Construction of an Electric Vehicle Implemented in Egypt

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Abstract

The design and manufacture of electric vehicles is becoming important with the rising cost of petrol, and the effect of emissions from petrol powered vehicles on our environment. Operating a battery electric vehicle will eliminate emissions inside our cities and reduce our dependence on oil. The number of electric vehicles on the roads is increasing every year as people become more environmentally conscious and gasoline prices are volatile.
This study produces a design and construction a battery electric vehicle, and describes the process of constructing and testing of an electric vehicle.
This design comprises many steps from choosing the vehicle design, sizing a motor, and the type of batteries used. Finally, a set of experimental results which showing the performance of the designed electric vehicle under certain conditions were conducted.

Key Words: electric vehicle, performance, experimental work, lead-acid battery and DC electric motor.

1. Introduction

The first demonstration electric vehicles were made in the 1830s, and commercial electric vehicles were available by the end of the 19th century. At the start of the 20th century electric vehicles must have looked a strong contender for future road transport [1] due to the environmental and economical issues which provide a compelling impetus to develop clean, efficient, and suitable vehicles for urban transportation [2]. In recent years, a significant interest in hybrid electric vehicle (HEV) and battery electric vehicle (BEV) has arisen globally due to the pressing environmental concerns and increasing price of oil. These vehicles which have an energy storage devices and electric drives allow the improving of fuel economy and reducing pollutants [3]. The design and manufacture of electric vehicles (EV) is becoming increasingly important with the rising cost of petrol, and the effects emissions from petrol powered vehicles on our environment [4]. Electric vehicles have improved their performance and made suitable for commercial and domestic use during the last decades [5]. Electric vehicles are sometimes referred to as “zero-emission vehicles” because they produce essentially no pollution from the tailpipe or through fuel evaporation. This is important, for it means that the use of electric vehicles could greatly reduce emissions of carbon monoxide and smog-forming pollutants in cities with dirty air [6].

2. Assignment

The task is to design, build and construct an electric vehicle. The performance of this electric vehicle and its construction has to be evaluated to be suitable for general uses. The final goal is an optimal power management of the electric vehicle, such that its velocity and acceleration is similar with that of conventional vehicles. Thus the choice of the components is part of the assignment. The main components of an electric vehicle are the motor and the batteries, but peripheral equipments such as brakes and sensors are essential for a safe vehicle too. Before the motor and batteries can be selected, the necessary vehicle power, torque and energy have to be determined.

3. Electric Vehicle Design Methodologies

The design and construction of an electric vehicle needs to a great effort and incorporate of many factors. The following looks into the components and systems that make up a battery electric vehicle. The structure and design of an electric vehicle begins with four main design stages, where these stages are the chassis, the mechanical components, the electrical system, and the body. All these components and systems in the battery electric vehicle are designed to be integrated, and many components depend on the design of others.

4. Battery Electric Vehicle Components and Systems

4.1 Experimental work (Setup)

The chassis forms the main structure of the vehicle. A large number of designs in pressed-steel frame form a skeleton on which the engine, wheels, axle assemblies, transmission, steering mechanism, brakes, and suspension members are mounted. During the manufacturing process the body is flexibly bolted to the chassis. This combination of the body and frame performs a variety of functions. It absorbs the reactions from the movements of the engine and axle, receives the reaction forces of the wheels in acceleration and braking, absorbs aerodynamic wind forces and road shocks through the suspension, and absorbs the major energy of impact in the event of an accident. There has been a gradual shift in modern small vehicle designs. There has been a trend toward combining the chassis frame and the body into a single structural element. In this grouping, the steel body shell is reinforced with braces that make it rigid enough to resist the forces that are applied to it [7]. In the present work, the vehicle body and chassis was designed with a specific features and dimensions according to the popular standard vehicle designs, taking in consideration durability and strength of the vehicle chassis and frame which qualify the parts to withstand the road vibrations and shocks coming from the road during the motion conditions of the vehicle, therefore, the selection of the material used must be durable, and posses a high strength to endure the stresses which the vehicle subjected to it during all operating conditions. Therefore, steel 37 with box-section has been the most convenient choice for the required material selection. The dimensions of the selected steel have been chosen to be suitable for the forces and stresses affecting both the structure and chassis. So that the material used for the frame with dimensions of 4cm * 4cm box-section with 1.8mm thickness, and for the chassis, the dimensions are 4cm * 4cm box-section too with thickness of 2.2mm. All these are very convenient to withstand and resist all loads and stresses acting the vehicle during the operating conditions. Also, the aerodynamics in the outer shape of the vehicle during the design and construction was taken in consideration to reduce the air resistance affecting the vehicle during the motion; especially the vehicle was designed to reach at least a maximum speed of 70 km/h.
Finally, the frame and chassis were assembled by bolting and welding, according to the nature of the parts that will be assembled.

4.2 Profile of the designed electric vehicle

The figure below showing an isometric and sectional view for a suggested shape and frame of our electric vehicle, which the design was executed by using 3D engineering design program (Autodesk Inventor Professional 2008).

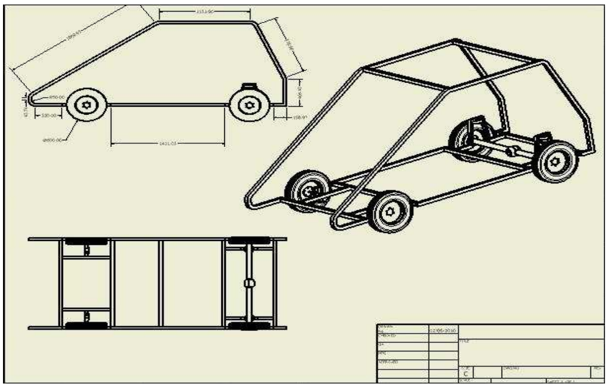

Figure (1) isometric and sectional view for designed EV.

The following figures show the stages of the construction and assembly for the frame and chassis of the executed battery electric vehicle.

Figure (2) the assembly of frame and chassis for the electric vehicle (side view).

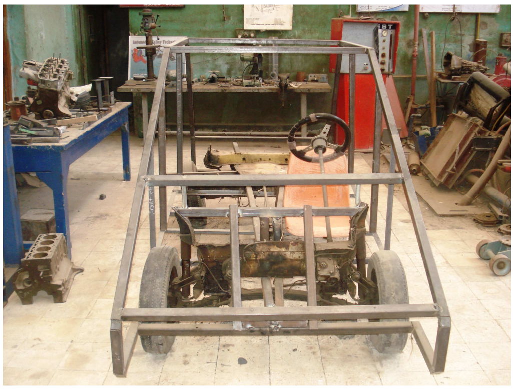

Figure (3) the assembly of frame and chassis for the electric vehicle (frontal view).

Figure (4) the final shape of the executed battery electric vehicle.

4.3 Suspension, steering and braking systems

The suspension, steering and braking system of an electric vehicle is one of key mechanical components. So those, the front, rear axles and transmission line are reused as well as steering and braking systems components from a conventional vehicle.

5. Electrical components

5.1 Electric Motor

The electric motor is the main component of an EV. It is very important to select proper type of motor with suitable rating. [8]. Electric motors are very efficient, up to around 95% instead of around 25% for a petrol engine, there are various types available, induction and direct current (DC) are the two families of electric motors typically used in electric vehicles each having their advantages and disadvantages [9]. These motors come in all different sizes and can provide wide range of horsepower and torque for any design needed. DC motors are more common and the cost of comparable power motors makes them more attractive than induction motors. Choosing a motor will depend on the design consideration such as weight, aerodynamics, vehicle speed, etc. therefore choosing the series DC motor 15 HP, 3200 RPM, and 72 Volt input was more reliable and suitable. The DC motor weight about 75 kg, about 30 cm diameter and is nearly 60 cm long. Motor dimensions and weight make it suitable for the design to be implemented, and the figure below shows the electric motor and its accessories.

Figure (5) shows the electric motor and its accessories.

For taking the movement from the electric motor, a specific flange with splined shaft has been manufactured; the flywheel then coupled with the flange by means of bolting, and the figure below shows the assembly of flange with flywheel.

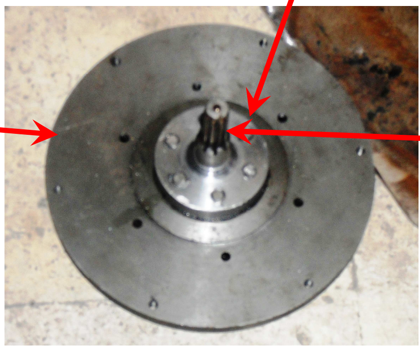

Figure (6) shows the assembly of flange with flywheel.

A clutch disc is mounted to the flywheel as it was in the original vehicle and is set inside the bell housing of the transmission.

Figure (7) shows the assembly of electric motor and the clutch set.

Figure (8) shows the assembly of electric motor with the transmission system.
Rubber pads are placed beneath every mount to isolate some of the vibrations. A brace was added to help supporting the electric motor. The figure below showing the electric motor used in our vehicle and how it connected and assembled with the transmission parts.

Figure (9) shows the mounting of the electric motor.

5.2 Batteries

A basic requirement for electric vehicles (EVs) is a portable source of electrical energy, which is converted to mechanical energy in the electric motor for vehicle propulsion [2]. Batteries typically account for one third or more of vehicle weight and one fourth or more of the life-cycle cost of an electric vehicle. Major improvements in batteries are expected because, until recently, little effort has been put into designing and building batteries of the size needed for vehicles. Many research efforts are under way to develop and commercialize advanced batteries. There are several options for batteries depending on the designing considerations. Many hybrids and electric vehicles uses nickel metal hydride to store energy for electric drive, which have a large energy density. But the disadvantage of this type of batteries is they are very expensive. Lithium ion batteries have similar benefits but are still just as expensive [8]. For the present designed and constructed electric vehicle, we found that the available and suitable type of batteries is the US 8VGC XC deep cycle lead acid batteries for the 8V 170 amp hours (AH). The energy of the battery pack is found by multiplying the number of batteries by the volts of each battery and by the estimated amp hours. According to the calculations, we were able to fit eight batteries in our vehicle. This would give a battery pack of 10.88 kWhr. We have them configured in two rows of eight series connected batteries creating a battery pack of 64V and 170 AH.
The figures below show the specifications of the selected battery and the set of batteries used for our design and how they connect together respectively.

Figure (10) shows the batteries arrangement within a special box.

5.3 Contactor

Contactors are used to switch high currents remotely by means of a low-level control voltage. In (EVs) high voltages, inductive loads, and extremely high current loads are encountered. To switch a current under these conditions requires specifically designed equipments. Contactors have continuous duty coils, silver-cadmium-oxide contacts to prevent welding, and magnetic blowouts, which extinguish electrical arcing. There are many types of contactors such as main contactors, single/double pole contactors, and reversing contactors. The main contactor is an easy way to manually isolate the power train components from the battery pack in an emergency, during charging, or while working on the car. The figure below shows the contactors and how the contactors connect with the other component of the electrical connections respectively.

Figure (11) shows the contactors used within the electrical connections.

Figure (11) shows how the main contactor connected with the auxiliary contactors and the electric motor where the current flows from the battery to the electric motor through the contactors and cables displayed in the figure.

6. Safety

Electric vehicles (EVs) must meet the same safety standards as conventional vehicles. In some instances, research shows that electric vehicles (EVs) can be safer than gasoline-powered vehicles. Electric vehicles (EVs) usually have lower centers of gravity, making them less likely to roll over in an accident. The danger of fire in a collision is also substantially reduced because electric vehicles (EVs) do not have a gas tank or reservoir of engine lubricating oil. As with conventional vehicles, however, electric vehicle batteries contain toxic elements that raise battery production, transport, use, and disposal safety issues [10]. Safety was the first concern during obtaining the introduced vehicle. So we are taking into account all the precautions to provide safety factors, which are represented in the durability in the welding and assembly operations and the use of appropriate materials in all stages of manufacturing and construction. In addition, a secure of all electrical wiring and isolate all points of contact to secure the use of the vehicle.

7. Social goals

The work presented will provide great features to the community. The first of these features is to reduce pollution from the vehicles powered by traditional fuel, which cause the production of the harmful pollutants that affects the human health and all the

surrounding of him. But the electric vehicles create no emissions whatsoever, so are infinitely cleaner and better for the environment than traditional vehicles.
The second feature is the financial costs, where the electric vehicles financial costs are almost twice less than conventional vehicles. Moreover, in certain cities, electric vehicles have discounted or free parking and highway fees, as well as tax breaks on the purchase price, and this to increase the spread of the use of such modern technology.
Finally, using electric vehicles can definitely influence your lifestyle, which reduces your more trips to the gas station. In addition, you'll charge your vehicle batteries at home by plugging it in the electricity every night with a charging time of 4–8 hours, and its limited range of 120 km. Then the electric vehicle can satisfy most of the needs of the average urban commuter.

8. Evaluation of EV performance

The implemented electric vehicle (EV) was tested to check its performance using a certain procedures; the aims of these tests were to describe the evaluation of the power and energy consumed by the electric vehicle under different modes of operations,
The tests allow plotting the variations of the volt, current, power, and energy consumed by the vehicle during the operation modes. The most interesting results are the power and energy consumed by the vehicle.

9. Conclusion

Development and construction of the first electric vehicle implemented in Minia city is presented. The vehicle used a high specific power DC electric motor, high performance power supplies (lead-acid deep cycle batteries). The vehicle has two seats and can accommodate to two passengers, and has a good performance during its operating tests. All tests presented showed excellent results regarding system behavior and efficiency. The research provides great features to the community. The first feature is reducing pollution of the vehicles powered by traditional fuel, which cause the production of the harmful pollutants that affects the human health and his surrounding. The second feature is the financial costs, where the electric vehicles financial costs are almost twice less than conventional vehicles. Moreover, in certain cities, electric vehicles have discounted or free parking and highway fees, as well as tax breaks on the purchase price, and this to increase the spread of the use of such modern technology.

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