Battery Electric Vehicles Vs Internal Combustion Engine Vehicles

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Abstract – We are all aware that the diesel transport is one of the world's major sources of black carbon. Not only it contains black carbon it also has significant warming effect, but it is also a major component of particulate matter, the air pollutant most closely associated with increased air-pollution related morbidity and mortality. According to The U.S. Environmental Protection Agency (EPA) "motor vehicles collectively cause 75% of carbon monoxide pollution in the U.S. The Environmental Defense Fund (EDF) estimates that on-road vehicles cause one-third of the air pollution that produces smog in the U.S., and transportation causes 27% of greenhouse gas emissions." As global warming has become a stringent issue, we need to embrace renewable energy programs which help us to reduce the global warming and achieve more sustainable transportation options. Pollution is one of the biggest reasons that people gravitate towards an electric vehicle. The environmental benefits surrounding electric cars are one of the most significant factors in switching from a fuel-powered engine to an electrical one. The total life cycle economic cost and environmental impact analysis of Lithium-ion battery electric vehicles (BEVs) versus internal combustion engine vehicles (ICEVs) are elaborately compared and discussed in this paper.

Key Words: Battery Electric Vehicles (BEVs), Internal Combustion Engine Vehicles (ICEVs), Lithium-Ion Battery (Li-Ion Battery), Rotating Magnetic Field (RMF)

1. INTRODUCTION

Electric cars have made big waves in the automobile world. As electric cars give pollution free, noise free and high performance it is expected that the electric vehicle can surely capture the market and make the IC engine counterpart obsolete by 2025.Because of the technology behind the induction motor, inverter and Lithium-Iron power source and synchronized wheel mechanism make the electric cars work with astounding performance. The working principle and feature of electric vehicle and IC engine vehicle are presented in this paper. Power is converted from the DC battery to AC for the electric motor. The accelerator pedal sends a signal to the controller which adjusts the vehicle's speed by changing the frequency of the AC power from the inverter to the motor. The motor connects and turns the wheels through a cog. When the brakes are pressed or the electric car is decelerating, the motor becomes an alternator and produces power, which is sent back to the battery.

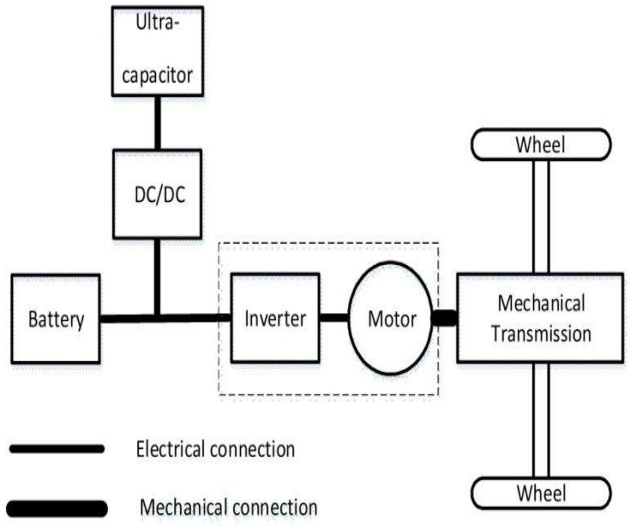

Figure 1: Block diagram of Battery operated Electric vehicle

1.1 Power source

Battery pack gives DC power so before giving supply to induction motor it has to be converted to AC. Hence inverter is connected with battery pack. This power electronics device not only converts DC into AC it also helps to adjust the AC power frequency. This is how the speed of the induction motor is easily controlled.

1.2 Battery: Lithium-ion battery

An Electric-Vehicle Battery EVB also known as a traction battery is a battery which is used to power the electric motors of a battery electric vehicle (BEV) or hybrid electric vehicle (HEV). These batteries are usually rechargeable (secondary) batteries, and are typically Lithium-Ion batteries. These batteries are specifically designed for a high ampere-hour (or kilowatt-hour) capacity.

Electric-vehicle batteries differ from starting, lighting, and ignition (SLI) batteries as they are designed to give power over sustained periods of time and are deep-cycle batteries. Batteries for electric vehicles are characterized by their relatively high power-to-weight ratio, specific energy and energy density; smaller, lighter batteries are desirable because they reduce the weight of the vehicle and therefore improve its performance. Compared to liquid fuels, most current battery technologies have much lower specific energy, and this often impacts the maximum all-electric range of the vehicles.

The most common battery types in modern electric vehicles are Lithium-Ion and lithium polymer, because of their high energy density compared to their weight. Other types of rechargeable batteries used in electric vehicles are lead–acid ("flooded", deep-cycle, and valve regulated lead acid), nickel-cadmium, nickel–metal hydride, and, less commonly, zinc–air, and sodium nickel chloride ("zebra") . The amount of electricity (i.e. electric charge) stored in batteries is measured in ampere hours or in coulombs, with the total energy often measured in kilowatt-hours

Most electric vehicles use lithium-ion batteries (Li-Ions or LIBs). Lithium Ion batteries have higher energy density, longer life span and higher power density than most other practical batteries. Complicating factors include safety, durability, thermal breakdown and cost. The energy density of lithium ion batteries currently used in electric vehicles is 100-180 Wh/Kg and the cost of cells is of the order of $400/kWh.

1.3 Induction. Motor

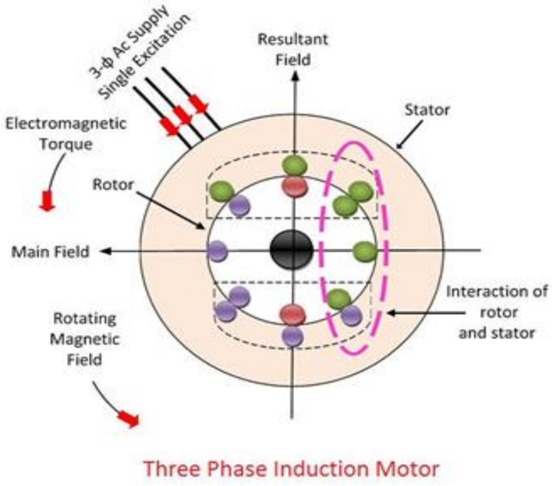

Figure 3: Induction Motor

When three phase AC supply is given to the stator of an induction motor, the three phase alternating current flowing in the stator coil produces rotating magnetic field. The flux from the stator cuts the short-circuited coil in the rotor. As the rotor coils are short-circuited, according to Faraday's law of electromagnetic induction, the current will start flowing through the coil of the rotor. When the current through the rotor coils flows, another flux gets generated in the rotor. Now there are two fluxes, one is stator flux, and another is rotor flux. The rotor flux will be lagging in respect of the stator flux. Because of that, the rotor will experience a torque which will make the rotor to rotate in the direction of the rotating magnetic field. This is the working principle of both single and three phase induction motors. The speed of the induction motor is directly proportional to the supply frequency. So just by varying the supply frequency with help of variable frequency drive the speed of the induction motor can be easily varied. This simple fact makes electric car speed control easy and reliable. The motor speed range can easily vary from 0 to 18000 rpm. This is the most significant advantages of electric vehicle over internal combustion engine vehicle.

1.4 Working Principles of BEV

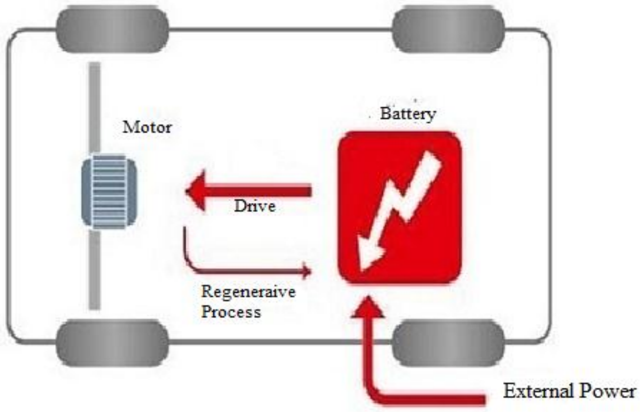

Figure 2: Working principle of BEV

The working principle and feature of electric vehicle and IC engine vehicle are presented in this paper. Power is converted from the DC battery to AC for the electric motor. The accelerator pedal sends a signal to the controller which adjusts the vehicle's speed by changing the frequency of the AC power from the inverter to the motor. The motor connects and turns the wheels through a cog. When the brakes are pressed or the electric car is decelerating, the motor becomes an alternator and produces power, which is sent back to the battery.

1.5 Internal Combustion Engine

Figure 4: Internal Combustion Engine

The number of cylinders that an engine contains is an important factor in the overall performance of the engine. Each cylinder contains a piston that pumps inside of it and those pistons connect to and turn the crankshaft. Based on number of pistons the pumping, and more combustive events are taking place during any given moment. That means that more power can be generated in less time. In an internal combustion engine (ICE), the ignition and combustion of the fuel occur within the engine itself. Then it partially converts the energy from the combustion to work. After the piston compresses the fuel-air mixture the spark ignites it, causing combustion. Now the Internal combustion engine produces the required torque and power output with limited range of speed. Hence it requires a mechanical transmission to control the drive wheel speed. Moreover IC engine produces only linear motion and it doesn't produce direct rotational motion. Therefore IC engine rotation is not directly connected with drive wheel. Moreover the power output of IC engine is not uniform. Therefore it requires some accessories to get the even power output.

2. COMPARISON BETWEEN ELECTRIC VEHICLE AND CONVENTIONAL ICE VEHICLE

Table1: Comparison between Electric vehicle and conventional ICE vehicle.

Feature	Battery Electric vehicles	I.C. Engine vehicles
Powered by	Charged battery, ultra capacitors	Diesel, Petrol
Self weight	High due to battery's bank	Low as compared to EV
Power Transmission	Both mechanical as well as electrical	Mechanical only
Braking system	Regenerative braking	Mechanical only
Eco friendly	Yes	No
Running cost	Low	very high

3. RESULT AND DISCUSSION

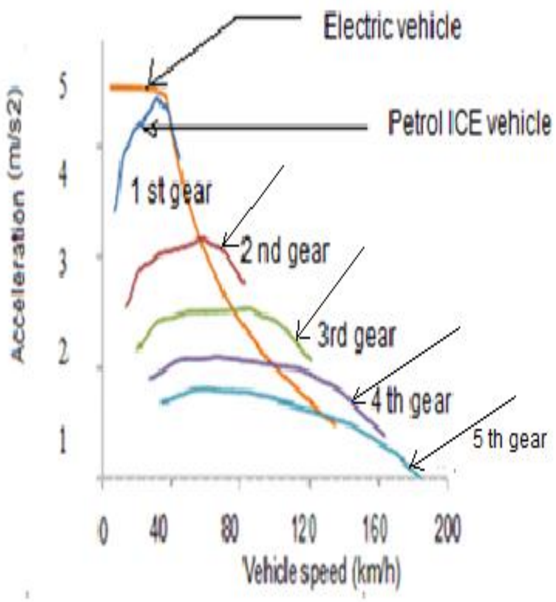

Figure 5: Acceleration versus Speed of EV and petrol ICE vehicles

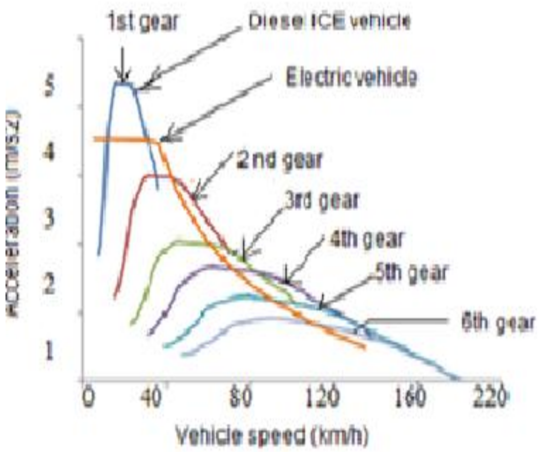

Figure 6: Acceleration versus Speed of EV and Diesel ICE vehicles

Figure 5 shows that the EV attains higher values of acceleration until it reaches a speed of 38.5 km/h in comparison with the vehicle with petrol ICE. After reaching that speed the vehicle with the petrol ICE achieves higher values of acceleration until it reaches its maximum speed of motion in the first gear 45.24 km/h. After shifting from the first to the second gear a decline in its acceleration happens by which the EV attains higher acceleration until reaching a speed of 56.3 km/h. After attaining this speed the vehicle with the petrol ICE again attains higher acceleration values and retains them until it reaches the maximum speed on the horizontal road. The advantage of attaining better acceleration performance from starting from standing state to reaching a speed of 36 km/h is an important feature in many conditions such as for example, city driving, which becomes multiplied benefit if we add the previously explained characteristics of electric propulsion. Concerning that there are benefits from acceleration when moving in a speed range from zero to 38.5 km / h and from 45.25 to 56.3 km/h it can be concluded that the electric vehicle provides significant advantages in specific conditions such as driving in a city traffic. When compared to the vehicle propelled by the diesel ICE Figure 6, it is concluded that the EV achieves greater values of acceleration from starting the vehicle from standing to reaching a speed of 12.27 km/h, and also in the speed range of 30.7 km/h to 42.95 km/h .with, greater value of maximum engine torque. However, previously presented acceleration advantage of the EV is significant from the aspect of city traffic where faster starting the vehicle from standing and overtaking at certain speeds is important.

Torque is a measure of how much rotational force can be produced, whereas power is a measure of how hard an engine has to work to produce the rotational force. As shown below, the power and torque characteristics of a combustion engine means that although a conventional car might have a *top capacity* of 120 kW of power and 250 Newton metres of torque, this is only when the engine is running at high speeds.

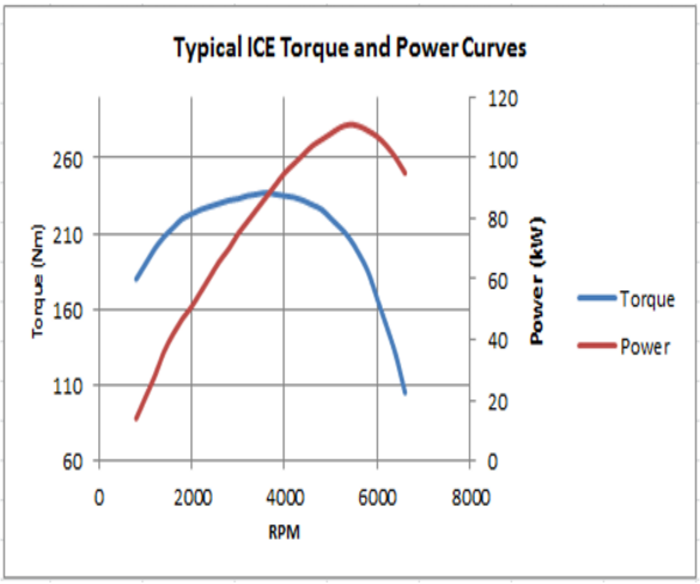

Figure 7: Torque versus Speed characteristics of ICE vehicle

In contrast, an electric motor provides full torque from zero kilo metres an hour, with a linear relationship between how fast the motor is spinning and the power required. These characteristics translate to a vehicle that is extremely fast at accelerating, with the ability to push load very quickly

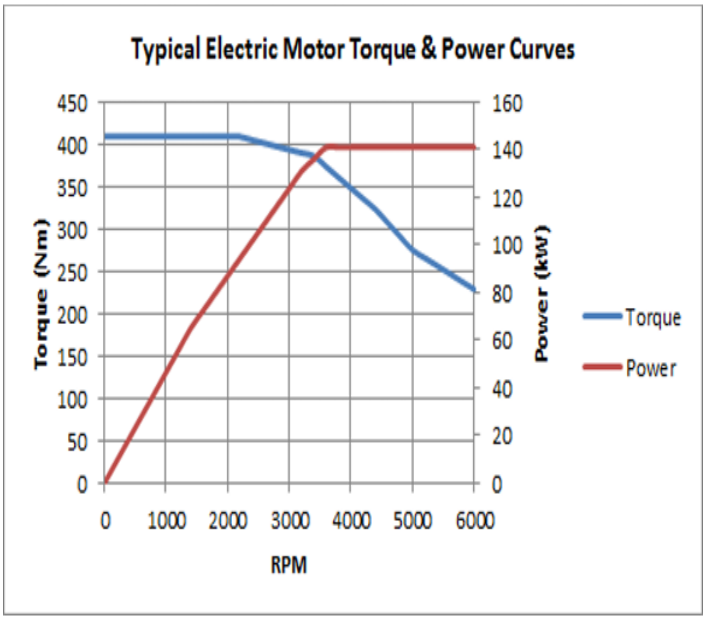

Figure 8: Torque versus Speed characteristics of BEV

4. CONCLUSION

BEV enjoys some distinct advantages. First, the electricity cost associated with operating a BEV over a distance of one mile is significantly lower than the gasoline cost required for operating a comparable ICEV over the same distance. Second, BEV cost less to maintain owing to the relative elegance and simplicity of a battery-electric motor system compared with the frequent maintenance required for operation of an internal combustion system. More over battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs) and hybrid electric vehicles (HEVs) among these vehicles, the BEV does not require gasoline at any point during operation, relying solely upon pure electric battery power. Apart from that electric cars produce peak torque at zero RPM On the other hand internal combustion engines need to be spinning up at a much higher speed than electric motors before they produce peak torque

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