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DESIGN OPTIMISATION AND FABRICATION OF HYBRID TWO-WHEEL DRIVE MOTORCYCLE

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Abstract - *The major source pollution in the environment the exhaust gases from the vehicles and it is increasing day by day. This is leading to many environmental problems such as global warming. This effects plants and animal life's. One of the innovation to avoid this problem is the Hybrid Electric Vehicle (HEV). The hybrid electric vehicle consists of two or more energy sources for total propulsion of the vehicle. In this project, two independent power units consisting of electric drive unit and IC engine unit have been used. The power of electric dive unit can be used up to 20kms and it makes the vehicle more eco- friendly. For high speed and long distance operations, it can be switched to IC engine drive which makes the vehicle more flexible.*

Key Words: **Hybrid bike, Two wheel drive, Front wheel drive, Hybrid electric vehicle, Independent drive vehicle.**

1. INTRODUCTION

The hybrid vehicle is getting more and more popular among the people due to is economical and ecofriendly operating characters. Today many car manufactures have introduced the hybrid technology in the cars successfully. But the hybrid technology in two wheelers are very limited. The concept of two-wheel drive motorcycles was not successfully and economically implemented.

The implementation of hybrid technology in motorcycle will make it more affordable than a hybrid car. In the proposed design the front wheel is driven by the electric hub motor and the rear wheel is driven by conventional SI engine. The hub motor is driven by the battery which is rechargeable after every use. This will make the motorcycle more efficient in terms of fuel consumption and it will also reduce the pollution rate with respect to the distance travelled.

2. PREVIOUS DESIGNS

Siegfried Hieble, et al [1999] A two-wheel drive motor cycle consisting of a single power unit with a mechanical and hydraulic power train. The chain drive connects the engine and the rear wheel. The front wheel gets power from the hydraulic pump which driven by hydraulic motor connected to the engine. The hydraulic pump is connected to the front wheel by chain drive.

Andrew Schoenberg, et al [2006] A tricycle which can be operated either manually using pedal or by using electric motor. In this the manual pedalling done on the front wheel. The rear wheel is driven by induction motor which is powered by battery. The battery is charged by the solar panel attached to the top of the vehicle.

James W. Hollingsworth, et al [2012] In this motorcycle both the front and rear wheels are driven by a single power unit (petrol engine). The rear wheel gets its power in a conventional way. The front wheel is driven by the combination of two chain drives. The first chain from the engine is connected to chain sprocket assembly in the steering fork. The second chain connects the sprocket assembly and the front wheel.

Darshil G. Kothari, et al [2014] The Hybrid Bicycle System is a systems project that incorporates three different ways of charging a lithium-ion battery: the 220VAC wall outlet, regenerative braking, and solar power; which is used to power an electric hub motor running a bicycle. In this electric hybrid bicycle, the front wheel has a compact & light weight hub motor. It will be having regenerative charge system and solar panels, which enables substantially longer distance power assist cycling by regenerating power from pedalling energy (human energy) and solar energy and charging it in the battery.

Ben Jose, et al [2014] A two-wheel drive motorcycle providing economical and user friendly two-wheel drive. The use of chain drive and sprockets help in reduction of power loss during transmission of power from the engine to front and rear wheels. Under optimum traction conditions, the rear wheel is driving faster than the front wheel and the one-way clutch within the system allow the front wheel to freewheel under these conditions. At this point, the two-wheel drive system is effectively passive. Though the front drive system is turning, it is not actually transferring power to the front wheel. When the rear wheel loses traction, the drive ratio, relative to your forward speed, changes. The two-wheel drive system engages transferring power to the front wheel until traction is re-established at the rear wheel.

3. DRAWBACKS OF PREVIOUS DESIGNS

The two-wheel drive technology used so far uses only a single power unit and it uses chain drives which has high transmission losses and power losses.

Some two-wheel drive vehicles use hydraulic drive in the front wheel which is powered by the same engine which powers the rear wheel. So, the engine load increases and its efficiency drops considerably.

4. MATERIALS AND METHODOLOGY

A new and improved design for hybrid two-wheel drive motor cycle was developed based on the problem identification and literature review. The proposed design consists of a electric front wheel drive and a conventional IC engine rear wheel drive. The electric front wheel drive consists of a brushless hub motor, sine wave controller and battery. The rear wheel drive consists of a two-stroke gasoline engine connected to the rear wheel by means of chain drive. A suitable control circuit was designed to switch between the electric drive and IC engine drive when and then required.

Fig -1: Proposed design

4.1 COMPONENT SELECTION

The components are selected based on the power, speed and the range required for the motorcycle. The following calculations are made to select the components.

SECLECTION OF MOTOR

Considering the average operating distance as published in the journal "A Study on Motorcycle Usage and Comfort in Urban India" by "Sai Praveen Velagapudi, Ray G.G" is claimed to be 610kms per month. Which is equal to 19.67kms a day. So, the bike must be designed in such a way that it must operate in electric drive for at least ten kilometers and continue to operate further for much longer in IC engine.

Considering the weight and load applied to the vehicle, 60V 350W BLDC hub motor which is suitable for the required load is selected.

SELECTION OF BATTERY

The battery should be selected based on the vehicle operating parameters such as speed, load, torque and average operating distance of the vehicle. For that the following calculations are done.

Load calculation

The total load applied to the hub motor is calculated based on the following weights of the vehicle and its accessories

Vehicle weight	=61 kg
Motor weight	=10kg
Battery weight	=6kg
Rider and accessories	=123kg
Total load	=200 kg

Force calculation

The force required to pull the calculated load is calculated based on the total load of the vehicle. The force required is given by

$$F = Crr \times m \times g$$

Where

F = force in newton
Crr = co efficient of rolling resistance
= 0.01
G = acceleration due to gravity
= 9.81 m/s^2
M = mass of the vehicle (total load)

F= 0.001 x 200 x 9.81
F= 19.62 N

Power calculation

In India, the maximum speed of the electric motorcycle is limited to 25 km/hr. assuming the maximum velocity of 25km/hr the power required to pull the rated load is calculated by using the formula

$$P = F \times \left(\frac{V}{3600}\right)$$

Where

P = Power in watts
V = Velocity
= 25 Km/hr = 25000 m/hr
= 19.62 x (25000/3600)
P = 136.25 Watts

SELECTION OF BATTERY TYPE

The lithium ion battery is the most efficient battery available today. Though the lead acid battery is more economical battery than this it is quite heavy and it has less life time when compared to lithium ion battery.
The 60V 10.4Ah battery is available in the regular market. After calculating its performance, it can be used.
The watt hour of the battery is given by

Ah X V = wh

Where
Ah = Ampere hour
V = Voltage
Wh = Watt hour

(i). 60V 10.4 Ah battery
= 60 X 10.4
= 624 wh
Since the battery produces 624 watts, it is higher than our required watt hour. so this battery can be used to power the hub motor.

DISTANCE CALCULATION

The distance that can be travelled using this battery is given by

d= wh / f
= 624/ 20
= 31.2 kms

The road conditions may not be same during the whole journey so we can calculate the distance that can be travelled for double the actual load.

d= wh / f
= 624/ 40
= 15.6 kms

CHARGING TIME CALCULATION
The charging time of a lithium ion battery varies depending upon the charger used for it. The charging time of the lithium battery is given by

T = Ah / A

Where
Ah = Ampere hour rating of battery
A = Current in amps (charger)
T = 10.4 ÷ 5
= 2.08 hours

So, it will take 2.5 hours and 10.4amps current to charge the battery. With this charge the vehicle can be operated up to 30kms

CUTTENT CONSUMPTION CALCULATION

For charging all the four batteries fully it takes 2.5 hours and 10.4 amps current
1 amps = 1.4 kvah
10.4 amps = 10.4 / 1.4
= 7.428 kvah
In Tamil Nadu electricity is charged based on Kilowatts. So we can convert Kvah to KW

Where
PF = Power factor

For a single-phase line

Voltage = 240V
Frequency = 60Hz
Real power = 2KW

Using power factor calculator, we get the power factor for single phase line as 0.174

KW = 7.428 X 0.174
= 1.292 (2 units)

5. WORKING PRINCIPLE

The rear wheel drive in the vehicle is operated by the conventional 50cc two stroke petrol engine. The chain drive is employed to connect the engine and the rear wheel.

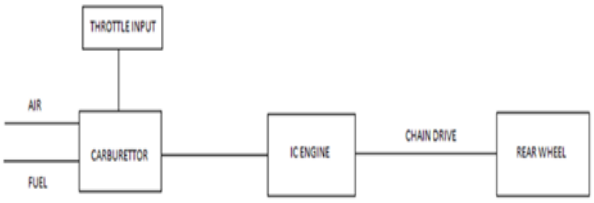

Fig -2: Layout of IC engine drive

The figure 2 shows the layout of the IC engine drive. In this vehicle, the IC engine drive is used only during the long distance and high speed operations. For the shorter drives the vehicle is operated by the electric drive.

The front wheel drive in this vehicle is operated by the electric drive. The electric drive is powered by a 60V 350Watt hub motor. Which is controlled by a sine wave controller. The figure 4.2 shows the assembled hub motor in the front wheel. The hub motor is powered by a 60V 10.4Ah lithium ion battery. This provides an operating range of about 25kilometrs. The can be used for shorter rides to avoid pollution.

Fig -3: Hub motor assembly

5.1 OPERATING METHOD

The figure 4 To operate the vehicle in the front wheel, drive the battery is switched ON using the key in the battery. Then the power button in the right side of the handle bar is turned ON. Then the throttle can be given to the motor by using the accelerator in the inner side.

Fig -4 Throttle setup

Figure 5 shows the integrated brake assembly of the vehicle. During the operation in the electric drive the integrated brake in the left side of the handlebar is used.

Fig -5: Integrated brake assembly

The motor will not operate until the brake is released since the brake cuts off the power supply to the motor.

To operate the vehicle in the rear-wheel drive the electric drive is switched off and then the engine is started manually. The speed is controlled by the twist throttle in outer end of the handle bar. The front brake is operated by the right brake lever and the rear brake is operated by the left brake lever.

6. RESULT AND DISCUSSION

The vehicle can travel a maximum of 31kilometers for single charge of the battery. Then it can be switched to IC engine drive. The vehicle attained a top speed of 32kmph during the test in the electric drive and 37kmph in IC engine drive.

The range and top speed of the electric drive can be increased by increasing the power of the battery and the hub motor respectively. Once the top speed of the vehicle is increased the brake capacity of the vehicle should also be increased to ensure safety.

On-board charging for the battery can also be implanted to increase the operating range of the vehicle.

7. CONCLUSION

In the existing two-wheel drive motorcycle the use of single power unit reduced efficiency of the vehicle. The front wheel drive mechanism had many complications too. The suspension setup for the vehicle also had many defects. The hybrid technology was also not implemented properly in the existing vehicles.

Now with the implementation for the electric drive the for the front wheel we can overcome the existing problems in the hybrid and two-wheel drive motorcycles.

8. CONTRIBUTION TO THE SOCIETY

By using this project, we can reduce the emission of the vehicle with respect to the distance travelled. The operating cost of the vehicle is also reduced as the electric drive is more economical than the conventional IC engine drive.

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