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Transmutation of Conventional Fuel Based Two wheeler Vehicles into Electric Vehicles

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Abstract

The preliminary intention of this study is to comprehensively understand converting a conventional vehicle into a fully electric vehicle. In today's technologically forward world of travelling, it is crucial for commuters to travel effectively and help maintain a sustainable environment. To accomplish this, the rider should travel as quickly and effectively as feasible. This study provides information on battery-powered electric scooters, including information on the controller, battery, hub motor and other components. Details on converting a scooter with an Internal Combustion (IC) engine into an Electric vehicle (EV) are provided in this work. This uses electricity as their main energy source. It also draws attention to the scooter's modifications. The battery can be charged by being ejected by the main system. ARAI AIS 039 (Rev 1): Electric Power Train Vehicles– Measurement of Electrical Energy Consumption is the standard used for testing the vehicle. When compared to a traditional vehicle, the scooter's electrical power can provide a longer range, higher performance and no emissions.

***Major Findings:** The experimental range of the vehicle under ARAI test conditions is found to be 15km. The experimental top speed of the vehicle under a total load of 150kg is 30kmph.*

Keywords: *Aerodynamic Drag, Battery, Hub Motor, IC Engine*

1.0 Introduction

The majority of automobiles rely on non-renewable energy sources. The primary fuels needed to operate an IC engine car are gasoline and diesel, but due to the quick depletion of crude oil supplies, frequent price increases, high levels of air and acoustic pollution and the necessity to build automobiles using alternative fuels by converting a gearless IC engine scooter into an electrical scooter and recycling obsolete cars, EVs (battery-operated) can

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solve a majority of these issues. This lowers the quantity of scrap created. Today, vehicles are widely used in daily life.

The operating cost of a fully electric vehicle is very much lower in comparison to a corresponding petrol or diesel vehicle. Conventional vehicles run with the help of fuels such as gasoline or diesel whereas electric vehicles make use of electricity to operate their batteries. Using more structured electric vehicles combined with the electricity cost implies that charging an electric vehicle is much cheaper than filling petrol or diesel for travel necessities. Electric Vehicles are more eco-friendly as they rely on renewable energy sources. The installation of renewable energy sources such as solar panels in localities can bring down the cost of electricity as its production depends on renewable energy sources.

As there are not many moving parts, the maintenance cost of EVs is lesser when compared to conventional fuel-based vehicles. The servicing requirement of an EV in comparison to a petrol or diesel vehicle is significantly low. Hence the yearly operating cost of an EV is very low.

The carbon footprint can be significantly brought down as an EV has a zero tailpipe emissions.

The availability of conventional fossil fuels is very limited, and their use is poisoning the atmosphere, our earth has turned poisonous for living. The poisonous emissions from diesel and petrol vehicles result in long-term, unfavourable effects on the health of people. The conventional petrol or diesel vehicle has more emission impact in comparison to the EV. From the point of efficiency, gasoline or diesel cars can transform 17%-21% of the energy stored in the conventional fuel to the wheels

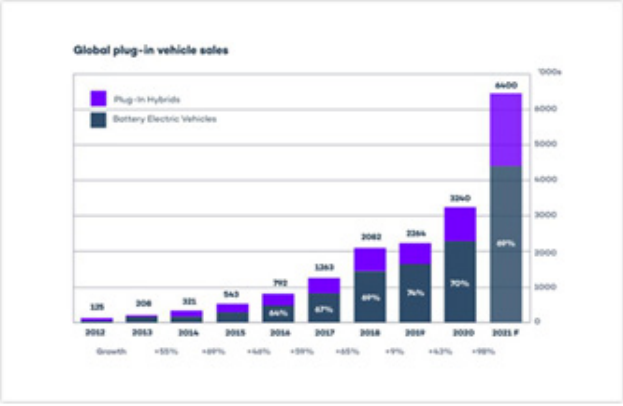


Figure 1. Global plug-in vehicle sales.

whereas an EV can transform about 60% of the electrical energy from the charging grid to power and move the wheels.

Metropolitan areas have more vehicles per square mile each day. The primary issue at hand is pollution, which is getting worse as a result of the rise in the number of cars running on gasoline and diesel. This influences human life. The present plans of the Arab countries to cut their crude oil production by as much as 40% are significantly raising fuel prices.

Organisation for Economic Cooperation and Development non-members (non-OECD) regions with particular focus may cause a world energy consumption increase of 28% between 2015 to 2040. Between 2015 to 2040, the improvement in world gross domestic product may increase by 3.0% whereas the North Sea Brent crude oil price would rise to 109 $/barrel[1].

For the past couple of years, there have been extensive efforts to develop Battery Electric Vehicles (BEV) to bring down the environmental issues caused by conventional fuel vehicles[2].

Recognising the benefit of using BEV, the penetration of alternate vehicle technologies has been slow but promising for the future market. The enhanced demand for BEV which fascinates many customers is due to increased transmission efficiency, zero emissions in the fuel tank to wheels, cost-effective maintenance and lesser operational cost[3].

The challenges of saving energy and and bringing down the pollution have prompted the automobile manufacturing players to work in that direction and improve the efficiency[4].

The automobile industry in India is the fourth largest in the world and is developing with a Compounded Annual Growth Rate (CAGR) of 7.01%, which accounts for 4.02 million units (excluding light motor vehicles) in 2018[5].

The researchers involved in developing electric vehicle technology feel that the hurdles involved in the large-scale implementations of EVs include insufficient charging facilities, lack of charging infrastructure and programming involved in the charging stations[6].

Governments around the world are extending substantial subsidies for the players in the EV sector to promote the sales of electric vehicles as the price of a Plug-In Hybrid Electric Vehicle (PHEV) and battery-

powered vehicle is considerably high in comparison to conventional vehicles[7].

There has been a decrease in conventional fuel consumption (around 2.5 mb/d) due to the increase in EV density which is much less profound. For every 100 million electric vehicles on the road, there has been a decrease of around 1.2-1.4 mb/d, million barrels per day[8].

To facilitate technological advancements, governments have initiated many policies to accomplish and mitigate climate change which has become a prime concern for countries and to limit the rise in global warming temperature to 1.5°C by reducing greenhouse gas emissions by 2050[9].

2.0 Methodology

i. Literature Survey: Going through different research articles helped generate various ideas and techniques to understand the concepts of EVs and how to convert existing vehicles into EVs.

ii. Selection of Vehicles: By looking at the parameters of EVs which determine the performance of the vehicle, this study came up with the idea of converting a lightweight easily operatable vehicle into an EV.

iii. Vehicle Dismantle: The vehicle was dismantled by taking the necessary steps and precautions. The vehicle engine, fuel container and related accessories were removed from the vehicle.

iv. Calculations for an E-Bike: After reviewing relevant studies, this investigation focuses on calculating the thrust force and torque required to draw a specific load, as well as motor speed and operational range.

v. Component Selection: Using the computations and findings as a guide, this work chose the Direct Current (DC) motor, motor controller and battery based on their capacities and operating ranges.

vi. Construction: By mounting the electrical hub motor immediately to the back wheel, this study can protect the battery from vibrations by placing it close to the vertical structure that supports it.

vii. Testing: Following a successful conversion of an existing vehicle into an electric vehicle, numerous tests were performed on the EV, including those that measure its speed in kilometres per hour, range (the distance it can go on a single charge) and carrying capacity.

viii. Testing Factors: Various important factors like vehicle speed, range and charging time were observed and recorded.

2.1 Major Components of the E-Scooter

2.1.1Wheel Hub Motor

Similar in many ways to the Brushless Direct Current (BLDC) motors used in Radio Controlled (RC) electric aeroplanes and quadcopters, they have an exterior shell that rotates and is lined with many concave magnets that are fastened inside. The shell can revolve around a stationary axle thanks to bearings. The motor has an inside component that is fastened to the axle and does not spin. Coils of wire facing the magnets are contained in this inner fixed portion. This coil configuration comprises three electrical phases, which work together to produce a rotating magnetic field.

2.1.2 Battery

The category of secondary batteries includes lead-acid batteries. Reversible chemical processes take place in secondary cells. The reactants that create an electric current in secondary batteries are used in the chemical process of discharging (forward reaction), which entails the removal of electricity from these cells (through chemical reactions). Regenerating active material is done through the charging process.

2.2 Formulas Used

2.2.1 Rolling Resistance

Rolling resistance is the resistance a vehicle comes across while rolling. The following equation provides the formula to estimate the force created due to rolling resistance: Froll = Crr * m* g.

Here, Crr = The Coefficient of Rolling Resistance. m = mass in kgs, g = acceleration due to gravity = 9.81 m/s^2

Then, Froll = C_{rr}*m*g = 0.005*160*9.81= 7.848 N.

2.2.2 Gradient Resistance:

Gradient resistors of a vehicle are the resistance that a vehicle comes across when ascending a hill, crossing the flyover or moving downhill. The below sketch shows the angle present between the slope of the path and the ground.

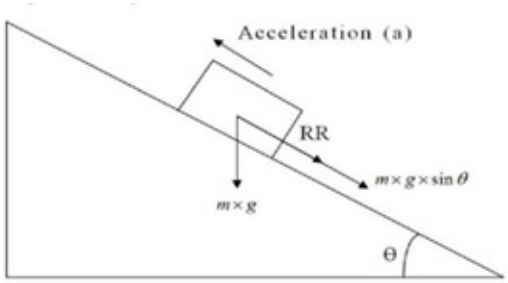


Figure 2. Gradient resistance.

The formulae to calculate the gradient resistance have been given by the equation,

Fgradient resistance = ±m * g * sin θ

Fgradient resistance = ±m*g*sinθ =160*9.81*sin2.5 = 68.464 N

2.2.3 Aerodynamic Drag

Aerodynamic drag is the resistive force provided by the viscous force pressing on the vehicle. The shape of the vehicle ascertains it in a straight line. The equation below gives the formula for calculating aerodynamic drag.

Table 1. Drag coefficient and frontal area for vehicles

Vehicle	C_D	A_f
Motorcycle with rider	0.5-0.7	0.7-0.9
Open convertible	0.5-0.7	1.7-0.9
Limousine	0.22-0.4	1.7-2.0
Coach	0.4-0.8	6-10
Truck without trailer	0.45-0.8	6.0-10.0
Truck with trailer	0.55-1.0	6.0-10.0
Articulated vehicle	0.5-0.9	6.0-10.0

$F_{aerodynamic\ drag} = 0.5 * C_D * Af * \rho * v^2$

Here, C_D = Coefficient of drag, A_f = Frontal area

ρ = Density of air in kg/m^3, v = velocity in m/s

2.3. Specifications of Components

Consider that the scooter has a frontal area of 0.9, it can travel with the highest speed of 35kmph (9.72222 m/s), the density of air is 1.1644 kg/m^3 at 300^0 Fahrenheit, the coefficient of drag is 0.5.

$F_{aerodynamic\ drag} = 0.5*0.5*0.7*1.1644* (9.72222)^2 = 19.2606$ N

Then, the force necessary for driving a scooter is,

$F_{total} = F_{gradient} + F_{aerodynamic\ drag} + F_{roll}$

= + 68.464+ 19.2606 +7.848

= 95.5726N

The power necessary for moving a vehicle is given by,

Power = Force *Velocity * (1000 ÷ 3600)

= 95.5726*35*(1000÷3600)

= 929.17805 W.

Here, Power is in Watts, Force in Newton, and Velocity in kmph.

Hence, the power necessary to move the scooter is 929.17805 W.

2.3.1 Hub Motor Calculation

1. Motor Capacity: Voltage, V = 48V= 960watts
2. Power Equation

Power (P) = Voltage(V)*Current(I)

Therefore, I = P ÷ V = 960÷ 48 = 20A.

3. Motor speed in rpm

N = K÷(d*0.001885) = 35÷(30.14*0.001885) = 616.04rpm

Here, N = Speed in rpm, d = Wheel diameter in cm, K = Speed in kmph

The diameter of the wheel (d) is 12in.

1inch = 2.54cm, so, d = 12inch = 30.14cm

35 kmph is the speed of the vehicle(given)

4. Torque of Motor (T)

T = (P*60)÷(2*pi*N)

= (960*60) ÷ (2*3.14*616.04)

= 14.8886 N-m

Wheel hub motor torque, T = 14.8886 Nm

2.3.2 Battery Calculation

80% of the battery charge must be in use and 20% should be remaining of the available full battery charge.

Battery W.hr= 960W.hr *1.20 = 1152W-hr

Therefore, Amperage (A-hr) in battery =1152W-hr ÷ 48V = 20A-hr.

2.3.3 Battery Charger Calculations

Charging time calculation-

Charger used – 12V 5Amps charger

Battery used – 12V 18A-hr =864Watt.hr

Charging time = Battery capacity / charger capacity = 18/5 = 3.6hrs for each battery.

3. Conversion Stages



Figure 2 (A). Stage 1.



Figure 2 (B). Stage 2.



Figure 2 (C). Stage 3.



Figure 2 (D). Stage 4.



Figure 2 (E). Stage 4.

3.0 Results and Discussions

3.1 Experimental Results

Table 2. Maximum speed of the vehicle when total travel distance is constant

	Test 1	Test 2	Test 3
Total Travel (km)	10	10	10
Total Weight(kg)	130	145	156
Max Speed(km/hr)	31	28	29



Figure 3 (A). Maximum speed of the vehicle when total travel distance is constant.

Table 3. Range of the vehicle when weight is constant.

	Test 1	Test 2	Test 3
Avg. Speed(km/hr)	15	20	24
Total Weight(kg)	130	130	130
Range(km)	15.3	13.7	12.6

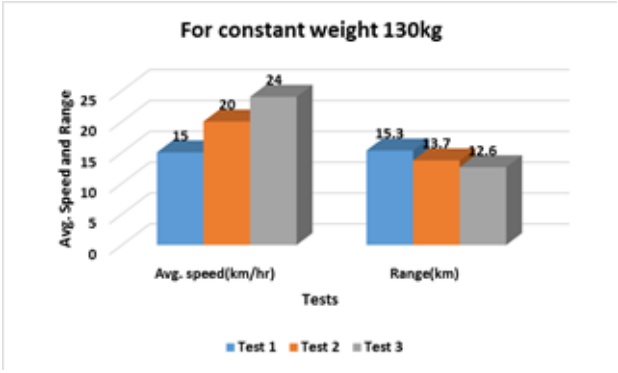


Figure 3 (B). Range of the vehicle when weight is constant.

Table 4. Range of the vehicle when speed is constant

	Test 1	Test 2	Test 3
Avg. speed(km/hr)	15	15	15
Total weight(kg)	130	145	156
Range(km)	15.3	12.4	11.2

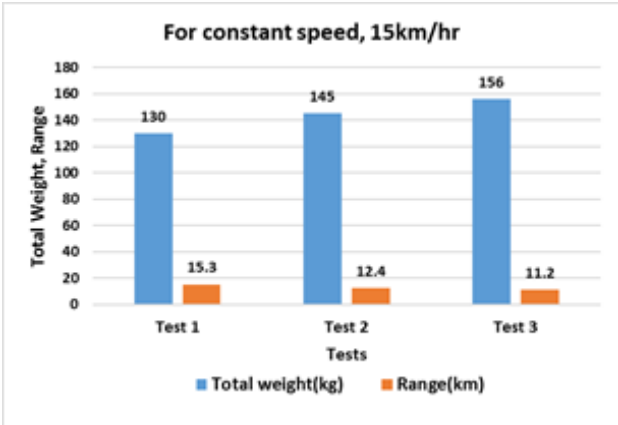


Figure 3 (C). Range of the vehicle when speed is constant.

- The experimental range of the vehicle under ARAI test conditions is found to be 15km.
- The experimental top speed of the vehicle under a total load of 150kg is 30kmph.
- This study hereby concludes that the objectives mentioned above are achieved under the required conditions (Note:- With the help of more energy-dense batteries, the range of electric vehicles can be increased.)
- Conversion of scrap vehicles helps us to reuse and it also makes the environment a greener and cleaner place as it does not emit any carbon dioxide.

4.0 Conclusions

- India has 34 lakh light vehicles older than 15 years and 51 lakh that are more than 20 years old. According to information from the Road Transport and Highways Ministry, 17 lakh medium and heavy commercial vehicles have been on the road for more than 15 years without a current fitness certificate.
- Considering these figures, this work can greatly expand the number of EVs running in India by assisting in the conversion of conventional vehicles to electric ones.
- Using high-energy density batteries, such as lithium-ion batteries, the present work can enhance the range and cycle needed for the electric vehicle. Lead acid batteries were used to convert a conventional vehicle into an electric vehicle.

5.0 Future Scope

- The range, as well as the top speed of the scooter, can be improved with the help of lithium-ion batteries
- Older IC engine scooters can be rectified into electrical scooters as done with this study, thus making them affordable to the masses and reducing scrap.

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