SELF-CHARGING CAPABILITY OF ELECTRIC TRUCKS WITH ITS OWN PROPULSION SYSTEM

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Abstract: *Automobile industries are in supreme search of electric trucks comparing to present fuel trucks due to its eco-friendly properties, trouble-free maintenance, and low conservation of energy. This paper focuses on the concept of constructing and analysing of a self-charging arrangement in an electric truck. As the self-charging method uses its own rotational energy of wheels to charge the battery, by this arrangement one can increase the range and efficiency of the vehicle as well as can cover more distance. This review paper discloses that the BLDC motor can spring-out high torque, an alternator can positively generate 12v–14v by means of the rotational energy created by the wheels under action, and the given voltage can be step-up by DC-DC converter to 56v which is sufficient to charge the second set of batteries (Lithium Ion batteries) which stores high energy, and can produce 60% of energy back. Thus, the electric truck can become more efficient, be charged while the vehicle is in motion. And equally, the distance travelled with charging system is also more than the distance travelled without charging system.*

Keywords: Electric trucks, Self-charging, Lithium Ion Batteries, BLDC motor, Alternator, DC-DC convertor

1. Introduction

A truck which is propelled using batteries is known as electric truck, which is used to deliver goods and services. As Don Ake (vice president of commercial vehicles at FTR Transportation Intelligence) said, Electric trucks are slowly gaining momentum and it would be a competitive option for upcoming 5 years. Electric trucks reduce and overcome the environmental pollution, compared to diesel engine trucks. With its high efficiency and low component-counts the maintenance rate and environmental pollution can be reduced dramatically.

Nowadays the electric truck replaced the internal combustion engines because of its most useful parameters and zero emission of deadly gases like CO_2, CO, NO, hydrocarbons and SO_2 into the atmosphere. Electric motors are more compact and smaller in size when compared to normal combustion engine, electric motors have higher torque and the minimum rotational speed, due to less components in electric vehicle it does not require much maintenance or there components are less compared to fuel vehicles, not require much maintenance or replacement of filters and operating fluids, The electric motor has a ability of large changes in rotational speed in a short time, and has the capability of applying regenerative braking[1].

According to the 21st century, EVs have seen a upturn due to technological developments, and its mainly focused on renewable energy and reducing effect on climate change and all other environmental issues[2]. Nowadays electric truck production is mainly focused towards entirely remove the usage of fuel engine and use the In-wheel motor system. By using that we can increase the performance and strength of the motor and dramatically reduce the size and mass of the motor [3].

The main defect of an electric truck is to recharge a battery after certain part of time. A new technique was described by Faisal H. Khan is from the capacitor clamped dc-dc convertor the isolated dc voltage is obtained. There are various key features on the multilevel modular capacitor clamped converter (MMCCC), which is feasible to produce an AC outputs (10 KHz) from dc-dc converter circuit [4]. This method will improve the range of the vehicle by recharging the battery of the vehicle with its own propulsion system. This self-charging system used to reduce the toxic gases present in the atmosphere, and also the operating cost of electric vehicle will be reduced by more than half the fuel consuming vehicle.

A battery powered vehicle is a vehicle which use battery to transport goods and services from one location to another location is called as an electric vehicle. In the early 20th century the main aim of automobile industry to produce electric vehicles with more economical, eco-friendly, more energy, noiseless with self-charging system which could not be given by fuel vehicles [5]. Therefore, by this method we can overcome the main drawback of which the electric truck needs to be charged again after certain period of time by implementing this arrangement the electric vehicle can be charged itself by its own propulsion system and store the self -generated energy to increase the range and efficiency of the truck.

2. Materials Used

2.1 Brushless DC Motor

Brushless DC electric motor (BLDC motor or BL motor) is a motor which use an electric servo motor and eliminate the brushes and commutator. This type of motors is also known as synchronous DC motor, which uses a direct current (DC) power supply.

Fig-1. BLDC MOTOR

In Brushless DC motor, a mechanical commutator was replaced by the electronic servo system [6]. Most probably the BLDC Motor and PMSM Motor are almost similar. BLDC motors have features like high starting torque, low friction and also it can produce high efficiency around 95-98%, etc. BLDC motors are suitable for high power density design approach. Most probably The BLDC motors are the most preferred motors for the electric vehicle application due to its traction characteristics.

2.2 Alternator

An electric generator which develop electrical energy from mechanical energy is known as alternator. For basis of cost and simplicity, a rotating magnetic field with stationary armature was used by most alternators. An alternator is used as a diode rectifier to convert the current from AC to DC.

Fig-2. ALTERNATOR

Alternators produce the power for the electrical systems of modern electric vehicles. Earlier, Dynamos were used instead. But after the growth of the alternator, they replaced DC dynamos since alternators are stronger and more lightweight. Since the electrical system of motor vehicles requires DC current and not an AC current.

2.3 Lithium Ion Battery

A lithium-ion battery or Li-ion battery is a type of rechargeable battery. Lithium-ion batteries are currently used in most of the electric vehicles, because of their high energy per unit mass relative to other electrical energy storage systems. In lithium ion battery Instead of metallic lithium an intercalated lithium compound used as its electrode. It has many uses like low weight, high energy efficiency, good high-temperature performance, and low self-discharge and also most components of lithium-ion batteries can be recycled.

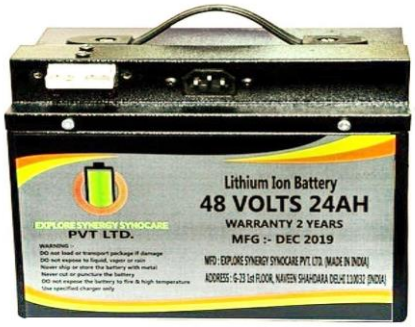

Fig-3. LITHIUM ION BATTERY

According to the current scenario electric vehicles (EV) and plug-in hybrid electric vehicles (PHEV) lithium-ion batteries to store energy. The only drawback is the lithium ion battery is cost but many research and development are going on to reduce the cost and increase the efficiency of the battery.

2.4 Motor Controller

A device or group of devices used to control an electric motor is known as motor controller, which is used to start or stop the motor, regulating the speed, controlling the torque power, controlling the forward and reverse rotations of the motor and protecting the motor from electrical faults and overload by manual or automatic process. Motor controllers regulates the speed and direction of the motor.

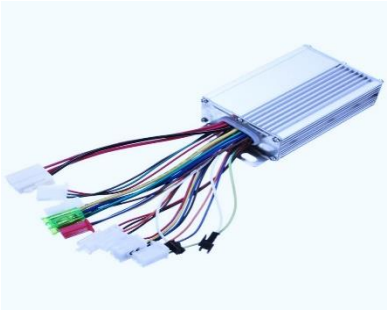

Fig-4. MOTOR CONTROLLER

Motor controllers can be used in both DC current and AC current motors. A Motor controller not only control the motor but also it detects the over-current in motor or wiring, low voltage and high temperature. Small motors have assembled with overload devices to automatically cutdown the circuit on overload. Larger motors will be having a protective overload relay or temperature sensing relay included in the motor controller and fuses or circuit breakers will be used in over current protection.

2.5 DC to DC Converter

A DC-to-DC converter is an electronic circuit used to converts a produced direct current (DC) from one voltage level to another. The convertor will temporarily store the given input energy and then transmit the voltage to the output at different level. The storage can be either electric compound (capacitors) or magnetic compound (inductors, transformers). The voltage will be increased or decreased during this conversion. DC to DC converters are used to supply a constant voltage over time and to switch the voltage on or off in a predictable manner.

Fig-5. DC TO DC CONVERTOR

The power created by DC-to-DC converters will be moved in only one direction, from allotted input to output. Even so, by replacing all diodes with separately controlled active rectification, we can able to achieve the bidirectional converter which helps the power to move either direction. It is valuable for many applications like regenerative braking system of an electric vehicles.

3. Working and Operation

In operation, the BLDC motor is operated using the first set of batteries connected in an order which supply 48v. Then by using the chain drive system, the motor has been connected to sprocket in rear axle to propel the vehicle and drive train system takes place. As soon as the vehicle begins to move, the 2 pulleys which logged to the rear axle and connected to the alternator through the spindle starts to spin with the help of belt. Then the magnetic flux and current will be induced as a voltage directed towards the dc-dc converters which is connected with 2 alternators to steps up and allows the voltage to charge second set of four batteries connected in set. A sum of 24volts will be used to charge the second battery set with the power produced using alternator. When first set of battery gets observed, second set of battery gets charged with the produced voltage. As a result, the first set of battery works as a main battery when second set being charged and this operation will make the vehicle being self-charged with its own propulsion system as shown in the (figure 6).

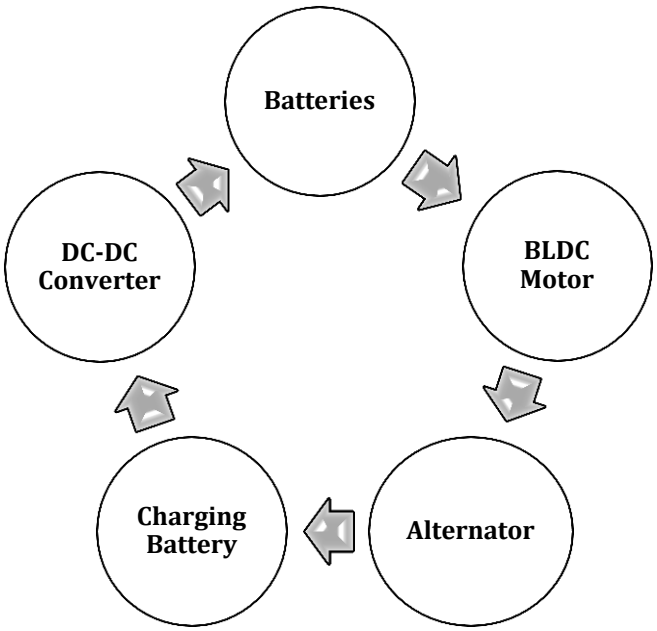

Fig-6. Working cycle

4. Principles and Methods

According to the Faraday's Law, the constructed vehicle stores its own energy and works on the principle that an electromotive force (EMF) generated when a conductor moving relative to a magnetic field. This EMF moves under the magnetic poles of opposite polarity to reverse its polarity. Generally, a rotating magnet inside the motor is known as rotor

surrounded with a stationary part of conductors wounded with coils, called the stator. The second set of battery is charged by the generated voltage produced by the alternator and passed by a dc-dc convertor. A cut-out mechanism can be used to switch the batteries automatically after certain low voltage in use.

In 1970's the development of semiconductor electronics caused the DC motor to eliminate commutator and brushes. In BLDC motors, the mechanical commutator system was replaced by an electronic Servo system [7][8]. An electronic sensor is a device used to determine rotor angle, and controls semiconductor switches such as transistors which uses windings to switch the current either reversing the direction of the current, or it will turn off in some motors.

The maximum torque can be produced by brushed DC motors when stationary and linearly decreasing as velocity increases. Two key performance parameters of BLDC motors are described below [9].

1. Motor constant $\mathbf{K_T}$ (torque constant)
$$\mathbf{K_t = \frac{newton\ meter}{Amp} = \frac{Kilogrammeter^2}{Amperesecond^2}}$$

2. Speed constant $\mathbf{K_e}$ (back EMF constant)
$$\mathbf{K_e = \frac{Volt\ second}{Radian} = \frac{Kilogrammeter^2}{amperesecond^2}}$$

The formula to calculate K_v for brushless motors is:

$$\mathbf{K_v = \frac{Speed}{Volts * 1.414 * 0.95}}$$

5. Observations

Electric trucks with self-charging capability is constructed with proper connections that could load 200/ 240 kg of weight or even more by the support of the strongly made chassis, enhancing the distance travelled with self- charging system more (chart.1&2). The development of self-charging vehicle is to supply the necessary amount of voltage to charge the second set of battery.

The electric trucks are made with the given self-charging arrangements which is able to supply voltage to the batteries while the vehicle is moving by utilizing its own propulsion system. The end results of the made arrangements is observed with different number of loads. A set of 4 lithium ion batteries which has a power of 12v and 50Ah is used. The power for 3hrs of propulsion can be made by using this battery setup. The outcomes of the system are noted for several times with different load. By using this system, the alternator extracts the rotational energy from the wheel of the vehicle which is in motion. Then the extracted energy is transferred to dc to dc converter which steps up the voltage. This will result in supplying the voltage to the second set of battery. The battery of the electric truck will be charged by its own propulsion with rotational energy and the system is observed for certain number of times using Multimeter and recorded output is shown in graphs below.

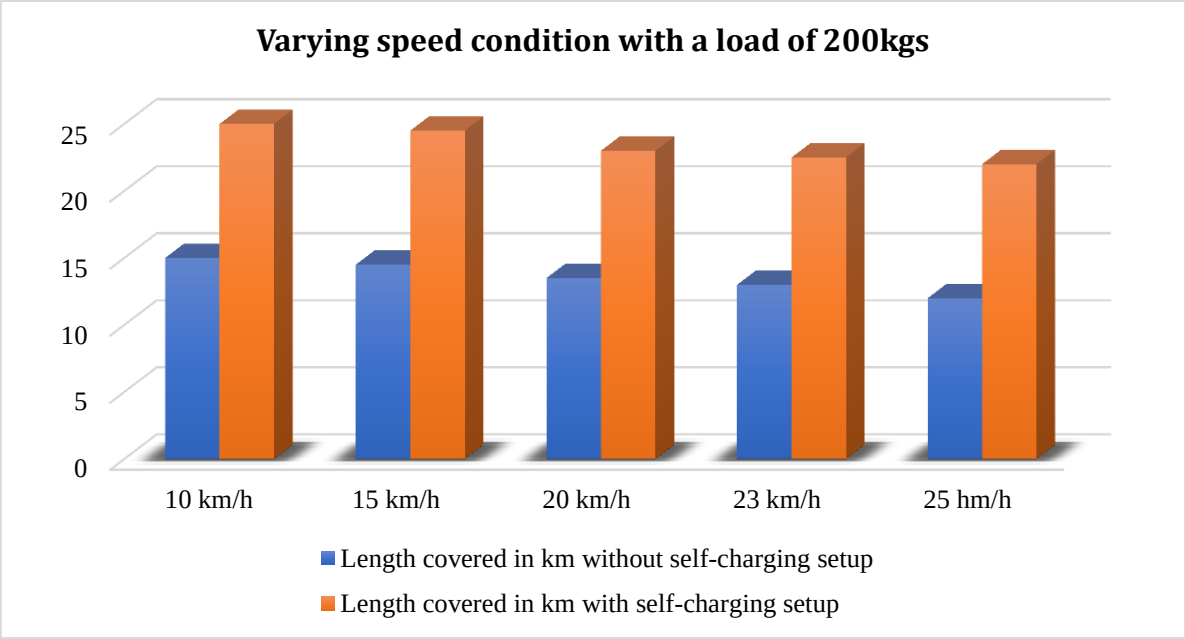

Chart 1. Analysing the distance length with varying speed with a load of 200 kgs

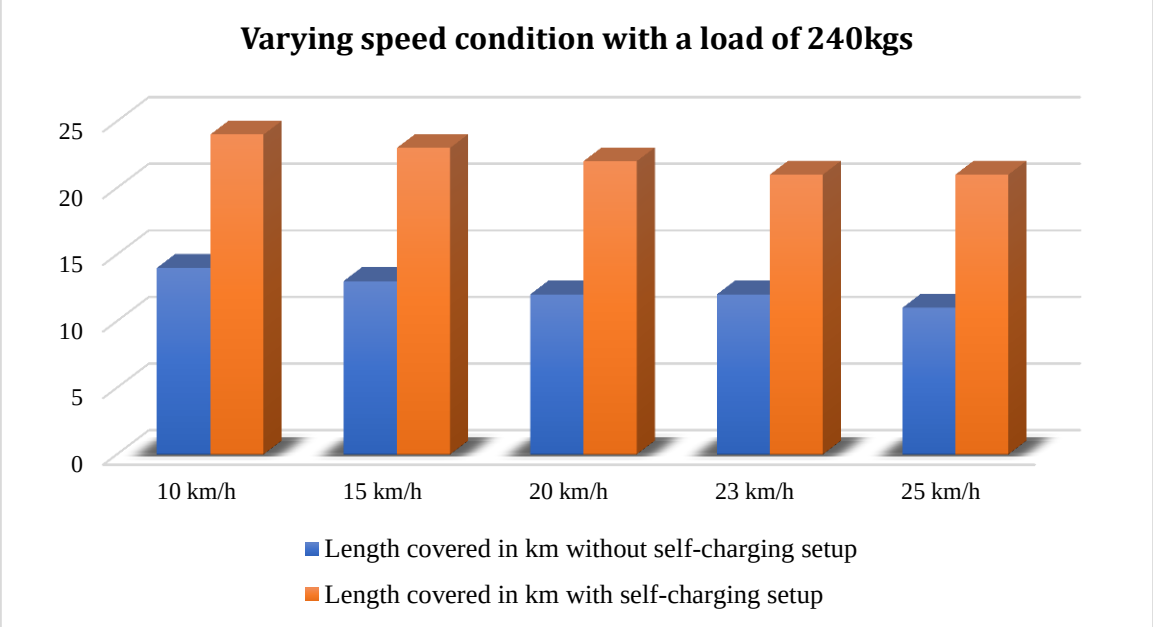

Chart 2. Analysing the length covered with varying speed with a load of 240 kgs

6. Conclusions

The purpose of this work was to bring out the best design, and develop an innovative self-charging electric truck with its own propulsion system for closed circuit usages, like hospital corridors, industries, railway station, and airport etc. As the self-charging method uses its own rotational energy of wheels to charge the battery, by these arrangements one can increase the range and efficiency of the vehicle as well as can cover more distance. This review paper concluded that the BLDC motor can spring out high torque, alternator can positively generate 12v–14v by means of the rotational energy created by the wheels under action, and the given voltage can be step-up by DC-DC converter to 56v which is sufficient to charge the second set of Lithium Ion batteries which stores high energy for effective functioning. Henceforth, the electric truck can become more efficient, be charged while the vehicle is in motion. And equally, the distance travelled with charging system is also more than the distance travelled without charging system.

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