transition occurs almost exactly where the number of chainwheel teeth and of rear sprocket teeth is equal. So, for example, if the chain wheel has 28 teeth and the sprocket, 30 teeth, a hard pedal stroke can lift the frontwheel.

**Stress-StrainRelationship**

The drive shaft with two gears experience twokinds of stresses, bending stress and shear stress. The maximum bending stress generated at the outermost fiber of the shaft. And on the other hand, the shear stress is generated at the inner most fiber. Also, the value of maximum bending stress is much more than the shear stress. So, the design of the shaft will be based onthe maximum bending stress andwill be driven by the followingformula:

Maximum bending stress **Tb = (M \* r) / I**

Where,

**M** is maximum bending moment on the shaft.

**r** is the radius of the shaft.

**I** is area moment of inertia of the shaft.

* 1. **DesignOptimization**

Optimization of an engineering design is an improvement of a proposed design that results in the best properties for minimum cost. Most ofthe methods used for design optimization assume that the design variables are continuous. In structural optimization, almost all design variables arediscrete.

**Chapter 5**

**Manufacturing Process**

**5.1. Introduction**

Manufacturing involves turning raw material to finished products, to be used for various purposes.

There are a large number of processes available. These processes can be broadly classified into four

categories*.*

* Casting process
* Forming process
* Fabrication process

**5.2. CASTING PROCESS**

These processes only processes where the liquid metal is used. Casting is also the oldest known

manufacturing process. Basically, it consists of inducing the molten metal into a cavity of mould of the required form and allowing the metal to solidify. Casting is the most flexible and cheapest method

and given high strength of rigidity to the parts which are difficult to produce by other manufacturing

processes. The principle process among these sand casting where sand is used as the raw material. The

process is equally suitable for the production of a small batch as well as on a large scale. Some of the

other classified casting processes for specialized need are :-

* + - * Shell mould casting
      * Precision mould casting
      * Plaster mould casing

**5.3. Forming process**

These are solid state manufacturing processes involve minimum amount of material wastage. In

forming process metal may be heated to temperature which is slightly below. These solidify

temperature and large force is applied such the material flows and act in desired shape. The desire

shape is controlled by means of a set of tool ties and dies, which may be closed during manufacturing

These processes are normally used for large scale production rates. These are generally economical

and, in many cases, improve the mechanical properties. These are some of the metal forming

processes.

* Rolling forging
* Drop forging
* Press forging
* Upset forging

**5.4. Fabrication Process**

These are secondary manufacturing processes where the starting raw materials are produced by any

one of the previous manufacturing processes desired. Its assembly involves joining pieces either

temporary or permanent. So that they would be perform the necessary function. The joining can be

achieved by either or both of heat and pressure joining materials. Many of the steel structure

construction, we see are first rolled and then joined together by a fabrication process are

* Gas welding
* Electric arc welding
* Electrical resistance welding
* Thermo welding

**5.5. Material Removal Process**

These are also a secondary removal manufacturing process, where the additional unwanted material is

removed in the form of chips from the blank material by a hard tool so as to obtain the final desired

shape. Material removal is normally a most expensive manufacturing process. Because more energy is

consumed and also a lot of waste material is generated in this process. Still this process is widely used

because it delivers very good dimensional accuracy and good surface finished. Material removal

process are also called machining processes as shown in figure 8,9,10 and figure11. Various processes

in this category are

* Turning
* Drilling
* Shaping and planning
* Milling
* Grinding



**Fig 5.1. Drilling Operations**

****

**Fig 5.2. Turning Operations**

** **

**Fig 5.3. Grinding Operation Fig 5.4. Milling Operation**

**5.6. Welding**

Welding is a process of joining two metal pieces by the application of heat. Welding is the least

expensive process and widely used now a days in fabrication. Welding joints different metals with the

help of a number of processes in which heat is supplied either electrically or by mean of a gas torch.

Different welding processes are used in the manufacturing of Auto mobiles bodies, structural work,

tanks, and general machine repair work. In the industries, welding is used in refineries and pipe line

fabrication. It may be called a secondary manufacturing process as shown in figure 12 and 13.

* **Types of Welding Process**

1. GAS WELDING
2. Oxy-Acetylene
3. Air-Acetylene
4. Oxy-Hydrogen

* **Resistance Welding**

1. Butt Welding
2. Spot Welding
3. Seam Welding
4. Projection Welding

* **Arc Welding**

1. Carbon Arc Welding
2. Metal Arc Welding
3. Plasma Arc Welding
4. Gas Metal Arc Welding
5. Gas Tungsten Arc Welding

* ***Newer Welding***

1. Electron Beam Welding
2. Laser Beam Welding

****

**Fig 5.5. Arc Welding**

* **Advantages of Shaft Driven bicycle are :**

1. Drive system is less likely tobecome jammed,acommonproblemwithchain-driven bicycles.
2. The rider cannot become dirtied fromchain greaseor injured by the chain from "Chain bite", which occurs when clothing or even a body partcatchesbetweenthechainanda sprocket.
3. Lower maintenance than a chain system when the drive shaft is enclosed in atube.
4. Dynamic Bicycles claims that a drive shaft bicycle can deliver 94% efficiency, whereas a chain-driven bicycle can deliver anywhere from 75-97% efficiency based oncondition.
5. Greater clearance: with the absence of a derailleur orother low-hanging machinery, the bicycle has nearly twice the groundclearance.
6. Another advantage that may be noticed about the chainless bicycle is that itprotects your clothes better. Your footwear and your pants do not get accidentally damaged, and youdo not have the same amount of cleaning to do. However, those who are not socrazyaboutthis alternative type of bicycle say that it is enough to choose a bicycle with encased chain, or with chain guards, and the problem issolved.

**Limitations of this cycle :**

1. A drive shaft system weighs more than a chain system, usually 1-2 pounds heavier.
2. Many of the advantages claimed by drive shaft's proponents can be achievedon a chain driven bicycle, such as covering the chain and gears with a metal or plasticcover.
3. Use of lightweight derailleur gears with a high number of ratios is impossible, although hub.
4. Gears can beused.
5. Wheel removal can be complicated in some designs (as it isfor some chain-driven bicycles with hubgears).

**TROUBLESHOOTING**

* + When abnormal vibrations or noises are detected in the driveshaft area, this chart can be used to help diagnose possible causes. Remember that other components such as wheels, tires, rear axle and suspension can also produce similarconditions.

**Table 5.1 :**

|  |  |  |
| --- | --- | --- |
| **Problem** | **Caused by** | **What to do** |
| As bicycle is accelerated from  Stop | torque is required | Apply more torque at  starting |
| when gears are not shifting | Rusting | Clean with fluids |
| Vibration at speed | High speed | Maintain low speed |
| Noise at low speed | Universal joint | Apply grease |
| Gears pitch circle is not coincide | Vibrations | Adjust the position of gears |
| Gear backlash | Noise, Overloading, Overheating | Follow design  characteristics |

**CONCLUSION**

* + Firstly the project were unable to be completed with the drive shaft due to various problems around circumference of the bicycle ,later on this wasrealizedto runsuccessfully with two bevel gears at both end of thedrive shaft
  + 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.
  + The presented work alsodeals with design optimization i.e. converting rotarymotion in linear motion with aid of two bevelgears.
  + Instead of chain drive one piece drive shaft for rear wheel drive bicycle havebeen optimally designed and manufactured for easily powertransmission.
  + 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
  + The torque transmission capacity of the bicycle drive shaft has been calculated by neglecting and considering the effect of centrifugal forces and it has been observed that centrifugal force will reduce the torque transmission capacity of theshaft.
  + The stress distribution and the maximum deformation in the drive shaft are the functions of the stacking of material. The optimum stackingof material layers can be used as the effective tool to reduce weight and stress acting on the driveshaft.
  + The design of drive shaft is critical as it is subjected to combined loads. Thedesigner

has two options for designing the drive shaft whether to select solid or hollow shaft. The solid shaft gives a maximum value of torque transmission but at same time due to increase in weight of shaft, For a given weight, the hollow shaft is stronger because it has a bigger diameter due to less weight &less bending moment.

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 adesign.

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