Design and Fabrication of Hybrid Scooter

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Abstract— A 'Hybrid electric vehicle' is a vehicle which relies not only on batteries but also on an internal combustion engine which drives a generator to provide the electricity and may also drive a wheel. It has great advantages over the previously used gasoline engine that drives the power from gasoline only. It is a major source of air pollution. The objective is to design and fabricate a two wheeler hybrid electric vehicle powered by both battery and gasoline (PETROL). The combination of both the power makes the vehicle dynamic in nature over conventional automobiles. Hybrid electric vehicles combine an electric motor, battery and power system with an internal combustion engine to achieve better fuel economy and reduce toxic emissions. Equipment and their cost analysis are done. It deals with the fabrication of the vehicle. The final stage would consist of increasing the efficiency of the vehicle in economic ways.

Key words: Hybrid vehicle, heat flux, CFD, ANSYS

I. INTRODUCTION

Around 93% of today's automobiles run on petroleum based product, which are estimated to be depleted by 2050. Moreover, current automobiles utilize only 25% of the energy released from petroleum and rest is wasted into the atmosphere. For preservation of gasoline for future and increasing the efficiency of vehicle an electric vehicle can be a major breakthrough. An electric vehicle is pollution free and is efficient at low speed conditions mainly in high traffic areas. But battery charging is time consuming. Gasoline engine proves its efficiency at higher speeds in high ways and waste a lot of energy in urban areas. A hybrid vehicle solves these problems by combining the advantages of both the systems and uses both the power sources at their efficient conditions. The objective of this project aims at better utilization of fuel energy and reduces dependence on non-renewable resources using latest technology. The implementation involves development of HEV that uses battery as well as gasoline power for propulsion of vehicle.

A 'gasoline-electric hybrid vehicle' is an automobile which relies not only on gasoline but also on electric power source. In HEV, the battery alone provides power for low-speed driving conditions. During long highways or hill climbing, the gasoline engine drives the vehicle solely. Hybrid electric vehicles comprise of an electric motor, inverter, battery as electric drive and an internal combustion engine with transmission connected as gasoline based drive. It has great advantages over the previously used gasoline engine that is driven solely from gasoline. This hybrid combination makes the vehicle dynamic in nature and provides its owner a better fuel economy and lesser environmental impact over conventional automobile.

HEVs have been vehicles of numerous advantages. Hybrids do indeed get superior gas mileage. They use less gasoline, and therefore emit less greenhouse gas. Thus the problem of environmental pollution can be avoided to certain extent. Apart from that they use less gasoline in comparison to the other vehicles of same power that run only on gasoline. Thus this reduces the extreme dependence on gasoline which is a non-renewable source of energy. This encourages the method of sustainable development that has been the topic of concern in the modern society.

Moreover, HEVs mode of operation are maximum efficient to the conditions, i.e at low speed and high traffic areas where gasoline engine is least efficient with a lot of energy wasted, HEV moves with power from battery. At up slopes where high power is required and battery is inefficient, gasoline power is used for vehicle motion. Thus the advantages of HEV make it superior than any other vehicle of today.

II. ENGINE MODELING

The work discloses a hybrid system consisting of an Electric and Internal Combustion(IC) based power drives. The front wheel is being propelled by battery and the rear wheel is powered by gasoline, i.e, it includes a single cylinder, air cooled internal combustion engine and a BLDC motor based electric power drive used for hybrid powering of the vehicle. The controller is designed to implement the switching between IC Engine and Electric motor depending on the power requirement and load conditions.

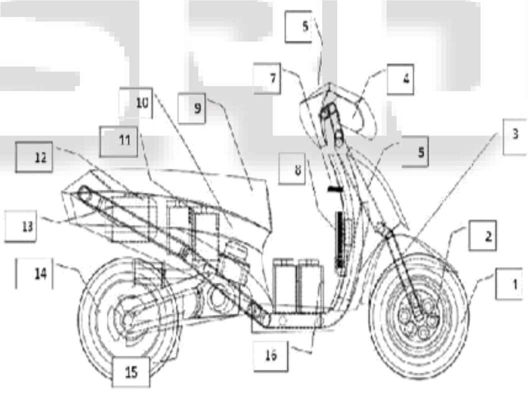

Fig. 1: Hybrid scooter parts

1)Tyre 2)Hub Motor 3)Suspension 4)Headlamp 5) Body Cover 6)Display 7)Microcontroller 8) Hub Motor Controller 9)Seat 10)Engine 11)Front Battery 12)Fuel Tank 13)Chassis 14)RearTyre 15)Transmission 16)Rear Battery

The vehicle at lower speed act as front wheel drive and at high speed gets switched to rear wheel drive automatically. Component 1 in Fig 7 shows the attachment of tyre with the hub motor (2). There is no need for any gear reduction since the torque produced is sufficient enough to drive the vehicle. The axel of the motor is connected to the suspension (3). Suspension is connected to the handle which is connected to the main chassis. Accessories such as headlamp (4), display (6) are included as user aid. A microcontroller (7) powered up from battery, performs the switching from electric to internal combustion or vice versa as per the requirement. It senses throttle position and controls the hub motor speed via controller circuit and the IC Engine via servo motor to control speed of rear wheel.

Due to space constraints, two batteries (16) are placed in front and two are placed near the fuel tank. Engine (10) is connected to the main chassis and seat (9) is situated above the engine. CVT is connected to the crank shaft of the engine to avoid any shocks while switching and it makes the controlling simpler and easier.

In HEV, the battery alone provides power for low-speed driving conditions where internal combustion engines are least efficient. In accelerating, passing, or hill climbing where high power is required battery provides power to electric motor as an additional power to assist the engine. This allows a smaller, more efficient engine to be used.

A throttle position sensor (TPS) is a sensor used to monitor the position of the throttle in an internal combustion engine. It consists of a hall sensor. When the accelerator throttle angle changes magnetic field is created and it creates voltage across position sensor terminal. Thus for various angles, various voltages are obtained.

Rotational Angle (Degree ^{o})		Signal Voltage (V)
2	Under Travel	0.000
10		0.450
13	Closed Throttle	0.901
20		1.440
30		1.900
40		2.370
50		2.840
60		3.310
70		3.780
80		4.240

Table 1: Throttle Position Sensor

HEV consists of a throttle position sensor, i.e, hall sensor. It gives voltage as output with respect to the angle displacement in the accelerator. The analog voltage generated is converted to digital through ADC and is given to microcontroller. If the speed corresponding to the angle deviation in accelerator is less than 30km/hr then the relay is switched on. The relay switching completes the circuit of the battery, inverter and hub motor; and vehicle is motioned by electric power. If the speed directed by accelerator is greater than 30km/hr, then the engine is started by closing the circuit of starting motor through a relay. The starting motor circuit is activated for five hundred milliseconds such that the vehicle is started. Once the vehicle starts the valve of engine for gasoline intake opens by servo motor. The amount of opening is controlled by the PWM generated by the microcontroller as directed by the accelerator.

Fig. 2: Engine CAD Model

III. MATHEMATICAL MODELING

POWER (the rate of doing work) is dependent on torque and rpm. Torque and rpm are the measured quantities of engine output.

Power is calculated from torque and rpm, by the following equation:

HP = Torque x RPM ÷ 5252

An engine produces power by providing a rotating shaft which can exert a given amount of torque on a load at a given rpm.

TORQUE is defined as a force around a given point, applied at a radius from that point. Note that the unit of torque is one pound-foot, while the unit of work is one foot-pound.

POWER is the measure of how much work can be done in a specified time. In the example on the Work and Energy page, the guy pushing the car did 16,500 foot-pounds of work. If he did that work in two minutes, he would have produced 8250 foot-pounds per minute of power.(165 feet x 100 pounds ÷ 2 minutes).

In the same way that one ton is a large amount of weight (by definition, 2000 pounds), one horsepower is a large amount of power.

The definition of one horsepower is 33,000 foot-pounds per minute. The power which the guy produced by pushing his car across the lot.

(8250 foot-pounds-per-minute) equals ¼ horsepower (8,250 ÷ 33,000).

POWER = FORCE x DISTANCE ÷ TIME

Power = 100 pounds x distance per minute The distance it moves in one revolution:

DISTANCE per revolution = 2 x π x radius

DISTANCE per revolution. = 2 x 3.1416 x 1 ft = 6.283 ft.

Now we know how far the crank moves in one revolution.

DISTANCE per min. = 6.283 ft .per rev. x 2000 rev. per min. = 12,566 feet per minute

Now we know enough to calculate the power, defined as:

POWER=FORCE x DISTANCE ÷ TIME

Power = 100 lb x 12,566 ft. per minute

= 1,256,600 ft-lb per minute

= 453.5 x 3830.11

= 1736.95 KN/m

HP = (1,256,600 ÷ 33,000) = 38.1 HP.

TORQUE = FORCE x RADIUS.

If we divide both sides of that equation by RADIUS, we get:

(a) FORCE = TORQUE ÷ RADIUS Now, if

Distance per revolution = Radius x 2 x π, then

(b) Distance per minute = Radius x 2 x π x Rpm

We know

(c) Power = Force x Distance per minute

So if we plug the equivalent for Force from equation (a) and distance per minute from equation (b) into equation(c), we get:

POWER = (TORQUE ÷ RADIUS) x (RPM x RADIUS x 2 x π)

Dividing both sides by 33,000 to find Hp,

Hp = Torque ÷ Radius x Rpm x Radius x 2 x π ÷ 33,000 By reducing, we get

Hp = Torque x Rpm x 6.28 ÷ 33,000

Since

33,000 ÷ 6.2832 = 5252 Therefore

Hp = Torque x Rpm ÷ 5252

Note that at 5252 Rpm, torque and Hp are equal. At any Rpm below 5252, the value of torque is greater than the value of Hp;

Above 5252 RPM, the value of torque is less than the value of Hp.

A. *Torque Calculation:*

Example: How much Torque is required to produce 300 Hp at 2700 Rpm
since Hp = Torque x Rpm ÷ 5252
then by rearranging the equation:
Torque = Hp x 5252 ÷ Rpm
Answer: Torque = 300 x 5252 ÷ 2700 = 584 lb-ft.
= 742.988 N-m

1) Note:
(N-m =0.73775621 lb-ft 1 N =0.2248089 lb
1 ft = 0.30480 m)

B. *Motor Selection:*

1) Calculation of Total Resistance:

The first stage of the design process involved in measuring the total force requirement of two wheeler is mentioned below.

Formula for Calculating total Resistance is,

- F res = F aero + F roll + F la + F grad (N)
- F aero = Cd . A .ϐ . V2 . 0.5 (N)
- F roll = m . g . Crr (N)
- F la = m . a (N)
- F rad = m. g . sin (θ) (N)
- F aero is the aerodynamic force required.
- F roll is the rolling resistance required.
- F la is acceleration force required.
- F grad is gradient resistance required.
- F res is Total resistance required.

sin (θ) = F tr - (F aero + F roll + F la) / mg
V = √ (F tr - F roll) / 0.5 Cd . A
F tr = F aero + F roll + F la
F tr is Tractive force required: 30
Based on above calculation: Tractive Force Ftr = 123.09N.

2) Calculation of Motor Power Requirements:

Wheel Radius r =0.35 is selected on based on vehicle manual. Final Drive Ratio (Fixed Gear Ratio)
G=1
N wheel = 303.2 Rpm
N motor = N wheel * G = 303.2 Rpm
Torque at Wheel = Tractive force * wheel radius = 123.09* 0.35= 43.08 Nm Motor Power = 485.84 W

IV. Results and Discussions

During combustion of gasoline, high temperature gases are generated which increase the temperature of the cylinder head. A long, conductive radiating fins are casted with the cylinder head to remove the heat from the interior to the environment.. The simulation is colour coded which depicts that red colour shows higher temperature and blue colour shows the region of lower temperature. Fig. 3(b) shows the heat flux distribution in a cylinder head. Fig 4 shows the stress analysis of the chassis. The bluish portions experience less stress and the reddish portions have more stress.

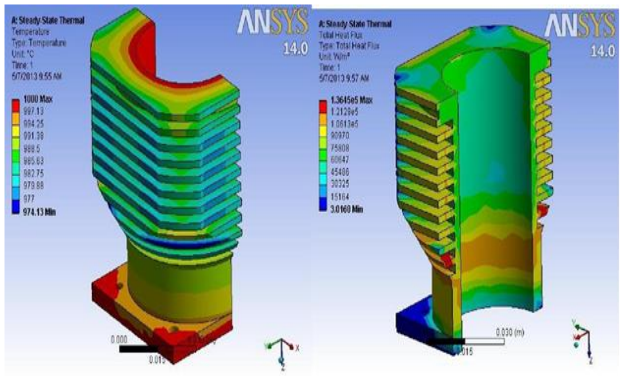

Fig. 3(a): Temperature Distribution of Cylinder Head, 3(b) Heat flux distribution

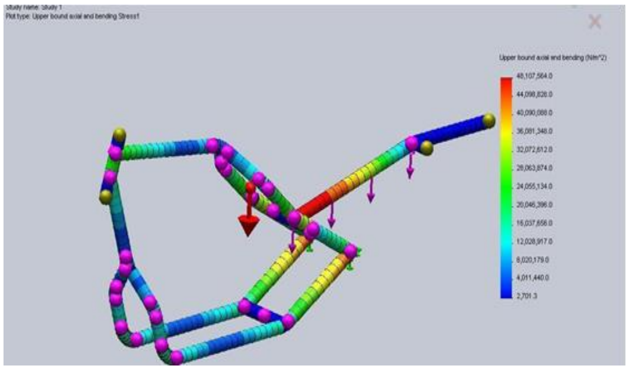

Fig. 4: Stress analysis of chassis

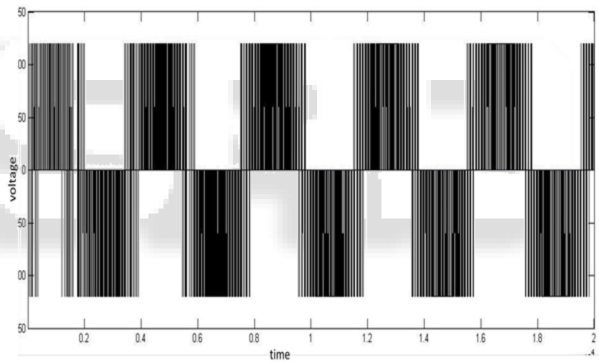

Fig. 5: Output of inverter circuit

The chassis portion with red in colour is to be made with proper care. Fig 5 shows the inverter output of the electric vehicle. The square wave produced is fed to the BLDC motor for maximum efficiency. Fig 6 shows the variation of torque, speed, output voltage and armature current with time of the electric drive

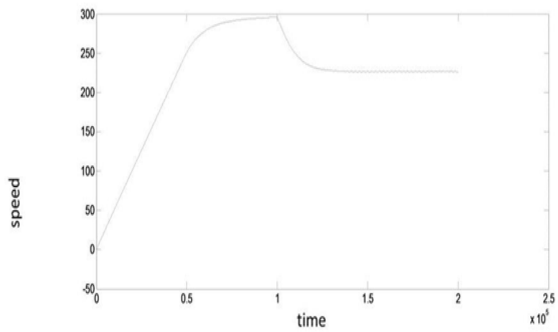

Fig. 6: Speed of BLDC motor at no load

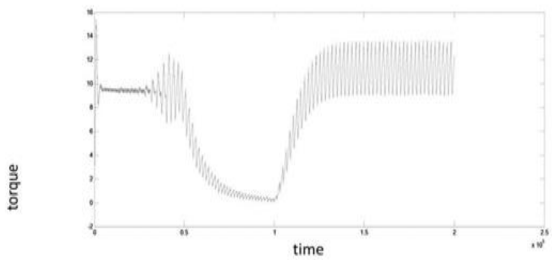

Fig. 7: Output torque of BLDC motor at no load

Fig. 8: Real time model of two wheeler HEV

A. *Dimension and Specification of Two Wheeler*

1) *Brakes*

Front Drum brake 110 mm dia

Rear Drum brakes 130 mm dia

2) *Dimension*

Overall height 1060mm

Overall length 1685mm

Overall Width 1220 mm

Wheelbase 120 mm

Kerb weight 79.5 kg

Fuel Tank Capacity 3.5 Litres

3) *Engine*

Type Air Cooled

Stroke (2/4) 2 Stroke

No. of cylinders Single Cylinder

Bore x stroke 42.6 mm x 42 mm

Displacement 59.9cc

Electrical 12 v, 5 Ah

4) *Performance*

Maximum Power 3.5 bhp @ 5500 rpm

Max. Torque 4.5 Nm @ 5000 rpm

Start Kick, Electric start

5) *Suspension*

Front Telescopic Suspensions at front

Rear Helical spring and Hydraulic damper

6) *Transmission*

No. of Gears Auto gear V-aromatic drive

Clutch Centrifugally operated radial clutch

V. CONCLUSIONS

HEV is a vehicle that uses two sources of power- gasoline and battery. For low power application battery drive is used whereas for high power application where power requirement is very high gasoline engine is used. Gasoline drive is most efficient at high speed drive. Thus HEV's both mode of operation occurs at their maximum efficiency. But in gasoline engine low speed operation is not efficient. Its high speed mode is only efficient. Therefore, it gives twice the mileage given by a normal vehicle. As this hybrid vehicle emits 50% less emission than normal vehicle it plays an important role for reducing pollution to certain extent without compromising with efficiency. Thus it is most efficient in urban areas mainly in high traffic where gasoline engines are least efficient as the energy from gasoline is being wasted away and creates pollution.

The current society mostly depends on petroleum as the major source power for vehicle propulsion. The electric vehicle is not very efficient for all power conditions, i.e, it cannot provide power for high speed conditions. Through the project a hybrid method of both the vehicles is proposed which utilizes the efficiency of both the vehicles. This method is implemented in two-wheeled vehicles that are mostly preferred by public. Thus proper manufacturing and cost analysis can make the vehicle a major breakthrough.

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