Design And Fabrication of Shaft Driven E-Bicycle

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Abstract*- In this project we fabricate a shaft driven bicycle which is coupled with a brushless D.C motor. A shaft-driven bicycle is a chainless 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. A multispeed Brushless DC motor is coupled to this system which helps in driving the cycle with ease.*

Keywords- Brushless D.C motor, shaft, multispeed, chailess.

I. INTRODUCTION

All vehicles that are in the market cause pollution and the fuel cost is also increasing day by day. In order to compensate the fluctuating fuel cost and reducing the pollution a good remedy is needed i.e. our transporting system.Due to ignition of the hydrocarbon fuels, in the vehicle, sometime difficulties such as wear and tear may be high and more attention is needed for proper maintenance. Our vehicle is easy to handle and no fuel cost to the other existing vehicles. Hence a need for a change in the existing alternative system which can produce higher efficiency at minimum cost was though about an attempt has been made to design and fabricate such an alternative system.So this project "**DESIGN AND FABRICATION OF SHAFT DRIVEN E-Bicycle"** is very much useful, since it is provided with good quality of power sources and the shaft driven mechanism makes pedaling easy, especially for mountain riders. "EACH AND EVERY DROP OF FUEL SAVES OUR ECONOMY AND MEET THE NEEDS" is the saturation point that is to be attained as soon as possible. In order to achieve this saturation point we have to save and seek for some other source of power. This power, the alternate power must be much more convenient in availability and usage.

The next important reason for the search of effective, unadulterated power are to save the surrounding environments including men, machine and material of both the existing and the next forth generation from pollution, the cause for many harmful happenings and to reach the saturation point.The most talented power against the natural resource is supposed to be the electric and solar energies that best suit the automobiles. The unadulterated zero emission electrical and solar power, is the only easily attainable alternate source. Hence we decided to incorporate the electric power in the field of automobile, the concept of many Multi National Companies (MNC) and to get relieved from the incorrigible air pollution.This implementation concept is tried to the best two-wheeler Cycle. The various simple arrangements done for the good driving conditions of the battery powered Cycle with its most needed specifications was summarized in this report.

1.1 Use of drive shaft

The torque that is produced from the pedal 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 this torque.

1.2 Functions of the Drive Shaft

1. First, it must transmit torque from the transmission to the foot pedal.
2. During the operation, it is necessary to transmit maximum low-gear torque developed by the pedal.
3. The drive shafts must also be capable of rotating at the very fast speeds required by the vehicle.
4. The drive shaft must also operate through constantly changing angles between the transmission, the differential and the axles.

II. COMPONENTS OF BICYCLE:

2.1 Pedal

A bicycle pedal is the part of a bicycle that the rider pushes with their foot to propel the bicycle. It provides the connection between the cyclist's foot or shoe and the crank allowing the leg to turn the bottom bracket spindle and propel the bicycle's wheels. Pedals usually consist of a spindle that threads into the end of the crank and a body, on which the foot rests or is attached, that is free to rotate on bearings with respect to the spindle. Part attached to crank that cyclist rotate to provide the bicycle power; it consists of three segments as shown in figure

2.2 Fender

Piece of curved metal covering a part of wheel to protect the cyclist from being splashed.

2.3 Front Brake

Mechanism activated by brake cable compressing a caliper of return springs. It forces a pair of brake pads against the sidewalls to stop the bicycle.

2.4 Bevel gear

A kind of gear in which the two wheels working together lie in different planes and have their teeth cut at right angles to the surfaces of two cones whose apices coincide with the point where the axes of the wheels would meet.

2.5 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.

2.6 Brushless DC motor

These are synchronous motors powered by direct current (DC) electricity via an inverter or switching power supplywhich produces electricity in the form of alternating current (AC) to drive each phase of the motor via a closed loop controller. The controller provides pulses of current to the motor windings that control the speed and torque of the motor. This control system replaces the commutator(brushes) used in many conventional electric motors.The construction of a brushless motor system is typically similar to a permanent magnet synchronous motor (PMSM), but can also be a switched reluctance motor, or an induction (asynchronous) motor. They may also use neodymium magnets and be outrunners (the stator is surrounded by the rotor), inrunners (the rotor is surrounded by the stator), or axial (the rotor and stator are flat and parallel).

2.7 Lithium-ion battery or **Li-ion battery**:

It is a type of rechargeable battery. Lithium-ion batteries are commonly used for portable electronics and electric vehicles and are growing in popularity for military and aerospace applications.[9] A prototype Li-ion battery was developed by Akira Yoshino in 1985, based on earlier research by John Goodenough, M. Stanley Whittingham, RachidYazami and Koichi Mizushima during the 1970s–1980s, and then a commercial Li-ion battery was developed by a Sonyand Asahi Kasei team led by Yoshio Nishi in 1991.In the batteries, lithiumions move from the negative electrode through an electrolyte to the positive electrode during discharge, and back when charging. Li-ion batteries use an intercalated lithium compound as the material at the positive electrode and typically graphite at the negative electrode. The batteries have a high energy density, no memory effect (other than LFP cells) and low self-discharge. They can however be a safety hazard since they contain flammable electrolytes, and if damaged or incorrectly charged can lead to explosions and fires

2.8 Advantages of Lithium ion Battery

1)Weight: Lithium-ion batteries are one-third the weight of lead acid batteries

2) Efficiency: Lithium-ion batteries are nearly 100% efficient in both charge and discharge, allowing for the same amp hours both in and out. Lead acid batteries' inefficiency leads to a loss of 15 amps while charging and rapid discharging drops voltage quickly and reduces the batteries' capacity.

3) Discharge: Lithium-ion batteries are discharged 100% versus less than 80% for lead acid. Most lead acid batteries do not recommend more than 50% depth of discharge.

4) Cycle Life: Lithium-ion batteries cycle 5000 times or more compared to just 400-500 cycles in lead acid. Cycle life is greatly affected by higher levels of discharge in lead acid, versus only slightly affected in lithium-ion batteries.

5) Voltage: Lithium-ion batteries maintain their voltage throughout the entire discharge cycle. This allows for greater and longer-lasting efficiency of electrical components. Lead acid voltage drops consistently throughout the discharge cycle.

6) Cost: Despite the higher upfront cost of lithium-ion batteries, the true cost of ownership is far less than lead acid when considering life span and performance.

7) Environmental Impact: Lithium-ion batteries are a much cleaner technology and are safer for the environment.

2.9 Advantages of Shaft drive

1. They have high specific modulus and strength.
2. Reduced weight.

3. Due to the weight reduction, energy consumption will be reduced.
4. They have high damping capacity hence they produce less vibration and noise.
5. They have good corrosion resistance.
6. Greater torque capacity than steel or aluminum shaft.
7. Longer fatigue life than steel or aluminum shaft.
8. Lower rotating weight transmits more of available power

III. 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, thesetransmitting the motion and propelling the front end. The design of drive shaft as shown in fig. Thus the terms Drive Shaft and Propeller Shafts are used interchangeably. In other words, a drive shaft is a longitudinal power transmitting, used in vehicle where the 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 pieces and joints depends on the distance between the two wheels. The job involved is the design for suitable propeller shaft and replacement of chain drive smoothly to transmit power from the pedal to the wheel without slip. It needs only a less maintenance. It is cost effective. Propeller shaft strength is more and also propeller shaft diameter is less. it absorbs the shock. Because the propeller shaft center is fittedwith the universal joint is a flexible joint. It turns into 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 derailleur maintenance.

IV. DESIGN ASSUMPTIONS

1. The shaft rotates at a constant speed about its longitudinal axis.
2. The shaft has a uniform, circular cross section.
3. The shaft is perfectly balanced, i.e., at every cross section, the mass center coincides with the Geometric center.
4. All damping and nonlinear effects are excluded.
5. The stress-strain relationship for composite material 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 in a vacuum.
7. Since lamina is thin and no out-of-plane loads are applied, it is considered as under the plane Stress.

4.1 Design Calculation:

TORQUE AND POWER REQUIREMENT

Torque T = Fc x r
Where,
Fc - Circumferential force

Motor shaft is connected to the sprocket
∴Fc - Centrifugal tension in the sprocket

Tc = m x v^2
V - Velocity of the chain
Where,
m - Mass of the chain per unit length
m = Area x length x density= b x t x l x ρ
Where,
b = Breadth of the chain = 0.015 m
t = Thickness =0.007 m
l = Length = 1 m
ρ = Mass density = 1140 kg/m^3

So,
m = 0.1197 kg/m

Now,
v = (3.14 x d x n) / 60 = (3.14 x 0.2286 x 3000) / 60
= 35.90 m/sec
Tc = m x v^2 =0.1197 x $(35.9)^2$ = 154.27 N

Fc = Tc
(Circumferential force on the motor is the centrifugal tension in the chain)

Now torque = Fc x radius of sprocket in the motor
= 154.27 x 0.1143
= 17.633 N-m

4.1.1 POWER RATING OF THE MOTOR:

Torque at motor sprocket = 17.633 N-m
Torque at the reduction gear = 5.289 N-m

Power of the motor = Torque x (2 x 3.14 x N) / 60

= (5.289 x 2 x 3.14 x 900) / 60

= 498 Watts

= 498/735.5

= 0.6 H.P

Our project Motor H.P is 0.5 H.P

4.1.2 Specification:

Material	:	Aluminium
Input Voltage	:	12-90 Voltage
Type	:	Permanent Magnet D.C
Horse Power	:	1/2 H.P
Ampere	:	7Ampere
Rated R.P.M	:	1800 R.P.M
Duty	:	Continuous

4.1.3 SPEED OF THE CYCLE: -

The motor Sprocket Diameter (D1)	=	75 mm
The Motor Speed (N1)	=	900
The cycle drive sprocket diameter (D2)	=	178 mm

The speed of the cycle (N2) = (75/178) x900 (D1/D2) x N1

= 380 RPM

4.1.4Shaft drive calculation

Inner Diameter of shaft (di) = 0.026 m
Outer Diameter of shaft (do) = 0.028 m
Length of shaft (L) = 0.335 m
Number of teeth = 16

0.008*16/2 = 0.128/2 =0.064 m
Module (m) = 0.008 m
Mass Moment of Inertia (I) = MR2 /2 = 4*0.0142 = 0.0039
Polar Moment of Inertia (J) = π (do 4 – di 4)/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 in „m" g = 9.81 m/sec2 (Assume mass of rider = 60 kgs

= 60 x 9.81 x 0.335 = 197.2 Nm
Power (P) = 2πNT / 60 = (2π x 110 x197.2) / 60 = 2271.5 watts
Shear Stress (r) = Tρ/J = (197.2)(7209) /1.548 X 10-8 = 9.18 X 1013 N/m4
Max.Shear Stress (rmax) = TRo/J = (197.2)(0.014) / (1.548 x 10-8) = 17.83 X 107

Bending moment (M) = EI / R Where E = Youngs modulus I = Moment of Inertia R = Radius (Ro) M = (105 X 0.0039)/ 0.014 = 29.25
Rate of twist = T/GJ = 197.2/(36.75)(1.548X10-8) = 3.46 X 108
Shear Strain = ρ (rate of twist) = 7209 X 3.46 X108 = 2.49 X 1012 ϴ = TL/GJ = (197.2)(0.335)/(36.75)(1.548 X 10-8) = 66.06/(5.68X10-7) = 1.163X109

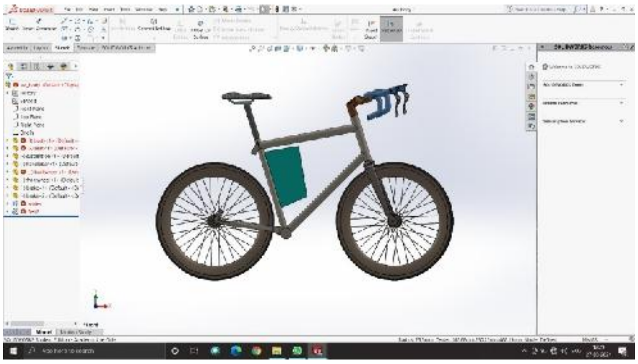
Torsion is the twisting of an object due to an applied torque. It is expressed in newton metres (N·m), In sections perpendicular to the torque axis, the resultant shear stress in this section is perpendicular to the radius.

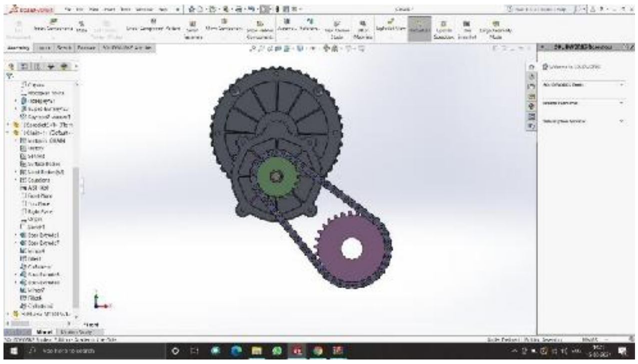
For shafts of uniform cross-section the torsion is:
T - is the applied torque
Nm - is the maximum shear stress at the outer surface
JT = Jzz for concentric circular tubes
r = the distance between the rotational axis
ℓ = the length of the object the torque is being applied to or over.
θ = angle of twist in radians.
G =shear modulus or more commonly the modulus of rigidity (GPa),
ro = outer radius
Torsion (T) = JT.Gϴ/L = (1.548 X 10-8)(36.75)(1.163 X 109) / 0.335.
Torsion (T) = 1974.9 Nm Deflection (YMax) = ML2 /2EI = (29.25 X 0.3352) / (2 X 105 X 0.0039) = 4.008 m
Max.Deflection = [T X do / 2] / I = [29.25 X 0.014] / 0.0039 = 105
Max.Shear Stress (Γmax) = (29.25 X 0.014) / (1.548 X 10-8) = 26.45 X 107 Pa
Torque Transmission Capacity (T) is given by T = Ss x π [(do 4 – di 4)do] / 16 (Assume shear strength (Ss) = 360 to 1200 Mpa)
T = 360 X π [(0.0284 – 0.0264)0.028] / 16 = 3.120 X 10-7 N-m
Tensional Buckling Capacity = (t x L2 t) / .2r3 = (0.003 x 0.3352 x 0.003) / √(1 – 0.232).2x0.0143 = (1.01 x 10-6) /(√0.947(5.48 x 10-6) = 3.71 X 10-4 m

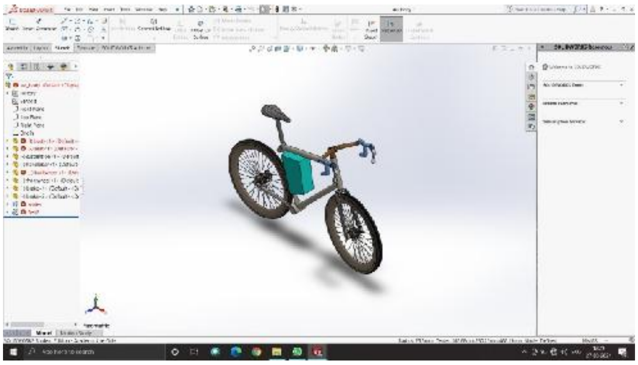
Bending Vibration Frequency is given by Fvb = (πp2 / 2L2)√(EIx / mi) = [(7.73 X 10-3)/(2 X 0.3352)].√(105 X 0.0039)/0.204 = (0.0344).√2.007= 1.4166 X 0.0344 = **0.0487**

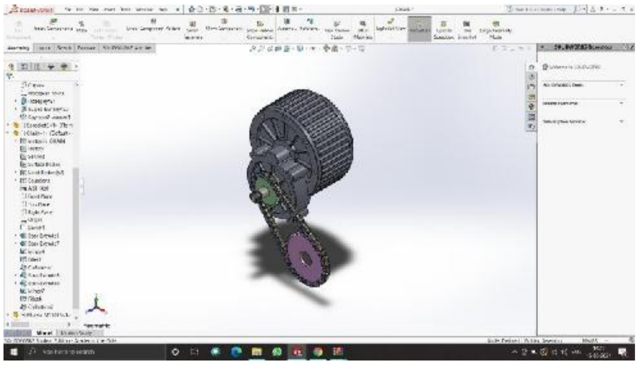
V. DESIGN

5.1 CYCLE

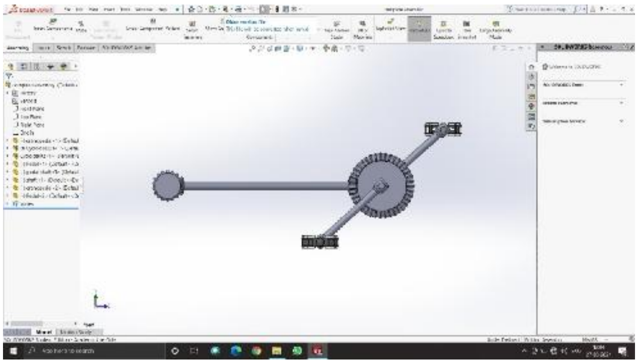


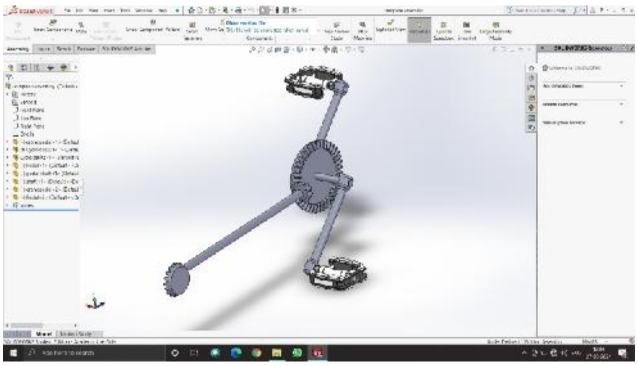






5.2 SHAFT DRIVE SYSTEM:





5.3 MOTOR DRIVE SYSTEM:

VI. CONCLUSION

1. The use of shaft drive mechanism helps in easy pedaling, and reduces the power required to drive the cycle.
2. The shaft driven bicycle are gaining more interest among young the mountain riders, who find it easy for pedaling.
3. The addition of a brushless D.C motor helps in driving the cycle without any effort.
4. A recent survey conducted by Ti cycles states that 57% of college students who owns a cycle doesn't use it regularly, and the reason was laziness in 50% of the case.
5. So this project makes it easy for these people. People can pedal the cycle and whenever they feel lazy they can use the motor drive system.
6. The coupling of shaft and motor drive system makes it a kind of Hybrid vehicle.

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