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CONVERSION OF CONVENTIONAL VEHICLE INTO AN ELECTRIC VEHICLE

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Abstract

At the mention of global warming, the first thing that comes to mind is an increasing number of vehicles in traffic, as well as exhaust gases these vehicles emit. To control the emission caused by gasoline vehicles, we aim to offer a cost effective and more environmental friendly way to travel. So, this project describes a modified procedure for a conversion of a specific IC engine vehicle into an electric powered vehicle. Our aim is to target a specific sector of Garbage collection vehicles where an electric motor can be more efficient than an Internal Combustion engine. The reason behind choosing this specific sector lies in observing the working of these vehicles, which mainly operates in lower gears leading to high amount of fuel burning and high emission of exhaust gases. Our project takes a step ahead to save resources and environment.

I. Introduction

At the mention of global warming, the first thing comes to mind is an increasing number of vehicles in traffic, as well as exhaust gases these vehicles emit. Analyses show that, from 1880-2012, average temperature on earth has increased by 0.85C [1], and it is prognosticated that by the end of

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21st century this will reach to 3.7C [2, 3]. EV's were invented in 1834, that is, about 60 years earlier than crude oil powered cars which were invented in 1895. As EV and HEV were more expensive than gasoline cars, produced less power compared to gasoline cars and also needed many hours to recharge the battery they faded away by 1930's.

An electric vehicle uses one or more electric motor or traction motor to provide momentum in a vehicle. EV's can be powered by a battery pack which is onboard. However, in hybrid electric vehicle (HEV) it is powered by converting fuel energy to electric energy which powers the motor. Transportation should provide user, freedom of mobility, sustainable mobility, economic growth of a country and prosperity for society. In order to achieve these, vehicle driven by electricity from clean secure and smart energy are essential.

The EV's comprises of basic components like motor, battery, controller, charger and drive train. Nowadays, technologies for motors like BLDC motor, Servo motors, Universal motors and AC induction motor are in use. OEM uses Lithium ion, Lead acid, Nickel Cadmium and Nickel Hydride for batteries.

We have two major problems first is of fuel because in garbage vehicles, consumption of fuel is almost doubled due to collection of garbage from door to door in a society which will result in running of vehicle in 1st and 2nd gears. The next problem arises from previous one i.e., driver effort, continuous operation of clutch pedal and shifting of gears results in driver fatigue. Due to this operation, wear and tear in a vehicle is increased which leads to high maintenance of vehicle as well as reduces life of vehicle.

To overcome this, we will convert an I.C engine vehicle to a more efficient electric vehicle. The process of conversion includes the replacement of existing parts like ICE, clutch assembly, transmission box, fuel tank and other components with motor, battery, controller and converters. As present conversion kits are expensive, we are trying to reduce this cost without any remarkable changes. One of the advantages includes the recycling of materials obtained from the replacement parts of the vehicle, which prevents wastage of those parts if scrapped.

Our motif comprises of targeting a sector of vehicles working in garbage collection. As we know that garbage collection vehicle requires a lot of fuel to work, just only to collect waste from societies which eventually results in generation of more pollutants in environment due to combustion of fuel. So, our main objective is to convert these high maintenance gasoline powered vehicles into an electric.

II. Research and Design

Research is on the basis of a conventional vehicle ACE HT, made by TATA. We have made our calculation on the basis of all standard values of given vehicle. [4] As our project mainly concerns converting a vehicle, we don't require any complex calculations as there are no major design changes in vehicle body constructions. Therefore the changes that we have to deal with are primarily required in the power train design.

We have thoroughly searched and analyzed all the aspects of conversion process from different research papers as well as books. Designing includes all the complexities of motor and differential calculations.

The cost of operating an electric vehicle can be directly compared to the equivalent operating costs of a diesel-powered vehicle. A litre of diesel contains about 10kWh of energy. Because automotive internal combustion engines are only about 20% efficient [5], then at most 20% of the total energy in that litre of diesel is used.

Now, let us consider a vehicle powered by an internal combustion engine at 20% efficiency and 5L/100km (20kmpl). To simply move the vehicle, it requires:

$$\left(10kWh * \frac{5l}{100km}\right) * 20\% \, eff = \frac{10kWh}{100km}.$$

At a cost of Rs. $75/L,$ the mileage of $5L/100\,\text{km}$ (20kmpl) equates to:

$$\frac{75Rs.}{L} * \frac{5l}{100km} = \frac{375Rs}{100km}.$$

An electric version of the same car with a charge/discharge efficiency of 75%.

The EV converts 75% of the chemical energy from the batteries to power the wheels. [6] Battery is charged at a cost of Rs.6 per kWh would cost:

$$\left(\frac{\frac{10kWh}{100km}}{75\%eff}\right) * \frac{6Rs.}{kWh} = \frac{80Rs.}{100km}.$$

This would equivalent to paying about Rs.16/L for diesel. The above calculations demonstrate that if we use electric energy as our fuel to drive a vehicle, we can save money as well as also save the environment in a significant way.

A. Motor Specifications

The motor which we have chosen for our conversion is 10KW (13H.P.), 4-pole 3 phase AC induction motor of 3000 rated R.P.M. Induction motor is very popular [7].

So, the required torque produced by motor at 3000 rpm (equivalent average vehicle speed of 34 kmph):

$$power = \frac{(2\pi NT)}{60} \tag{I}$$

Where, N = number of R.P.M,

T = torque (Nm)

Above equation results in torque = 33Nm, when motor is at 3000rpm.

Therefore, the torque required on road wheels for overcoming vehicle weight of around 1500kg will be calculated as,

By the given data of an engine, we know that maximum torque produced is 37.5Nm. So, it is 16 times in 1st gear that is 600Nm at road wheels.

Now, at 735 r.p.m of motor, we get 130Nm of torque.(deduced from Equation (i)) So, we are installing a differential of G.R. 1:5 which will result in 650Nm of torque at road wheels, equivalent vehicle speed of 8kmph which is required by vehicle for propulsion.

Table 1. Vehicle speed at different R.P.M.

R.P.M of Motor	735	3000	6000
Torque on motor (Nm)	130	33	16
Torque on wheels (Nm)*	650	165	80
Wheel Diameter (inches)	12	12	12
Vehicle Speed (kmph)	8.04	34.5	69

*Torque on wheels = Torque on motor/Gear ratio

Where, Gear ratio=1:5

B. Battery Specification

The battery is the main energy storage in the electric vehicle. The battery in-fact governs the success of electric vehicle. [8] According to motor of 96V, we must take 96 volt of battery pack which will draw 120 Ah of current so power of battery pack can be calculated by below method.

$$power = volt \times Ah. \quad \text{(ii)}$$

Therefore, power of battery pack will be equal to 11.5kwh.

The battery which we are going to use in this project is Lead-Acid, the reason behind choosing this is to make our conversion economical because Lithium-ion costs lacs of rupees, which can increase the budget of our conversion approx. two times. This battery pack will include 8 units of 12V 130 Ah of each battery, by connecting these 8 units in series combination, we get 96V of required battery pack. This is the basic method to calculate the power but it will be varied by some changes like addition of various components in the vehicle, which will result in increasing the power of the battery pack.

Table 2. Technical specification of each battery.

Nominal voltage (V)	12V
Capacity (Ah)	130Ah
Weight (kg)	35Kg
Dimensions (mm)	505×182×257

120 Ah of current will be consumed by motor to drive at its average rated speed. This amount of current is required by the vehicle to run at its average speed i.e. of 34 kmph.

C. Controller and its assembly parts

The controller which we are going to use for a 3-phase AC induction motor drive is Volts per Hertz control in closed-loop (V/HzCL). It is based on Freescale's 56F800/E microcontrollers, which are ideal for motor control applications. The system is designed as a motor control system for driving medium-power, 3-phase AC induction motors. [9]

Features of the controller:

1. Easy installation and automatic fault detection.

2. Smooth driving experience, powerful start.

3. Accurate response for acceleration,

4. Large torque for excellent ability in climbing.

5. Regenerative braking system to save energy.

6. Stable and reliable performance, and maximum protection design.

Accelerator pedal: The input from driver is reached to the controller by the help of this device. The measure of capacity to move is passed on to the controller by a potentiometer that is coupled to the accelerator pedal. Full force implies that the accelerator pedal is being pushed all way down by the driver, and the battery must convey greatest force through the controller to the motor to keep up the speed.

Programmer: This is an optional part for controller. It assists driver to alter specific parameters such as rise-up rate, maximum speed, base voltage (to adapt it to the voltage of battery system) and so forth. Via the programmer, you can also monitor operational status of motor control system by checking the following parameters for example:

- Error signs (flashed by LED light on the controller)
- Temperature of the motor
- Pedal accelerator status
- Motor speed
- Battery voltage
- Forward or reverse status

DC-DC converter: is used to lower the voltage of battery pack to 12V, in order to match suitable voltage requirement for specific components of an electric car such as headlights, dashboard, etc.

Dashboard: It indicates the speed of the vehicle by the help of speedometer. It also shows the battery percentage, battery temperature, motor speed, and other necessary information.

Charger: Due, to this the onboard battery is recharged when needed. It can take the electricity from main grid to charge the battery.

III. Implementation

As described in the figure 1 the proposed conversion procedure includes disassembling of parts like engine, clutch and clutch pedal, gearbox and its mechanism, fuel tank, exhaust system, radiator, catalytic converter, and tailpipe.

The above parts are replaced with Induction motor that is going to be coupled with propeller shaft with help of Universal joint and further the propeller shaft will transfer the power to road wheels through differential. Motor is also connected indirectly with accelerator pedal with the help of potentiometer which will transmit the signal to controller and then to the motor.

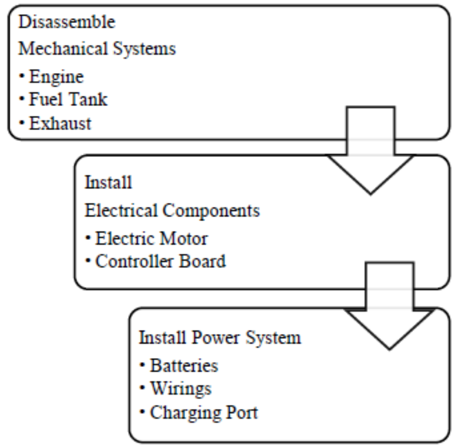

Figure 1. Conversion procedure as proposed.

To power motor a suitable battery pack is placed in the car. Battery is customized with the help of cells joined together in series Motor and battery both are connected with a series of controller and electronic system that controls the power given to the motor for varying speeds. The controller aims to deliver the power as obtained by the driver's input which can be zero when the car is stopped, full power when the accelerator pedal is pushed all way down, or any amount between. The fuel indicator is replaced with panel which indicates state of charge of battery.

The above procedure is listed in sequential ways to successfully perform a conversion.

IV. Results

We have successfully converted an IC engine vehicle into an electric vehicle (theoretically) and proved that it is more efficient from the existing vehicle. This conversion not only helps us saving environment but also save the non-renewable resources. It takes tedious time to build a new vehicle from scratch, our project aim for converting a pre-existing vehicle and saving time and labor. It will also result into reduce the driver effort because in conventional vehicle the driver tends to continuously operate the clutch pedal, gear and accelerator for collection of garbage from door to door, which leads in reduction of fuel efficiency and high maintenance of the vehicle.

Electrically driven vehicles have many advantages and challenges. Electricity is more efficient than the combustion of a fuel in a car. Studies show that EV's cost around 1Rs/km as compared to gasoline cars which cost around 4Rs/km for a compact car. Electricity can be generated through renewable sources such as hydroelectric, wind, bio mass and solar. EV's are cheaper to maintain because it has less moving parts for transmission of power than a conventional cars, there is relatively little servicing and no expensive exhaust system, starter motor, fuel injection system, radiator and many other parts that aren't needed in EV. EV's are helping to reduce harmful air pollution from exhaust emission and EV has a negligible exhaust emission.

V. Conclusion

The report describes that electric powered vehicle has number of advantages and benefits over the internal combustion engine. It is cleaner and much more efficient. This paper presents an efficient way for conversion of a conventional Internal Combustion Engine vehicle into an Electric Vehicle. This conversion will save the IC engine vehicles from going to scrap when the world oil resources gets completely depleted and also it saves the environment from toxic emissions by automobiles and prevent global warming. Government has to pay a lot of money for fuel just to collect garbage from society so this project will help in saving economy of the country, which can be used for other purposes. The EV's future is promising.

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