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Design and analysis of shaft driven bicycle

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Abstract:

A Shaft Driven Bicycle is a bicycle in which the power from pedals to rear wheel of the bicycle is transmitted by means of gear and shaft arrangement unlike the conventional chain drive. The main aim of the project is to obtain a maximum displacement of bicycle by transmitting the maximum possible torque from pedals to the rear wheel for a minimum applied force, reducing the human effort. This project is estimated to be a more reliable and safe system.

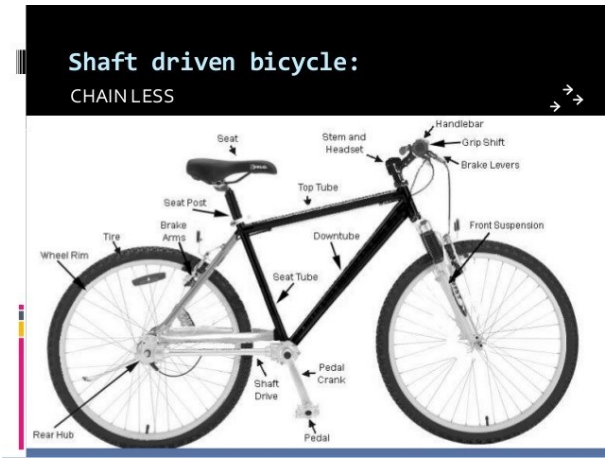
Shaft-driven bicycles have bevel gears and a connecting rod system where a conventional bicycle would have its chain ring. The bevel gear meshes with another bevel gear mounted on the drive shaft. The Bevel gears are the most efficient way of turning drives 90 degrees as compared to worm gears or crossed helical gear. This system consists of two set of bevel gears at both the ends. The shaft drive only needs periodic lubrication using a grease gun to keep the gears running quiet and smooth. This "chainless" drive system provides smooth, quite and efficient transfer of energy from the pedals to the rear wheels.

The methodology of the project is to design the chainless transmission system and carryout a analysis of the same using design and analysis tools. A comparison of theoretical and simulated results will be done.

Keywords: *Bicycle, Effect, Bevel Gear, Helical gear*

1. Introduction

A shaft-driven bicycle is a bicycle that uses a drive shaft instead of a chain to transmit power from the pedal to the rear wheel. Shaft drives were introduced over a century ago, but were mostly supplanted by chain-driven bicycles due to 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 great extent.



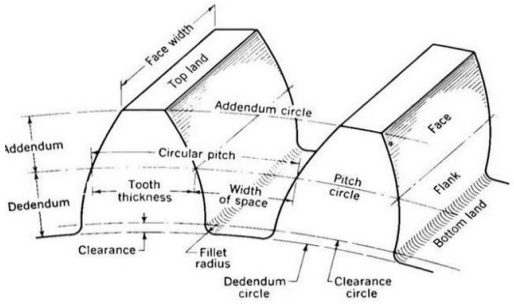
Proposed Model: Shaft Driven Bicycle

2. Types of Bevel Gear & Terminology

1. Straight Bevel Gear
2. Spiral Bevel Gear
3. Hypoid Bevel Gear

Gear Nomenclature Terms

Pinion, Gear, Velocity Ratio, Pitch Surface, Pitch Circle, Pitch circle diameter, Base circle, Addendum Circle, Dedendum Circle, Addendum, Dedendum, Clearance, Face of tooth, flank of tooth, face width, fillet radius, circular tooth thickness, tooth space, working depth, whole depth, center distance, pressure angle, line of action, circular pitch, diametral pitch, module.



Gear Nomenclature

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Types of Shafts
1. Transmission Shaft
2. Machine Shaft

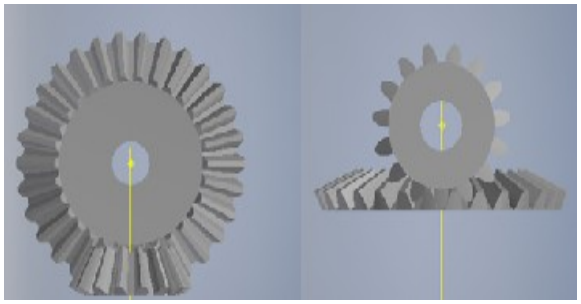
3. Modeling & Analysis

Design calculation of front gear set:

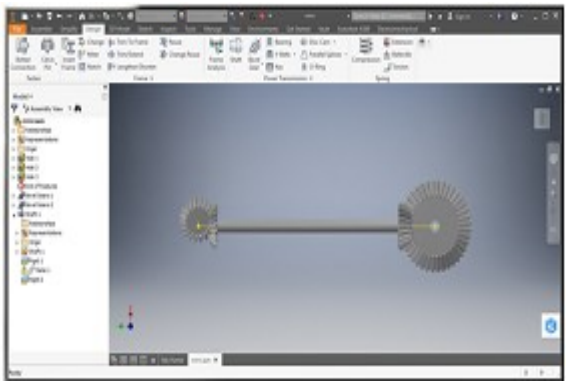
Module, m = 3
Pressure Angle, $\alpha = 20^0$
No. of teeth on Pinion, $Z_P = 20$
No. of teeth on Gear, $Z_G = 40$
Pitch Circle Diameter, D = m*Z
Pitch Circle Diameter of Pinion, $D_P = 3*20 = 60$ mm
Pitch Circle Diameter of Pinion, $D_G = 3*40 = 120$ mm
Cone Angle (Pitch Angle) of Pinion, $\partial_P = Tan^{-1}((\sin 90^0)/(Z_G/Z_P) + \cos 90^0)$
Cone Angle (Pitch Angle) of Gear, $\partial_G = \sum - \partial_P$
Cone Distance, $R = D/2\sin\partial$ $R = 60/2 \sin 26.56^0 = 67.09$ mm
Face Width, $b \leq R/3$ $b = 67.09 / 3 = 22.36$ mm
Addendum, $h_a = m = 3$ mm
Dedendum, $h_f = 1.25m = 1.25*3 = 3.75$ mm
Clearance, $c = 0.25m = 0.25*3 = 0.75$ mm
Working Depth, $h_k = 2m = 2*3 = 6$ mm
Whole Depth, $h = 2.25m = 2.25*3 = 6.75$ mm
Tooth Thickness, $s = 1.5708m = 1.5708*3 = 4.71$ mm
Tooth Space $= 1.5708m = 1.5708*3 = 4.71$ mm
Fillet Radius $= 0.4m = 1.2$ mm
Same as Rear Gear Set , Gear Tooth & Shaft Calculation are taken and it was done in Inventor Software

4. Design of Gears in Inventor

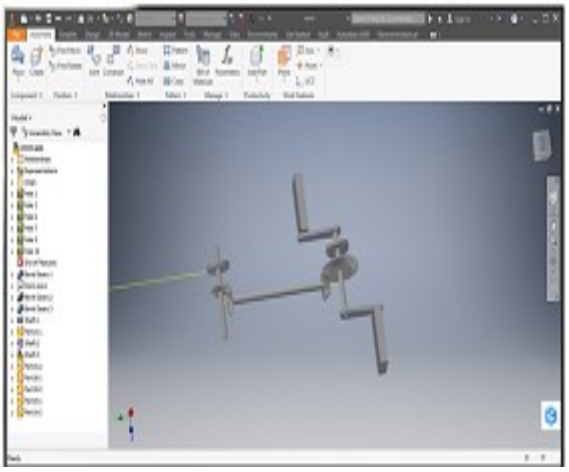
Design of Front & Rear Bevel Gear



Hole Generated on the Gear Surfaces

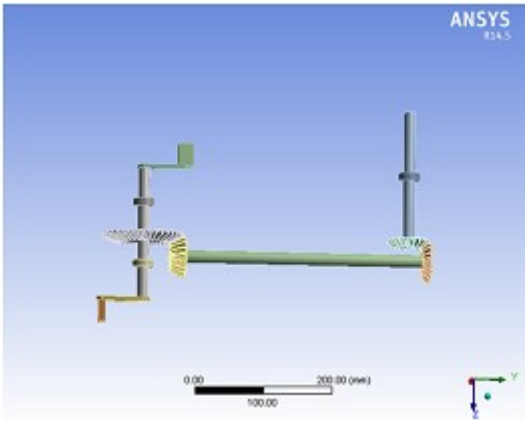


Assembly of Both Gears And Shaft



Final Assembly of The Components

5. Analysis of Components



Imported Figure in Ansys

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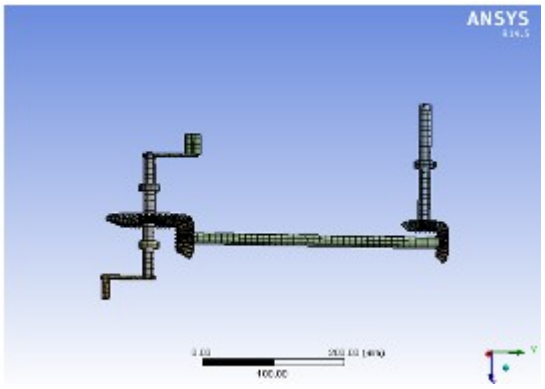
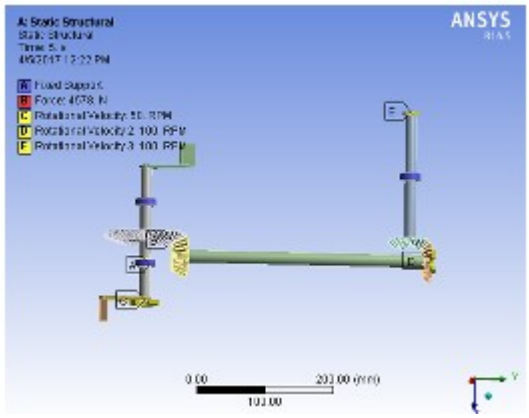


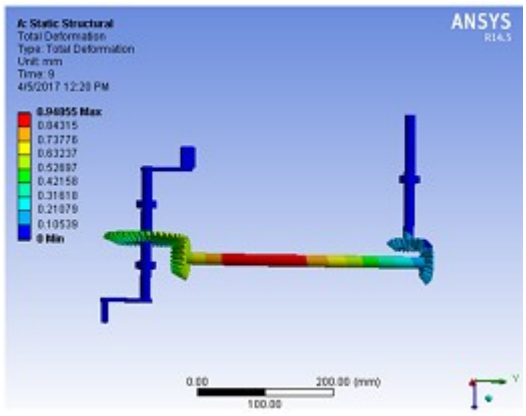
Meshed Figure in ANSYS



Applying Loads in ANSYS

Minimum Value Over Time					
Minimum	0. mm	1.4838e-005 MPa	-17.643 MPa	8.1934e-006 MPa	-141.1 MPa
Maximum	0. mm	1.4838e-005 MPa	-17.555 MPa	8.195e-006 MPa	-140.19 MPa
Maximum Value Over Time					
Minimum	0.94809 mm	338.12 MPa	348.44 MPa	187.93 MPa	90.067 MPa
Maximum	0.9486 mm	340.08 MPa	348.86 MPa	189.74 MPa	90.851 MPa
Information					

Maximum & Minimum Loads in ANSYS



Total Deformation in ANASYS

6. 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.

Comparison of Maximum Stress Induced (N/Mm^2)

MAXIMUM THEORETICAL STRESS	MAXIMUM SIMULATED STRESS
372.6268	348.86

7. SCOPE AND CONCLUSION

The shaft driven bicycle would replace the existing conventional bicycle which runs by means of chain and sprocket arrangement. As the manual load given by the rider results in increased displacement of the bicycle, the human effort is reduced. It would be very advantageous for off road racing. It also requires less maintenance with a comparatively longer life.

This system can be implemented for the high power vehicles, which are run by engines. This would definitely be a better transmission system and can be implemented for bikes. With some standardization of design and enhancement of the design it would generate a better output than that of the conventional system.

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