Fabrication and Performance Analysis of Two Wheeler Hybrid Vehicle

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ABSTRACT: The percentage of pollutants in the air from vehicular emission has increased manifold as market constitute of more fossil fuel powered vehicles than new green technology, due to less high speed capabilities. Hence to overcome drawbacks of both drives we have fabricated and analysed the hybrid system to gain high efficiency of the drive. In this project electric drive is given to front wheel where as the IC engine powers the rear wheel. Thus the project prototype can drive on dual supply of fuel. As the IC is least efficient at low speed (traffic condition), electric mounted on front wheel is utilised. The electric drive is not only silently but also low heat dissipation compared to petrol powered two-wheeler. The electric can't carry heavy load or travel a long distance, at such a times IC is used as driving source. Since, the hybrid works on dual mode of fuel supply it can cover greater distance than regular gasoline or electric drive vehicle. Hybrid can also be used as purely gasoline vehicle by detaching batteries or as pure electric by turning of the engine. Further concentrated efforts are mainly towards implementing a concept called as Electric-Electric hybrid system by which one system will be charged while the other system provides propulsive power to the vehicle.

KEYWORDS: Two Wheeler Hybrid Vehicle, Electric-Gasoline Scooters, Low carbon emissions, Cost Efficient.

I. INTRODUCTION

These days one of the major problems faced by our country is the increased demand and high prices of fuel with the increase in number of vehicles on the road. Air pollution is of serious concern in many Asian countries, especially in densely-populated countries like India where majority of the people use two wheelers as the means of their transportation.

Internal combustion engines are relatively less efficient in converting the on-board fuel energy to propulsion as most of the energy is wasted as heat. On the other hand, electric motors are efficient in converting the stored energy in driving a vehicle, and electric drive vehicles do not consume power while coasting. Typically petrol engines effectively use only 15% of its fuel content to move the vehicle. Whereas an electric drive vehicle has an on-board efficiency of about 80%. But due to reasons such as cost, inability to reach higher speeds electric drive vehicles failed to capture markets. Contrary to this petrol vehicles can cover longer distances with higher speed but it cannot cover shorter distance with slow speed (say in traffic) in an efficient way.

Objectives:
i. To reduce running cost of vehicle
ii. To reduce the emissions
iii. To overcome the draw backs of electric vehicle
iv. To increase life period and efficiency of existing gasoline vehicle
v. Use of renewable energy for gasoline vehicle

II. RELATED WORK

Following are the research paper related to the project:
Paper No. 1:
Internal combustion engine are less efficient in converting fossil fuel energy into useful power for driving the engine unlike electric vehicles. In electric vehicles propulsion is good. Most of the energy is used for propulsion and also the energy wasted in braking can be captured and reused for braking- regenerative braking. The efficiency of petrol engine is about 15% but on board efficiency of electric scooter or any vehicles is 80% but due to low speed and cost these

failed to capture the market. They used plug-in hybrid vehicle with rechargeable batteries with a hub motor and electronic speed controller. [1]

Paper No.2:
This paper introduces the main concept of battery charging and discharging of an electric car with an intelligent charging system. With the intelligent charger, the bottlenecks in the distribution system can be minimized. The charging system has also an option to discharge the batteries and provide backup power in the case of a distribution network failure. With the intelligent charging and discharging, the effects of electric cars on the distribution network and investments related to them can be essentially minimized. An intelligent charging system can be made for minimizing the effects. Electric cars can even be used as small scale backup power. However, for discharging applications the cycle life of the electric cars batteries must increase to become affordable. Also the efficiency of the charging and discharging cycle should be as high as possible for load controlling and electricity market applications to make them beneficial. [4]

Paper No.3:
In this paper, an analytical and experimental comparison of two different drives for the propulsion of light e-scooters is performed. Both are permanent magnet synchronous outer rotor motor drives but one placed inside the rear wheel and the other connected to the wheel trough a mechanical transmission. From this analysis can be conclude that the efficiency and mass is clearly favourable to the mid-term drive but this drive requires a mechanical transmission with a gear ratio of 4:1 in order to obtain the same torque capability than the in-wheel motor, although in addition provides the same advantages of manoeuvrability of a conventional scooter equipped with internal combustion engine. Anyway both alternatives could be a good option depending on the e-scooter design assumptions. [5]

III. METHODOLOGY

The hybrid technology is the combination of petrol and electrical system. The already existing technology of electric system for two wheeler is one in which the only source of energy is rechargeable batteries, which are externally charged with the help of a charger, which is connected to the 230V AC. As the batteries are fully charged, the power goes to the electronic controller through an MCB and a switch. Further this power goes to PMBL (Permanent Magnet Brushless) motor which starts rotating and finally the two-wheeler will run as shown in Fig.1. This scooter while operating on IC engine will give power to the rear wheel by consuming fuel (petrol).
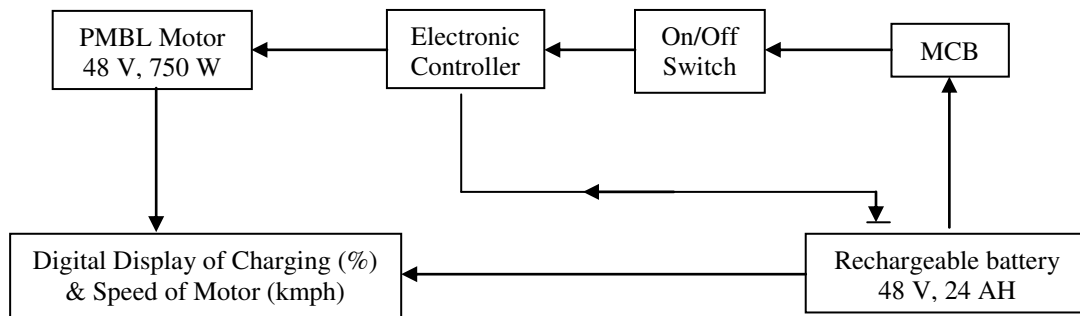

Fig. 1: Block diagram of already existing electric system in two-wheelers
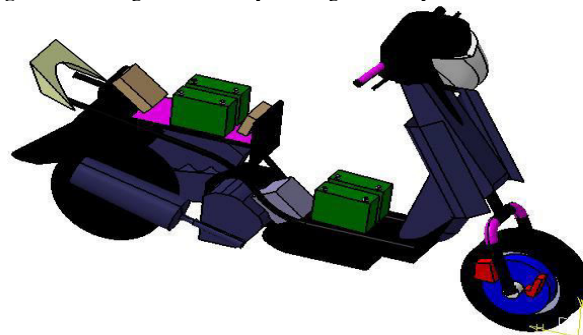

Fig. 2: CAD representation of actual prototype

The Fig. 2 represent CAD model of actual prototype showing batteries in green colour, hub motor in blue colour, controller and MCB in flaw colour and pink colour indicates the fabrication part.

Components:

1. Hub motor:

Hub motors are an interesting development which could offer benefits such as compactness, noiseless operation and high efficiency for electric vehicles. These motors have stators fixed at the axle, with the permanent magnet rotor embedded in the wheel. [1] Electric motors have their greatest torque at start-up, making them ideal for vehicles as they need the most torque at start-up too.

Fig. 3: Hub motor wheel

2. Battery:

Battery is like a fuel tank for the electric system and requires refilling by the means of charging. The Lead acid battery is the power source to the electric drive. While most of the electric vehicles are choosing Lead acid battery a variety of other alternative batteries can also be used. Sealed lead acid batteries have a good energy density and power density ratio. It has about 80% of charge/discharge efficiency. [2]

Lead acid based are chosen for the following reasons:

  i. High power
 ii. Energy density
iii. Durable [1]

(a)   **(b)**

Fig. 4: Battery position in hybrid two-wheeler prototype, (a) Batteries in boot & (b) Batteries on foot space

Fig. 4 shows the location of battery in proposed prototype:

Bajaj Kristal has very large volume of boot and enough space on foot to mount batteries. So in following cases battery can be mounted on vehicle,

i. Case 1: Both batteries in boot

Pay load of boot is 15 kg where as weight of batteries is 28 kg so it increases the load on IC engine reducing efficiency and increasing vibrations of vehicle.

ii. Case 2: Both batteries on foot

Weight of batteries exert extra load on electric drive and hence reduce in drive efficiency.

iii. Case 3: Two batteries on foot and two in boot

The load of batteries gets distributed and doesn't make any harm to chasse of bike. Hence, we preferred 'Case 3' for uniform weight distribution of load.

3. Controller:

The controller varies the speed and torque of the motor. The controller connects the power source-fuel cell or battery to the actual motor. It controls speed and direction, and optimises energy conversion. While batteries produce fairly constant voltages which decrease as they are used up, the voltage output by fuel cells varies as a function of power. It has extended fault detection and protection. Monitoring battery voltage, it will stop driving if battery voltage is too high. It will cut back then stop driving if voltage is going too low. It has built-in current loop and over current protection. The controller has thermal enhanced rugged aluminium housing. For thermal protection current is cut back on low temperature and high temperature to protect battery and controller from being damaged.
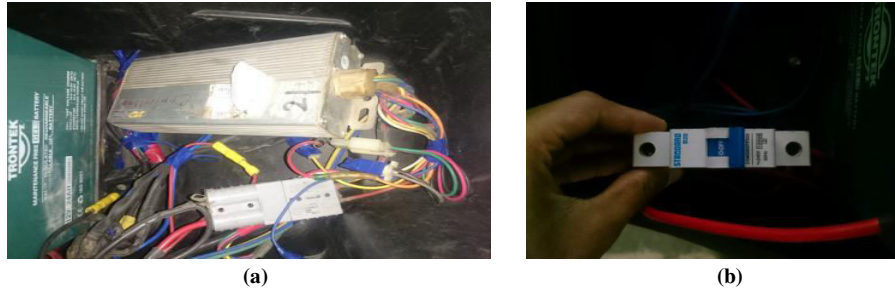
(a)   (b)

Fig. 5: Controlling units, (a) Controller and (b) MCB Switch

IV.   SPECIFICATION

Table 1: IC Engine

Specifications		Justification
SI Engine		
Stroke	4-stroke	4 stroke engines have better efficiency and this engine commercially cheaper than other engines.
No of Cylinders	Single Cylinder	
Displacement	100c	
Cooling	Air Cooled	
Fuel Supply	Carburettor	
Power Train		
Transmission	Variomatic (CVT)	Its automation is much simpler than geared transmission.
Availability	Comes with engine	

Table 2: Hub Motor

Specifications		Justification
BLDC Hub Motor		
Operating Voltage	48Volts	High efficiency and better load carrying capability.
Power	750 watts	
Max Current	24 amps	
Battery		
Voltage	48volts	High discharge capability
Capacity	24Ah	

These are specifications of IC engine vehicle (shown in Table No.1) and of hub motor (shown in Table No.2) used in project prototype.

V.   FABRICATION

The following Table No. 3 shows components that are fabricated in work shop and some which are directly used as standard components for project prototype.

Table 3: Fabrication of components

Component	Percentage Manufactured (Company made)	Percentage Fabricated in workshop
Engine	100%	-
Transmission	100%	-
Chassis	100%	-

Hub motor	100%	-
Suspension	50%	50%
Tyre	100%	-
Motor Controller	0%	100%
Power Control System	0%	100%
Assembly of components	0%	100%
Analysis System	0%	100%

VI. EXPERIMENTAL RESULTS

The results were plotted during experimentation of prototype which is being tabulated in following tables. Table No.4 represents speed of project prototype on electric drive with slope inclination of 15˚. Table No.5 represents speed of project prototype on gasoline drive with slope inclination of 15˚. Table No.6 represents the mileage of project prototype on gasoline drive.

Table 4: Top speed of project prototype on electric drive

Reading No.	On inclination less than 15 degree in kmph	On inclination more than 15 degree (varied slope) in kmph
1	30	19
2	31	9
3	30	7
4	30	15
5	30	14
6	32	14
Mean	**30**	**12.8**

Table 5: Top speed of project prototype on gasoline drive

Reading No.	On inclination less than 15 degree in kmph	On inclination more than 15 degree (varied slope) in kmph
1	70	45
2	68	40
3	65	47
4	68	46
5	62	40
6	65	42
Mean	66.3	43.3

Table 6: Mileage of project prototype on gasoline drive

Reading No.	Fuel economy in litre per km
1	37
2	38
3	40

4	41
5	40
6	40
Mean	39.66 ≈ 40

Range of electric drive = 32 km
Charge time of electric drive = 3 - 4 hour approx

Fuel	Gasoline drive	Electric Drive	Combine
Running cost/km	Rs 1.7	Rs 0.47	Rs 1.08-1.12

VII.   PAYBACK CALCULATION

Cost of Petrol = 68kmpl
Cost per km on petrol = Rs 1.7
Mileage of IC moped = 40kmpl
Range of selected battery = 32 km
Cost per km on electricity = Rs 0.473
Cost for making project prototype=Rs45420

The payback calculation has been shown in following tables.
The case 1 represents the running cost of project prototype on electric drive and IC engine separately and difference between both the drives has been calculated for per day basis as well as for per month & per year. Following data has been shown in Table No. 7.

Case 1: Comparison between running cost of IC engine and electric drive for distance of 32 km

Table 7: Payback Calculation

Parameters	IC engine, ₹	Electric drive, ₹	Difference, ₹
Cost of travelling 32km per day	54.4	12.257	42.143
Cost of travelling per month	1632	367.71	1264.29
Cost of travelling per year	19584	4412.52	15171.48
Cost of travelling per 4 year	78336	17650.08	60685.92
Maintenance cost after four year on servicing	5000	10650	
	83336	28300	55036

The case 2 represents the running cost of project prototype on electric drive(75%) and IC engine(25%) for total travelling, which is calculated for per day basis as well as for per month & per year. Following data has been shown in Table No. 8.
Case 2: Comparison between travelling cost of combine and IC engine drives

Table 8: Payback Calculation for actual case

Parameters	IC + Battery, ₹ (25%IC and 75%battery)	IC engine, ₹
Cost of travelling 40kms per day per day	17+14.1=31.1	68
Cost of travelling per month	933	2040
Cost of travelling per year	11196	24480
Cost of travelling per 4 year	44784	97920
Maintenance cost after four year on servicing	10650+5000 =15650	5000
Total expense	60434	102920
Saving over IC power vehicle after 4 year	42486	0
Cost of travelling per 8 year	89568	195840
Maintenance cost after 8 year on servicing	2*15650 =31300	20000
Total expense	120868	215840
Saving over IC power vehicle after 8 year	94972	0

When the project prototype is used in combined cycle the payback period for the project is slightly more than 4 years.

VIII. CONCLUSION

The Hybrid vehicle (project prototype) uses two sources of power: gasoline and battery. Electric drive is mounted on front wheel whereas IC engine powers the rear wheel. The hybrid vehicle combines best of both the worlds, for low power application battery drive is used whereas for high power application where power requirement is very high gasoline engine is used. The hybrid vehicle emits low emission compared to regular gasoline vehicle and has high load carrying capacity than electric motor vehicle. It also accounts to be more efficient in terms of running cost over gasoline vehicle. The hybrid vehicle seems to overcome drawback of both gasoline as well as electric vehicle thus being promising mode of transport for future.

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