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Design of Electric Trike (Bio-Hybrid)

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ABSTRACT

A hybrid vehicle is a conveyance with multiple energy sources, which could be discretely or simultaneously operated to propel the vehicle. That signifies amalgamating a petrol or diesel engine with an electric motor. The main advantages of a hybrid are that it should consume less fuel and emit less CO2 than a commensurable conventional petrol or diesel-engine conveyance. Nowadays, conveyance is very important for travel and this plays a paramount role in the magnification of economy. However, there are drawbacks additionally. Firstly, the fuel prices incrementing not only in India but additionally throughout the world day by day. Secondly, the vehicles which run on I.C. Engines engenders pollution by combustion of fossil fuels. These fuels are the main parameter for the increase in global warming. Additionally, there are hybrid drives available in the market but they work with the avail of I.C. Engine. In integration, complete electric drive is not eco-friendly because they run on electricity, which is produced by coal. Consequently, we mentally conceived that we must find an intermediate solution for this. Our research is the design of a machine, which utilizes human force in collaboration with an electric motor with the avail of PLANETARY GEAR SYSTEM. That signifies BIO for human force and HYBRID for multiple propulsion system. It gives an incipient way of transportation in urban areas, simultaneously focusing on abbreviating pollution caused by I.C. Engines and supersede it with the electric drive.

Keywords— Hybrid vehicle, I.C. Engine, Electric drive, Eco-friendly, PLANETARY GEAR SYSTEM,Propulsion system.

1. INTRODUCTION

It became obligatory to design a hybrid bicycle because of major problems arising like increasing pollution and skyrocketing fuel costs. Therefore, it was necessary to have an alternative solution. In today's world, there are many hybrid bicycles available but they either run on electric drive, and mechanical system charges the battery or they consummately run on mechanical drive. So, in a typical hybrid system, in any way, fuel is being utilized.

In integration, there are some electric bicycles equipped with rechargeable batteries that need to be charged after a definite use. Every battery requires charging depending on its capacity which requires an external electric source. As per the recent scenario, the cost of fossil fuels as well as consumption is incrementing in many countries. Most of the countries have commenced implementing schemes to promote the utilization of electric conveyances to curtail the pollution and environment cognate issues. In integration, the utilization and maintenance of electric vehicles are more frugal in comparison. E-bikes bring an abundance of indisputable advantages to the table. Being able to accommodate as a reliable denotes of travel without relying on gas is always a welcome advantage
for most motorists. Considering the ballooning prices of petrol, the growing number of people who are switching to e-vehicles cannot authentically surprise you. That is controvertibly just the tip of the iceberg.

2. LITERATUREREVIEW

2.1 Literature review of shaft driven bicycle: -

The first cycle shaft drives appear to have been developed independently in the United States and England in 1890. Fearnhead of 354 Caledonian Road in North London invented one in 1890 and was granted a patent in October 1891. His prototype shaft was housed in a tube that ran along the top of the chainstay; later iterations were housed within the chainstay itself. Walter Stillman filed a patent for a shaft-driven bicycle in the United States on December 10, 1890, and it was granted on July 21, 1891.
Because the shaft drive was not well received in England, Fearnhead moved it to the United States in 1894, where Colonel Pope of the Columbia business purchased the sole American rights. The English manufacturers finally took it up, with Humber in particular investing considerably in the contract. Professor Archibald Sharp, the finest of all Victorian cycle engineers, was an outspoken opponent of shaft drive, writing in his classic 1896

book "Bicycles and Tricycles," "The Fearnhead Gear." If bevel-wheels could be cut reliably and cheaply by equipment, this type of gear might potentially replace the chain-drive gear to a large extent.; but the fact that the teeth of the bevel-wheels cannot be accurately milled is a serious obstacle to their practical success".

They were first produced in 1893 in the United States by the League Cycle Company. Soon after, the Acatane was marketed by the French business Metropole. Columbia began aggressively marketing the chainless bicycle it had purchased from the League Cycle Company in 1897. In 1898 and 1899, chainless bicycles were relatively popular, albeit sales were still far lower than ordinary bicycles, owing to their high cost. The bikes were also less efficient than conventional bicycles: the gearing was reduced by about 8%, owing to limitations in manufacturing technology at the time. The rear wheel was also more difficult to remove to change flats. Many of these deficiencies have been overcome in the past century.

In 1902, The Hill-Climber Bicycle Mfg. Company released a three-speed shaft-driven bicycle featuring three sets of bevel gears for changing. While a small number of chainless bicycles were available, shaft-driven bicycles largely vanished from view for the majority of the twentieth century. However, there is still a small market for chainless bikes, particularly among commuters, and several manufacturers offer them as part of a larger range or as a primary focus. Biomega, a company based in Denmark, is a good example.

Kenneth S. Keyes has a patented innovation or work connected to a drive shaft driven bicycle. The goal of his innovation was to create a bicycle with a linear transmission system from the pedal to the hub that would provide better efficiency and speed ratios than previous bicycles. Traditional coaster or 3-speed bicycle chains can cause a variety of issues. They are prone to sliding if the chain length is not properly set.

Keyes devised a bicycle with a driver bevel gear attached to the pedals, a driven bevel gear at the rear wheel's hub, and one or more drive shafts with bevelled gears at either end capable of conveying the rotation of the driver gear to the driven gear. Improved cycling infrastructure is associated with increased rates of bicycle commuting, which could include the marketing of folding bicycles. Most people comprehend the basic notion of a folding bicycle, but they don't appreciate the overall benefit of better product design, especially since few people are prepared to pay for higher expenditures.

2.2 Literature review of electric bicycle: -

China is the world's leading e-bike manufacturer. According to the China Bicycle Association, a government-chartered industry body, Chinese manufacturers sold 7.5 million e-bikes in 2004, about double the number sold in 2003. In 2005, domestic sales totaled 10 million, rising to 16 to 18 million in 2006. In China, almost 210 million electric bikes were utilised on a daily basis in 2016.

In 2009, the United States had an estimated 200,000 e-bike fleet. They became more popular as food delivery trucks in New York in 2012.In the United States, Pedego Electric Bikes is the most popular brand. In the United States, many e-bikes are simply regular bicycles that have been converted using a kit. The motor (which is usually a hub motor incorporated into the front or rear wheel), a speed controller, throttle (commonly a twist-grip or thumb throttle), essential cabling and connectors, and a battery are all included in the kits.

Panasonic released the first e-BIKE in Japan, the "XM-I," in 2017, and YAMAHA released the "YPJ-R" in the same month. Some e-BIKE tours have been available since 2018. Shimanami, Izu Peninsula, and Kyoto Prefecture are all eager to promote E-Bike tourism.

In India, the first pedal-assisted bicycles were introduced in 1993. In 2008, e-bike sales surpassed moped sales for the first time. In recent years, India has seen the introduction of 2-passenger and even 3-passenger (two adults and a child) e-bikes. Many new manufacturers in India have begun to offer alternatives and changes in order to keep up with current trends while adhering to the law.

When we think of electric two-wheelers in India, low-powered scooters with short range come to mind. However, that is no longer the case as bonafide automakers are launching powerful electric bikes in the country. Hero, EeVe and Evolet showcased their electric bikes at the Auto Expo 2020.

METHODOLOGY

The main aim of the research was to ensure efficient operation of the Hybrid Trike by meeting the drive requirements. Considering legal limits on the speed of electric bicycles, the maximum speed of the Hybrid Trike was considered to be 28 km/h. Since regeneration is involved, determining the type of components to be used, given the constraints of weight and size became more crucial. The main components required for this research are listed below:

- MOTOR
- BATTERY
- CONTROLLER
- BICYCLE
- DISK BRAKES
- DYNAMO
- SUSPENSION SETUP

Hybrids are the vehicles with more than one energy source. The major challenge for the fabrication was to design the hybrid mechanism, motor mounting and reducing battery size. The dynamo on the front wheel should be utilized to charge the battery. The main challenge was to design & manage different energy sources at one axle of the hybrid trike. For that mechanism, we chose the PLANETARY GEAR MECHANISM.

3.1 SELECTION OF BICYCLE:

For the above purpose, we chose HERO SPUNKY 26TSS 26 T.

The HERO SPUNKY 26TSS is chosen because it is triangular frame so that we can fit our battery in that compartment. In addition, it is a cheaper model available in the market with the same configuration.

Specifications:

- Tire size: 26 inches
- Frame size: 23 inches
- Wheel: MTB
- Width: 142 cm
- Height: 68 cm
- Depth: 26 cm

3.2 SELECTION OF DC MOTOR:

Different types of motor are available in the market as per the consumer requirement. In today's industrial sector, direct current (DC) motors are everywhere. Robotics, automobiles, small and medium sized motoring applications often feature DC motors for their wide range of functionality. In automobile sector especially those vehicles which are converted into electrical vehicles require high performance quality of DC motors which are available in the market.

Requirements of DC motor:

- Motor having high performance characteristics
- It should have high rated rpm to carry different load capacities such as vertical load carrying capacity and various torque acting on motor with varying road condition.
- It should have low weight and low maintenance cost
- Size and shape should be compatible for attachment on any vehicle
- It should be easy to mount with proper weight balancing in overall assembly of bicycle.

Selected motor:

- Input Voltage: 24V/250W
- Input: DC supply
- Maximum speed: 1600 RPM
- Rated current: 12 A

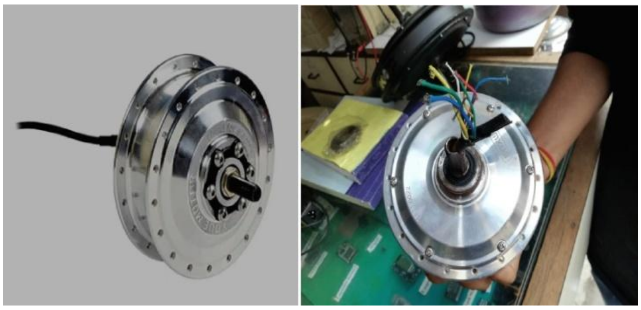
3.3 Selection of Battery:

- No of Battery: 2
- Output Voltage: 12V
- Battery Type: Lead Acid
- Charging Time: 2hr

Lead Acid Battery: Lead acid batteries are very common in our day-to-day life. Batteries use a chemical reaction to do work on charge and produce a voltage between their output terminals. The sulphuric acid electrolyte produces a voltage. The supplying of energy to and external resistance discharge the battery. The discharge reaction can be reversed by applying a voltage from a charging source. Thus this project demand for a battery with long life with longer running hour's lighter wright with respect to its high output voltage & higher energy density among all the available battery types the most suitable on to be selected.

3.4 Selection of Dynamo:

350W 36V Hub motor/Alternator:



Specifications:

- Rated Voltage (V): 36 V
- No load Current (A) :1A
- Rated Current (A): 14 A
- Rated Power: 350W (250 - 350W)
- Compatible Wheel Size: 20 to 28 inch
- Spoke Holes: 36 holes
- Wheel diameter: 130mm.

3.5 Selection of Controller:

- Voltage: DC 24V
- Under Pressure: 20V±1
- Current Limit: 21A ±1
- Level Brake: high / low
- Phase Angle: 60/120
- Power: 250W

Fig. Controller

Controller: A motor controller is an important element of the hybrid bicycle. It serves as a brain of bicycle. shown in (fig.4.) It controls the amount to power supplied to the hub motor & also to the lights, horn, etc. the motor controller is connected to a power source. Such as a battery pack & control circuitry in the form of analog or digital input signals. The motor controller performs the fun of conversion of DC voltage from battery to an alternating voltage with variable amplitude & frequency that drive the hub motor at different speed.

3.6 Selection of brakes:

Sram Disc Brake BB7 Road Platinum. Includes 160mm G2CS Rotor .Front& Rear IS Brackets.

Specifications:

- Weight: 329 grams (160mm rotor; front post mount)
- Caliper Design: Mechanical, Forged 2-piece Aluminum
- Pad: Sintered
- Adjustment: Dual Knob Pad Adjustment, Tri-Align Caliper Positioning
- Compatibility: Road style levers

DESIGN OVERVIEW

The following design of the BIO-HYBRID mechanism is done with the help of SOLIDWORKS.

4.1 Gear Calculations:

$Z1 = Z2 = 16$

$i = 1$

$N1 = N2 = N = 132.62$

Selecting material 40Ni2Cr1Mo28

Case hardened

$\sigma b = 4000$

$\sigma c = 11000$ kqf/ cm^2

$Mt = d/2 = 90/16 = 5.625 = 6mm$

T = mass * 9.81*length of pedal (0.16-0.19)

= (100*9.81*0.18)

= 176.58 mm

$P = 2\Pi nt/60 = 2452kw$

Yv= π (0.514 – 0.912/16) = 0.3047

Ψ m = 10 b=0.3R consider less b=10 Mt=6cm R =MtZ1/2 sin δ1

b=2.036 cm

Mt=Mav+(b/2) *sinδ

Mav =0.6 – (2.037/160) * sin45

=0.5

Mav =5mm

$$Mav= 1.28 \sqrt[3]{\frac{Mt}{Yv(\sigma b)\Psi mZ}}$$

Mt = 97420* (Kw/n) *1.5 (Kd.K=1.5)

=3305.61 Kgfcm

Now,

$$0.5= 1.28 \sqrt[3]{\frac{3305.61}{(\sigma b)\, 0.3047*16*10}}$$

=1137.57 < 4000 Kgf/ cm^2

$$\sigma c = 0.72/(R-0.5b) \sqrt{\frac{(i2+1)2 \quad * E * Mt}{ib}}$$

$$= \frac{0.72}{6.78-(0.5-2.037)} \sqrt{\frac{(1+1)2}{2.037} \times 2.15.10^5 \times 3305.61}$$

=10439.06 < 11000 kqf/ cm^2√

Checking for dynamic wear load, Using Buckingham's Eqn

$$Fd = Ft + [\frac{0.614Vm\ (Cb+Ft)}{0.614Vm + 1.485(\sqrt{Cb}+Ft)}]$$

$$Ft = \frac{P*1000}{746} * 75/Vm$$

$Vm =$ ΠDN/60 =0.624 m/s=37.49m/min

Ft= 483.34 Kgf

C = 11860e (steel n stee configuration) e =0.03

= 355.8 Kgfcm

Fd = 611.93 Kgf

Fdbtpsg 8.52,

Fd = CvNs+KmFt

$$= \frac{3.5+Vm^{\frac{1}{2}}}{5.5} * 1.5 * 1.3 * 483.34$$

=735.14 kgf

$$Fs = \frac{(\sigma b) b * Yv\ (1-\frac{b}{R})}{Pd}$$ Pd =1/Mt=1/0.6=1.67

$$= \frac{4000*2.037*0.3047\ (1-\frac{2.037}{6.78})}{Pd}$$

Fs = 1041.86 Kgf>Fd……….*Safe*

For wear load,

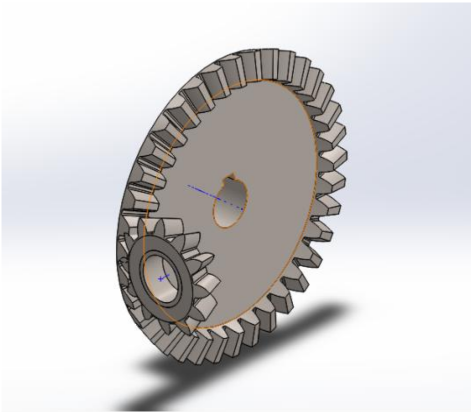
Fw = $\frac{\text{Dp B Q K}}{\cos\delta}\text{Dp} = 0.6 * 16 = 9.6$

K= $\frac{(\sigma c)^2 \sin 20 \ (\frac{2}{2.15*10^6})}{1.4}$

= 27.49 Kgf / cm^2

Fw = 760.24 Kgf / cm^2 >Fd …….*Safe*

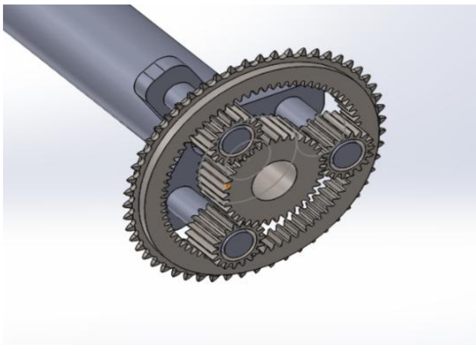
4.2 Front Bevel gear:



Specifications:

- Material: 40Ni2Cr1Mo28 (Case hardened)
- Design stress (Bending): 4000 Kgf/cm^2
- Design stress (Compression):11000 Kgf/cm^2

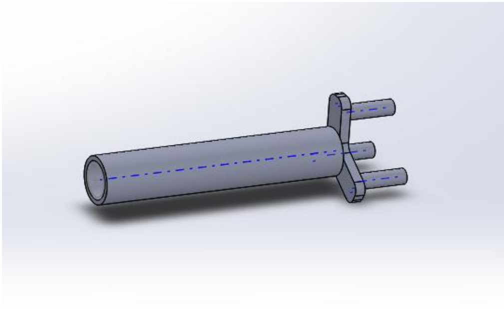
4.3 Epicyclic Gear Train:



Specifications:

- Material: 40Ni2Cr1Mo28 (Case hardened)
- Design stress (Bending): 4000 Kgf/cm^2
- Design stress (Compression):11000 Kgf/cm^2

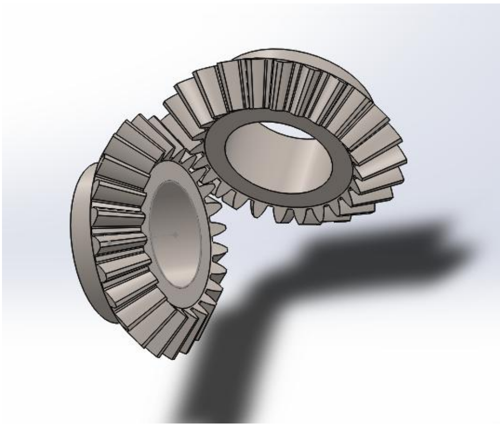
4.3 Shaft Design:



Specifications:

- Material: C-45
- Tensile strength: 710 N/mm^2
- Yield strength: 360 N/mm^2

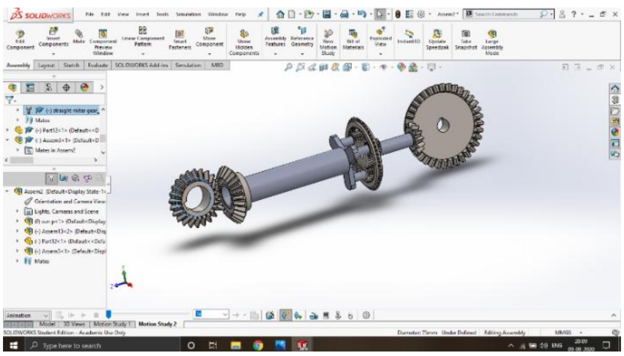
4.4 Rear Bevel gear:

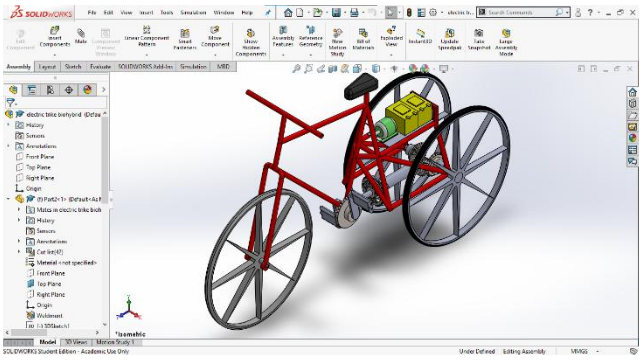


Specifications:

- Material: 40Ni2Cr1Mo28 (Case hardened).
- Design stress (Bending): 4000 Kgf/cm^2
- Design stress (Compression):11000 Kgf/cm^2

4.5 Assembly of BIO-HYBRID mechanism:





CONCLUSION

This research lays the foundation of the understanding of good engineering by following the procedure of understanding, evaluation, and study of the existing technology. This project is designed to improve the normal bicycle and make it extra efficient. The electric tricycle is a hybrid and so it can run electrically and can also be pedaled thereby still retaining the exercise people drive from riding bicycle.

The results of the research can serve as a platform to improve tricycle performance if new drive systems are designed around key parameters that will result in improvement of the system performance. Furthermore, they can be used for comparison of existing drives in a systematical, comprehensive, and technical way.

The central goals of the research have been accomplished, to some point; since a better understanding of how challenges are faced within each of these systems based on their limitations and how much effort is required to reformulate the standards to produce ELECTRIC TRIKE (BIO-HYBRID).

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