Performance Assessment of Electrically Converted Diesel Fuel Driven Commercial Vehicle

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Abstract. An electric vehicle has an alternative drive that uses electric motors and controllers to replace traditional internal combustion engines. Power comes from a battery or battery cell, not a carbon-based fuel. This not only saves money, but also has a low environmental impact. It also has a number of advantages over traditional internal combustion engines, particularly in terms of considerably reduced pollutants and increased energy efficiency. There are several impediments to the quick adoption of electric vehicles, including battery technical constraints, high purchasing costs, and a lack of charging infrastructure. In this conversion we can save and control the emission and pollution. In this work, a diesel fuel driven 909 CC commercial vehicle has been converted into the electric vehicle (EV) with suitable modifications in their power train. Then, the performance of the EV was analysed and it was found satisfactory. In this way, an attempt was made to retrofit the commercial diesel vehicle to work in electric power. The mileage of the EV was measured as 110 km per charge for the 25% load and 80 km per charge for the full load condition.

Keywords: electric vehicle; retrofit; BLDC; BMS; electric conversion.

1. Introduction

Oil prices are rising on a daily basis, owing to the widespread belief that oil will be depleted within the next 50 years. During the same time span, the total number of automobiles is predicted to rise from 700 million to 2.5 billion [1, 2]. Alternative solutions are required and are already being proposed. Electric vehicles, as proposed by major manufacturers, represent a shift in the urban mobility paradigm. Furthermore, a number of organization and energy experts are proposing new regulations to boost EV research, development, and demonstration projects [3, 4]. When it comes to EV research, there is a tendency to associate it with new and revolutionary automobiles. Low-cost solutions based on trustworthy off-the-shelf components, on the other hand, can be proposed [5, 6].

In terms of technology, this is a difficult procedure that necessitates knowledge of mechanics and electronics. The key systems that must be integrated are the electric motor and controller, an energy storage system, and a charging system. Various energy storage system options are being offered; however, batteries are the most commonly used. As a result, a battery charging mechanism is also required. Static power converters have traditionally been used in battery charging systems [7, 8]. Various topologies can be employed. Different charging algorithms must be utilized in order to respect
battery technology [9]. Batteries charging systems can also be utilized to convert EVs into energy storage vehicles.

When employing electric vehicles, the vehicle's expenditures can be decreased. It can be made as cheaply as possible. The public finds it difficult to operate internal combustion engine automobiles as a result of the impact of rising fuel prices [10, 11]. The era of electric vehicles will be the automobile's future. As a result, existing internal combustion engines cannot be dismantled [12, 13]. The pollution released by automobiles is steadily increasing, accounting for almost 73 percent of overall pollution related to the use of IC engines. The cost of newly developed electric motorcycles is greater. The biggest advantage of electric vehicles is that they reduce emissions. Electric vehicles utilize big battery packs for energy, which are more expensive [14, 15]. They employ lithium-ion batteries, which can cost thousands of dollars. Obviously, everyone is searching for ways to reduce the cost of electric vehicles. One option is to convert vehicle equipped with an internal combustion engine (ICE) in a new electric vehicle [16, 17]. There are various kits on the market that can be used to perform this conversion, but these kits are more expensive.

In the present work, the retrofitting was planned to convert a conventional diesel engine driven vehicle into the electric vehicle (EV). The performance of the EV was assessed and analyzed.

2. Methodology

Design calculation for EV

Modelling of EV

Component selection for EV

Converting IC Engine vehicle to EV

Testing of EV

Power optimization

Real time usage

Figure 1. Work flow during the conversion of conventional vehicle to EV.

Because the future is in the hands of electric vehicles, existing IC engine vehicles cannot be entirely dismantled if we are to transition to electric vehicles, as outlined in the problem identification stage. The conversion of IC engine drive to electric cars was devised based on the problem identification and literature review. The calculations were then performed in order to determine the necessary components. Following the manufacture of our vehicle with the proposed design, the vehicle's performance, efficiency, speed, and load carrying capability will be examined. Figure 1 shows the methodology of converting diesel vehicle to EV.
3. Drive system of Electric Vehicle (EV)

Electric vehicles are a challenge because they change over time. As a result, controllers must be robust and adaptable to enhance the dynamic and robust performance of the system. Range per battery charge is currently a key factor limiting widespread adoption of electric vehicles [18, 19].

As a result, the vehicle performance is monitoring, careful attention must be made to the battery's energy management. The improved performance of electric BLDC motor in motion control is a distinguishing feature of electric cars. Torque generation is extremely rapid and precise, enabling for considerably faster and more precise control of electric BLDC motor [20, 21]. The torque supply is simple to comprehend, and the motor may be tiny enough to be attached to each wheel. Controllers are also simple to design and install at a low cost.

There are several types of electric vehicle motors including DC motors, induction motors, brushless DC motors, permanent magnet synchronous motors, and switched reluctance motors. Here we use a brushless DC motor.

Brushless dc (BLDC) motors are synchronous electric motors that are powered by direct current energy (DC) and have an electronically controlled commutation mechanism rather than a mechanical modulation system based on brushes. The electromagnets of a BLDC motor do not move; instead, permanent magnets spin while the armature stays stationary static. An electrical three-phase square wave controller drives the motor. The motor features four connections: red, blue, and yellow coloured three-phase inputs, as well as a hall sensor output. The Brushless DC controllers are linked towards the hall sensor and also the 3-phase inputs of the motor [22, 23]. The BLDC controller activates the stator winding, and each phase is driven by the PWM signal, and stator is formed by the electromagnetic winding in the stator.

While BLDC motors are mechanically simple, they do necessitate complex control electronics and regulated power supplies. As a result, a drive controller is picked to control the BLDC motor. The controller chosen for the project must be compatible with both the battery and motor parameters. The present system used a 6kW BLDC motor. In this work, the motor capacity was chosen based on the payload of the vehicle.

4. Energy storage system of Electric Vehicle (EV)

The BLDC motor is powered mostly by the battery. The batteries to be utilised is chosen depending on the vehicle's operational characteristics; a lithium ion is chosen. When comparing to lead acid batteries, lithium ion batteries are lighter in weight and have higher energy density, lower self-discharge, and require less maintenance. As a result, the efficient battery necessary for running the motor is to be employed [24]. The battery should be quick to charge, efficient, and long lasting. The weight of the batteries and its energy output for rpm are important factors to consider. It just takes a short time to charge, which is one of the factors that led to the selection of this battery.

BMS also referred to as a battery management system. A battery system is made up of many battery packs. They are linked in parallel or series, depending on the design. Each unit must be supervised and controlled. As parts of the conditioning process, voltage, current, and temperature are all regulated. Measured parameters are used as decision parameters in order to govern and safeguard the system. Typically, two parameters are supplied. There are two kinds of states: state - of - charge (SoC) and health status (SoH). The SoC functions similarly to the oil tank metre in that it indicates the battery's state of charge [25]. Cell balancing forces all cells to work under same conditions, or it uses balanced control to charge and discharge each cell. This keeps a specific cell from getting overwhelmed.

Whether slow or fast charging, the charger required for a battery system must be able to handle high power. H-bridge power converters must be used. Converters are known for their efficiency and have been used in chargers and DC converters.

Energy storage is achieved utilizing several capacitors or in conjunction with the other power storage batteries, even in ultra-capacitor systems. Lithium Ferro-phosphate battery was used,
considering its efficiency and cost. For air conditioning, the same monitoring and control methods are equipped.

5. EV conversion process
The conversion technique is shown. All of the engine, muffler, exhaust pipe, silencer, and fuel tank were removed. Despite the removal of the clutch component, the original manual transmission was left intact, ignoring the fact that its clutch was no necessary. A new electric BLDC motor was attached to the transmission using an adapter plate. An electronic controller was fitted to regulate the motor. The controller is responsible for transferring batteries to the motor. The pedal is linked to a potentiometer, which transmits a signal to control indicating how much power to apply [26, 27, 28]. When the vehicle comes to a complete stop, the controller can provide low gain, maximum capacity when the pedal is completely pushed, or anywhere in between. The vehicle is equipped with a battery box that houses numerous lithium-ion battery packs. A vacuum pump was used to run the power brake and a heating element was fitted. A charger that can charge a battery and charger adaptor fitted. The photograph of vehicle during the conversion is given in Figure 2.

![Vehicle photographs (a) Before EV conversion (b) After EV conversion.](image)

6. Discussion on the performance
The EV vehicle was tested for the distance travelled per charge for different loading conditions. The range of travel varied according to the payload of the vehicle. The maximum mileage was achieved at the 25% load condition which was 110 km per charge as shown in Figure 3. The mileage dropped based on the payload and the minimum mileage was recorded for the full load condition which was 80 km per charge.
7. Conclusion
This study presented a transition from conventional internal combustion engine vehicles to electric vehicles. The primary change was accompanied by interchanging the 909 cc diesel engine with the BLDC motor of 6 kW capacity. This conversion will rescue internal combustion vehicles from being scrapped when the world's oil resources are depleted, as well as saving the environment from poisonous emissions from automobiles and preventing global warming. The maximum mileage of the converted EV was noted as 110 km per charge at the 25% load and 80 km per charge for the full load condition.

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