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E-Mobility: Smart, Sustainable and Eco-Friendly Mode of Future Transport

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Abstract – *This paper provides a brief overview of Electric Vehicle Transmission System in comparison to the Tail Pipe Emission of IC Engine Vehicles. It suggests the future scope of Electric Vehicle Technology to maximize the use of renewable sources of energy so as to fulfill sustainable goals for betterment of society. Besides this, it also includes the harmful impacts on environment and human beings caused by IC engines at a global level.*

Keywords – Electric vehicle, IC engine emissions, AC motor, Li-ion battery.

INTRODUCTION

The first commercially successful internal combustion engine was created by Étienne Lenoir around 1859 and the first modern internal combustion engine was created in 1876 by Nikolaus Otto [1]. Internal Combustion Engines, more popularly known as IC engines, are the ones in which the combustion of fuel takes place inside the engine block itself. After combustion of fuel, much heat energy is generated, this is converted into mechanical energy. There are two types of IC engines: rotary and reciprocating engines. In rotary engines, a rotor rotates inside the engine to produce power. In the case of the reciprocating engines, a piston reciprocates within a cylinder. Reciprocating engines are classified into two types: spark ignition (SI) engines or Petrol or Gasoline Engines and compression ignition (CI) engines or Diesel engines. The SI and CI engines are either two stroke or four stroke engines [2]. Modern gasoline engines have a maximum thermal efficiency of about 25% to 50% when used to power a car. In other words, about 50-75% of total power is emitted as heat without being turned into useful work when the engine is operating at its point of maximum thermal efficiency [3].

To conserve the non-renewable energy sources for upcoming generations and to minimize its harmful impact on the environment, various steps are needed to be taken in the direction of increasing the use of electric vehicle. An electric vehicle (EV), also referred to as an electric drive vehicle, is a vehicle which uses one or more electric motors for propulsion. At the beginning of the 21st century, interest in electric and other alternative fuel vehicles has increased due to growing concern over the problems associated with hydrocarbon-fueled vehicles. It includes damage to the environment caused by their emissions, and the sustainability of the current hydrocarbon-based transportation infrastructure. Utility of electric energy generated through renewable sources is the most viable way to achieve clean and efficient transportation that is crucial to the sustainable development of the whole world [4].

Table 1 - Electric vehicle vs. Gasoline vehicle

Sr. no.	Parameters	IC Engine Vehicles	Electric Vehicles
1.	Efficiency	Converts 20% of the energy stored in gasoline to power the vehicle.	Converts 75% of the chemical energy from the batteries to power the vehicle.
2.	Speed (Average Top Speed)	199.5 km per hour (kmph).	48-153 km per hour (kmph).
3.	Acceleration (average)	0-96.5 kmph in 8.4 seconds.	0-96.5 kmph in 4-6 seconds.
4.	Maintenance	High maintenance owing to more number of moving parts.	Maintenance is minimal due to lesser number of moving parts.

5.	Mileage (average)	Can go over 480-500 kms before refueling. Typically achieves 10-12 kmpl.	Can travel 120-200 kms before recharging.
6.	Cost (average)	INR 0.7-1.1 million.	INR 0.9-6 million.

HAZARDOUS EFFECTS OF IC ENGINE VEHICLES ON ENVIRONMENT

The automobiles play an important role in the transport system. With an increase in population and living standard, there is an increasing trend in fuel consumption - especially gasoline and diesel – because, today, over 90% vehicles on the road use gasoline and diesel fuels. In addition to this there is steep increase in the number of two wheelers during the last two decades. All these are increasing exhaust pollution and particularly in metros as density of these vehicles there is very high. The main pollutants contributed by I.C. engines are CO, NO_x, unburned hydro-carbons (HC), particulate matter (PM), CO_2, O_3 and other particulate emissions [5]. The effects on the environment are usually identified with pollutant emission through the tail-pipe of combustors, but handling of fuels, fuel losses at the inlet, and product losses from the combustor shell, are other sources (up to 20% of the hydrocarbon emissions in a car do not go out along the tail-pipe). Mass losses and energy losses may be a danger to humans, animals, plants and goods: explosion danger (in confined places), open flame danger, toxicity from CO (and other toxic gases in chemical fires), suffocation or anoxia from CO_2, hyperthermia by heat, respiratory and visual irritation by smoke and noxious gases, etc. [6]. Since there are limited reserves of fossil fuels, they will be depleted one day due to the current hydrocarbon-based transportation infrastructure. Mechanical pollution (noise) and electromagnetic pollution (interferences, EMI), are dealt apart. To avoid this more and more use of electric vehicles should be adopted. Using electric vehicle decreases the dependence on non-renewable sources of energy and hence reduces harmful impacts on environment [7].

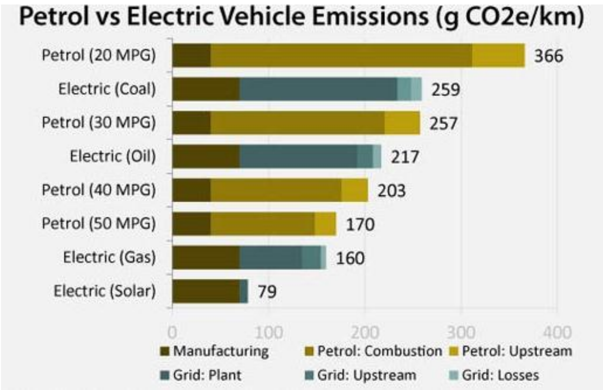

Fig. 1- fig shows petrol vs electric vehicle emissions

ELECTRIC VEHICLE TRANSMISSION SYSTEM

Electric vehicles (EVs) use an electric motor for traction, and chemical batteries, fuel cells, ultra-capacitors, and/or flywheels for their corresponding energy sources. Electric vehicle is an automobile propelled by one or more electric motors, drawing power from an onboard source of electricity. Electric cars are mechanically simpler and more durable than gasoline-powered cars. They produce less pollution than do gasoline-powered cars. An electric car stores its energy on board-typically in batteries, but alternatively with capacitors or flywheel storage devices. Electric cars can use AC or DC motors for actuation as:

- If the motor is a **DC motor**, then it may run on anything from 96 to 192 volts.
- If it is a three-phase **AC motor**, then it is running at 240 volts AC with a 300 volt battery pack.

The limitation of DC motor is heat build-up in the motor. As the motor heats up due to too much overdriving, it self-destructs. AC installations allow the use of almost any industrial three-phase AC motor, and that can make finding a motor with a specific size, shape or power rating easier. AC motors and controllers often have a regenerative feature. During braking the motor turns into a generator and delivers power back to the batteries [8].

The torque developed in an AC motor is given as,

$$T_d = \frac{\text{Mechanical power developed}}{\text{Mechanical angular velocity of rotor}} = \frac{P_m}{\omega_s}$$

$$T_d = \frac{kV^2 sR}{R^2 + (sX)^2} \qquad \text{......... (1)}$$

where,

$$k = \frac{3}{\omega_s} = \text{constant}$$

$\omega_s =$ angular velocity of stator

$V = \text{voltage}$

$s = \text{slip}$

$R = \text{resistance}$

$X = \text{reactance}$

At the start condition the value of s = 1. Therefore, the starting is obtained by putting the value of s = 1 in the equation (1), we get

$$T_d = \frac{kV^2 R}{R^2 + X^2} \qquad \text{......... (2)}$$

$$\therefore\ T_d \ \alpha\ V^2 \qquad \text{.......... (3)}$$

Hence, it is clear from the above equation (3) that the starting torque is proportional to the square of the stator applied voltage [9].

ENERGY STORAGE

Energy storage systems (ESSs) are becoming essential in power markets to increase the use of renewable energy and to reduce CO2 emission [10]. “Energy storages” are defined as the devices that store energy, deliver energy outside (discharge), and accept energy from outside (charge). For allocation on an EV, specific energy is the first consideration since it limits the vehicle range.

Since the first announcement of the Li-ion battery in 1991, Li-ion battery technology has seen an unprecedented rise to what is now considered to be the most promising rechargeable battery of the future. Although still at the development stage, the Li-ion battery has already gained acceptance for EV applications [11].

The Li-ion battery uses a lithiated carbon intercalation material (Li_xC) for the negative electrode instead of metallic lithium, a lithiated transition metal intercalation oxide ($Li_{1-x} M_yO_z$) for the positive electrode, and a liquid organic solution or a solid polymer for the electrolyte. Lithium ions swing through the electrolyte between the positive and negative electrodes during discharge and charge [12]. The general electrochemical reaction is described as:

$$Li_xC + Li_{1-x}xM_yO_z \leftrightarrow C + LiM_yO_z$$

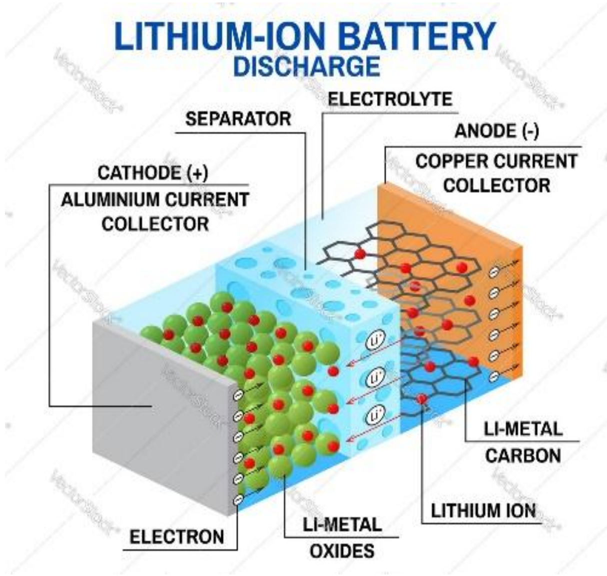

Fig. 2- fig shows the Lithium-ion battery

On discharge, lithium ions are released from the negative electrode, migrate via the electrolyte, and are taken up by the positive electrode. On charge, the process is reversed. Possible positive electrode materials include $Li_{1-x}CoO_2$, $Li_{1-x}NiO_2$, and $Li_{1-x}Mn_2O_4$, which have the advantages of stability in air, high voltage, and reversibility for the lithium intercalation reaction. The $Li_xC/Li_{1-x}NiO_2$ type, loosely written as C/LiNiO$_2$ or simply called the nickel-based Li-ion battery, has a nominal voltage of 4 V, a specific energy of 120 Wh/kg, an energy density of 200 Wh/l, and a specific power of 260 W/kg [13] .The cobalt-based type has a higher specific energy and energy density, but at a higher cost and significant increase in the self-discharge rate. The manganese-based type has the lowest cost and its specific energy and energy density lie between those of the cobalt- and nickel-based types. It is anticipated that the development of the Li-ion battery will ultimately move to the manganese-based type because of the low cost, abundance, and environmental friendliness of the manganese-based materials [14]. Although, hydrogen fuel cells have more advantages such as they offer a potentially very clean, energy dense and easy to recharge energy source for vehicles and other systems, but are currently complicated, expensive and hazardous to operate.

An electric vehicle charging station, also called ECS (electronic charging station), is an element in an infrastructure that supplies electric energy for the recharging of electric vehicles, such as plug-in electric vehicles, including electric cars, neighborhood electric vehicles and plug-in hybrids [15]. The electric energy can be produced through various number of sources such as Hydroelectric plants, nuclear power plants, thermal power plants and renewable sources. Due to advancements in technology, and with mass production, renewable sources other than hydroelectricity (solar power, wind energy, tidal power, etc.) experienced decreases in cost of production, and the energy is now in many cases cost-comparative with fossil fuels [16].

CONCLUSION

As seen in this report, the electric vehicle has many advantages and benefits over the internal combustion engine. The future of the EV relies on its battery. If researchers can overcome with the storage and safety issues of hydrogen fuel cells, the EV's future is promising as hydrogen could be a great solution to increase range and decrease charging time in electric vehicles. EVs have great potential of becoming the future of transport while saving this planet from imminent calamities caused by global warming. They are a viable alternative to conventional vehicles that depend directly on the diminishing fossil fuel reserves.

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