

## DESIGN AND ANALYSIS OF DRIVEN SHAFT

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**Abstract** - A shaft-driven bicycle is a bicycle 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 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. 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

**Key Words:** Driven Shaft, Gears, Rotary Motion, Creo Software, Ansys Workbench

### 1. INTRODUCTION

A shaft-driven bicycle is a bicycle that uses a drive shaft instead of a chain to transmit power from the pedals to the wheel. 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 advancements in internal gear technology, a small number of modern shaft-driven bicycles 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 canceling out the first drive torque change of axis.

The 90-degree change of the drive plane that occurs at the bottom bracket and again at the rear hub uses bevel gears for the most efficient performance, though other mechanisms could be used, e.g. Hobson's joints, worm gears or crossed helical gears.

The drive shaft is often mated to a hub gear which is an internal gear system housed inside the rear hub.

Manufacturers of internal hubs suitable for use with shaft drive systems include NuVinci, Rohloff, Shimano, SRAM, and Sturmey-Archer.

### 1.1 Applications

The bevel gear has many diverse applications such as locomotives, <sup>[1]</sup>marine applications, automobiles, printing presses, cooling towers, power plants, steel plants, railway track inspection machines, etc.

For examples, see the following articles on:

- Bevel gears are used in differential drives, which can transmit power to two axles spinning at different speeds, such as those on a cornering automobile.
- Bevel gears are used as the main mechanism for a hand drill. As the handle of the drill is turned in a vertical direction, the bevel gears change the rotation of the chuck to a horizontal rotation. The bevel gears in a hand drill have the added advantage of increasing the speed of rotation of the chuck and this makes it possible to drill a range of materials.
- The gears in a bevel gear planer permit minor adjustment during assembly and allow for some displacement due to deflection under operating loads without concentrating the load on the end of the tooth.
- Spiral bevel gears are important components on rotorcraft drive systems. These components are required to operate at high speeds, high loads, and for a large number of load cycles. In this application, spiral bevel gears are used to redirect the shaft from the horizontal gas turbine engine to the vertical rotor.

## 1.2 Driven Shaft

A shaft-driven bicycle is a bicycle that uses a drive shaft instead of a chain to transmit power from the pedals to the wheel. 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 advancements in internal gear technology, a small number of modern shaft-driven bicycles have been introduced.



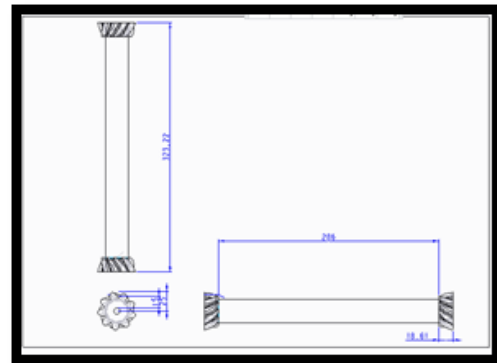
**Fig:1 Drive shaft housing**

## 2. Working principle

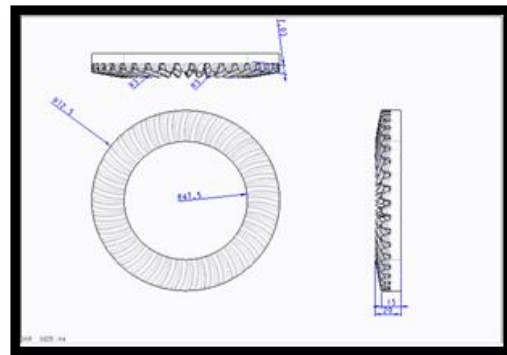
The term Drive shaft is used to refer to a shaft, which is used for the transfer of motion from one point to another. Whereas the shafts, which propel is referred to as the propeller shafts. However the drive shaft of the automobile is also referred to as the propeller shaft because apart from transmitting the rotary motion from the front end to the rear end of the vehicle, these shafts also propel the vehicle forward. The shaft is the primary connection between the front and the rear end, which performs both the jobs of transmitting the motion and propelling the front end.

## 3. Design of Shaft and Analysis

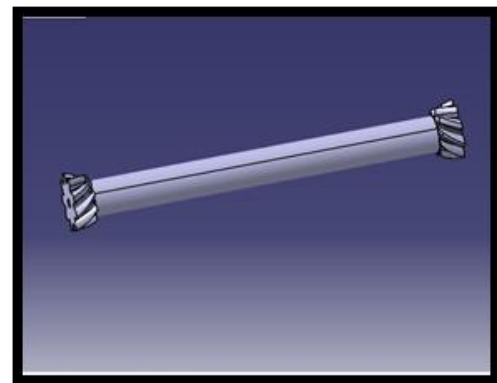
CATIA enables the creation of 3D parts, from 3D sketches, sheet metal, composites, and melded, forged or tooling parts up to the definition of mechanical assemblies. The software provides advanced technologies for mechanical surfacing. It provides tools to complete product definition, including functional tolerances as well as kinematics definition.



**Fig-3.1: 2D MODELS OF SHAFT**



**Fig-3.2: BEVEL GEAR**



**Fig-3.3: 3D MODELS OF SHAFT**

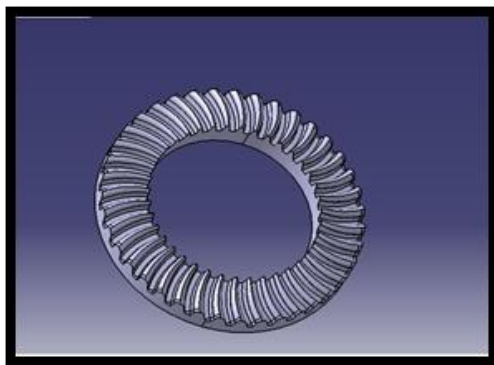


Fig-3.4: 3D BEVEL GEAR

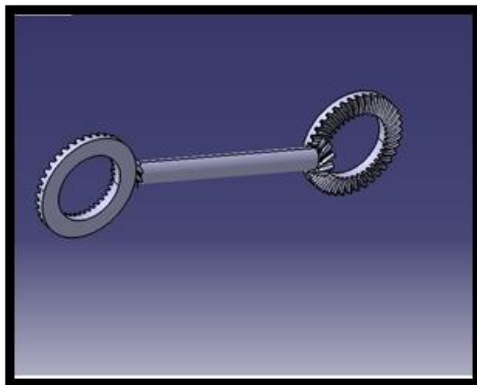


Fig-3.5: ASSEMBLY MODEL

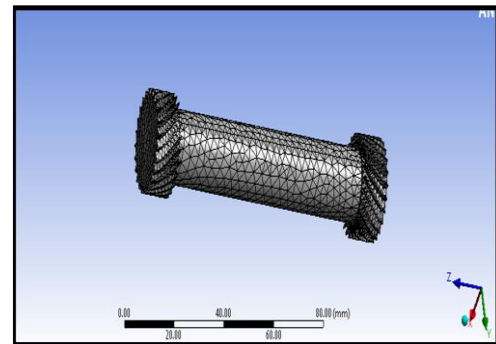


Fig-3.6: Meshed Model on driven shaft

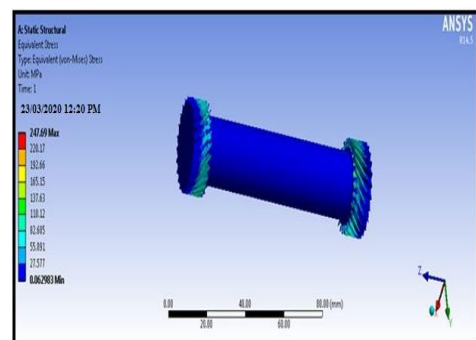


Fig-3.7: Stress formed on driven shaft

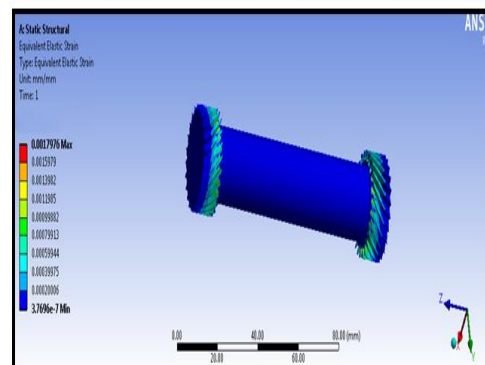


Fig-3.8: Strain Formed on driven shaft

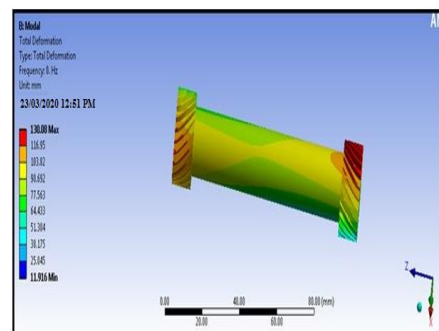


Fig-3.9: Total Deformation of driven shaft

Assumptions the shaft rotates at a constant speed about its longitudinal axis. The shaft has a uniform, circular cross section. The shaft is perfectly balanced. Hexa Mesh is made for better result and 20000 elements made with fine mesh size. The regular FEA procedure is followed and obtained results were plotted and compared.

ANSYS Mechanical is a finite element analysis tool for structural analysis, including linear, nonlinear and dynamic studies. This computer simulation product provides finite elements to model behavior, and supports material models and equation solvers for a wide range of mechanical design problems. ANSYS Mechanical also includes thermal analysis and coupled-physics capabilities involving acoustics, piezoelectric, thermal-structural and thermo-electric analysis.

#### 4. RESULTS AND DISCUSSIONS

The actual components of the shaft driven bicycle are being designed based on the design calculations and the analysis is being performed theoretically. The simulation is also performed on the designed model of the shaft and bevel gear assembly using the simulation tool ANSYS. It is found initially that the design is safe, based on the theoretical analysis performed. From the simulation of the design it is observed that the design is safe with respect to the given load. Hence, the designed shaft driven bicycle is a safe one with respect to the given load and rpm. On comparing the theoretical and simulated values it is found that they are approximately closer.

#### 5. 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 was realized to run successfully with two bevel gears at both end of the drive 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 also deals with design optimization i.e. converting rotary motion in linear motion with aid of two bevel gears. Instead of chain drive one piece drive shaft for rear wheel drive bicycle have been optimally designed and manufactured for easily power transmission. 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 the shaft. The stress distribution and the maximum deformation in the drive shaft are the functions of the stacking of material. The optimum stacking of material layers can be used as the effective tool to reduce weight and stress acting on the drive shaft. The design of drive shaft is critical as it is subjected to combined loads. The designer 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 a design. The drive shaft has served as an alternative to a chain-drive in bicycles for the past century, never becoming very popular

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