Comparison between Electric Vehicle and Internal Combustion Engine

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Abstract— Due to the problems caused by the gasoline engine on the environment and people, the automotive industry has moved to the electrical powered vehicle. This paper explains how an electric vehicle works and compares the electric vehicle and the internal combustion engine. This paper provides some of the advantages and disadvantages of the electric vehicle. In addition, a brief future view of the technology is given.
Keywords: Electric Vehicle and Internal Combustion Engine

I. Introduction

The 1960s and 1970s saw a need for alternative fueled vehicles to reduce the problems of exhaust emissions from internal combustion engines and to reduce the dependency on imported foreign crude oil. During the years from 1960 to the present, many attempts to produce practical electric vehicles occurred and continue to occur.

The purpose of this paper is to describe the technology used to produce an electric vehicle and explain why the electric engine is better than the internal combustion engine. It includes reasons why the electric vehicle grew rapidly and the reason it is a necessity to better the world today. The paper describes the most important parts in an electric vehicle and hybrid vehicle. It compares the electric vehicle and internal combustion engine vehicle. It also includes the future of the electric vehicle.

The overall impact of the electric vehicle ultimately benefits the people. Compared to gasoline powered vehicles, electric vehicles are considered to be ninety-seven percent cleaner, producing no tailpipe emissions that can place particulate matter into the air. Particulate matter, carcinogens released into the atmosphere by gas-powered vehicles, "can increase asthma conditions, as well as irritate respiratory systems" [1].

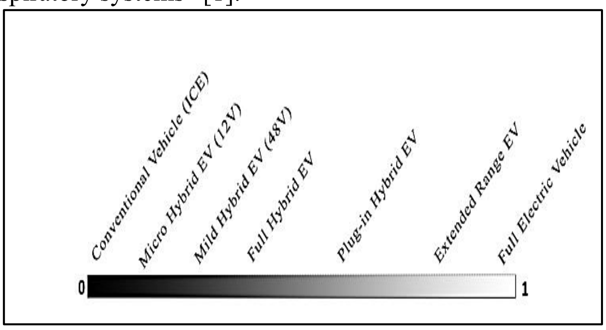

Fig. 1: Degree of Electrification

The paper begins with a history of the electric vehicle, specifically the lows and highs of production and the reasons for the change. The next section provides a technical description of an electric vehicle, including the parts, their functions, and the theory of operation. The following section describes the hybrid car, including parts, their functions and the theory of operation. Based on this understanding, I then compare the internal combustion engine and the electrical engine in terms of efficiency, speed, acceleration, maintenance, mileage, and cost. The paper concludes with sections on the advantages and disadvantages of the electric vehicle and its future.

II. History

The first electric vehicle (EV) was built between 1832 and 1839, the exact year is not known, in Scotland by Robert Anderson, who created the first crude electric carriage. It was not until 1895, after A.L. Ryker built an electric tricycle and William Morrison built a six passenger wagon, that America paid attention to the electric vehicle. In 1902 Wood created the Electric Phaeton, which was more than an electrified horseless carriage and surrey. "The Phaeton had a range of 18 miles, a top speed of 14 mph and cost $2,000" [2].

The decrease in use and production of the electric vehicle occurred in the 1920s. Causes of the decrease in production include: a better road system, reduced price of gasoline by the discovery of the Texas crude oil, invention of the electric starter, and the mass production of the internal combustion engine vehicles [2]. According to the History of Electric Vehicles, "In 1912, an electric roadster sold for $1,750, while a gasoline car sold for $650" [2]. By 1935, electric vehicles completely disappeared.

In the 1960s and 1970s electric vehicles reappeared because internal combustion vehicles were creating an unhealthy environment for the people in America at that time.

III. Types of Electrical Vehicles

EVs (also known as plug-in electric vehicles) derive all or part of their power from electricity supplied by the electric grid. They include AEVs and PHEVs.

AEVs (all-electric vehicles) are powered by one or more electric motors. They receive electricity by plugging into the grid and store it in batteries. They consume no petroleum-based fuel and produce no tailpipe emissions. AEVs include Battery Electric Vehicles (BEVs) and Fuel Cell Electric Vehicles (FCEVs).

PHEVs (plug-in hybrid electric vehicles) use batteries to power an electric motor, plug into the electric grid to charge, and use a petroleum-based or alternative fuel to power the internal combustion engine. Some types of PHEVs are also called extended-range electric vehicles (EREVs).

IV. Description of an Electric Vehicle

The electric vehicle (EV) is propelled by an electric motor, powered by rechargeable battery packs, rather than a gasoline engine. From the outside, the vehicle does not appear to be electric. In most cases, electric cars are created by converting a gasoline-powered car. Often, the only thing that clues the vehicle is electric is the fact that it is nearly silent [5].

Under the hood, the electric car has:

- An electric motor
- A controller.
- A rechargeable battery.

The electric motor gets its power from a controller and the controller gets its power from a rechargeable battery.

The electric vehicle operates on an electric/current principle. It uses a battery pack (batteries) to provide power for the electric motor. The motor then uses the power (voltage) received from the batteries to rotate a transmission and the transmission turns the wheels.

Four main parts make up the electric vehicle: the potentiometer, batteries, direct current (DC) controller, and motor. See Figure 1.

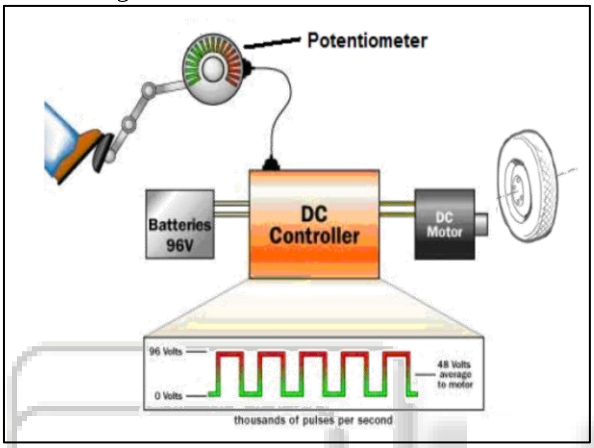

Fig. 2: Parts of an electric vehicle.

A. Description of Parts and their Functions

1) Potentiometer

It is circular in shape and it is hooked to the accelerator pedal. The potentiometer, also called the variable resistor, provides the signal that tells the controller how much power is it supposed to deliver.

2) Batteries

The batteries provide power for the controller. Three types of batteries: lead-acid, lithium ion, and nickel-metal hydride batteries. Batteries range in voltage (power).

3) DC Controller

The controller takes power from the batteries and delivers it to the motor. The controller can deliver zero power (when the car is stopped), full power (when the driver floors the accelerator pedal), or any power level in between. If the battery pack contains twelve 12-volt batteries, wired in series to create 144 volts, the controller takes in 144 volts direct current, and delivers it to the motor in a controlled way [3].

The controller reads the setting of the accelerator pedal from the two potentiometers and regulates the power accordingly. If the accelerator pedal is 25 percent of the way down, the controller pulses the power so it is on 25 percent of the time and off 75 percent of the time. If the signals of both potentiometers are not equal, the controller will not operate [3].

4) Motor

The motor receives power from the controller and turns a transmission. The transmission then turns the wheels, causing the vehicle to run.

B. Description of a Hybrid Vehicle

The hybrid vehicle (HV) is powered by both a gasoline engine and electric motor.

The HV runs using power from an internal combustion engine and electric motor. The engine provides most of the vehicle's power, and the electric motor provides additional power when needed, such as accelerating and passing [4].

The hybrid vehicle operates on a gasoline and electric energy principle. A hybrid car features a small fuel-efficient gas engine combined with an electric motor that assists the engine when accelerating. The electric motor is powered by batteries that recharge automatically while you drive [4].

Five main parts make up the hybrid vehicle: the battery, internal combustion engine (ICE), generator, power split device, and electric motor. See Figure 2.

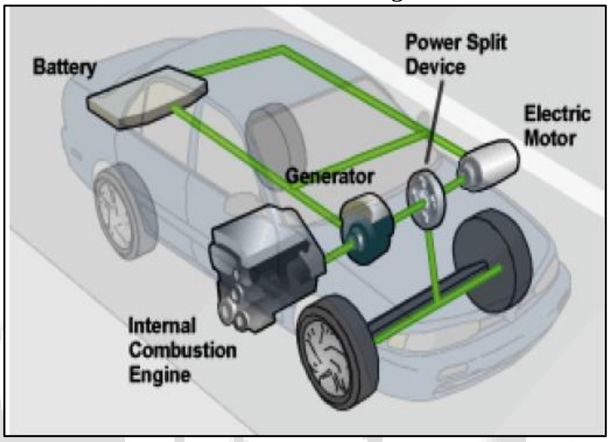

Fig. 3: Parts of a hybrid vehicle [4].

C. Description of Parts and their Functions

1) Battery

The batteries in a hybrid car are the energy storage device for the electric motor. Unlike the gasoline in the fuel tank, which can only power the gasoline engine, the electric motor on a hybrid car can put energy into the batteries as well as draw energy from them.

2) Internal Combustion Engine (ICE)

The hybrid car has an ICE, also known as a gasoline engine, much like the ones found on most cars. However, the engine on a hybrid is smaller and uses advanced technologies to reduce emissions and increase efficiency. Receives its energy from the fuel tank where the gasoline is stored.

3) Generator

The generator is similar to an electric motor, but it acts only to produce electrical power for the battery.

4) Power Split Device

The power-split-device resides between the two motors and together with the two motors creates a type of continuously variable transmission.

5) Electric Motor

The electric motor on a hybrid car acts as a motor as well as a generator. For example, when needed, it takes energy from the batteries to accelerate the car. But acting as a generator, it slows the car down and returns energy to the batteries.

D. Theory of Operation for Hybrid

When the driver steps on the pedal the generator converts energy from the engine into electricity and stores it in the battery. The battery then provides power to the electric motor. The internal combustion engine and electric motor work simultaneously and each provide power to the power split device. The power split device combines both powers and uses it to turn the transmission. The transmission then turns the wheels and propels the vehicle.

The energy used when braking is converted into electricity and stored in the battery. When braking, the electric motor is reversed so that, instead of using electricity to turn the wheels, the rotating wheels turn the motor and create electricity. Using energy from the wheels to turn the motor slows the vehicle down. When the vehicle is stopped, the gasoline engine and electric motor shut off automatically so that energy is not wasted in idling. The battery continues to power auxiliary systems, such as the air conditioning and dashboard displays.

E. Comparison of Internal Combustion Engine and Electric Vehicle

Parameters	ICE	EV
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 wheels [5].
Speed (average top speed)	124 miles per hour (mph)	30-95 mph
Acceleration (on average)	0-60 mph in 8.4 seconds	0-60 mph in 4-6 seconds
Maintenance	Wheels/tires Engine Fuel/gas Bodywork/paint Electrical Lights Dash/instrument warning lights	Does not require as much maintenance because it does not use a gasoline engine. No requirements to take it to the Department of Environmental Quality for an emissions inspection [1].
Mileage	Can go over 300 miles before refueling. Typically get 19.8 miles per gallon (mpg).	Can only go about 100 to 200 miles before recharging [5].
Cost (on average)	$14,000 to $17,000.	Extensive range, $6,000 to $100,000 [6].

Table 1: Comparison between the ICE and EV

F. Advantages and Disadvantages of the EV

The greatest challenge EVs face deal with the rechargeable battery. Most EVs can only go about 100–200 miles before recharging; fully recharging the battery pack can take four to eight hours. Battery packs are heavy, expensive, may need to be replaced, and take up considerable vehicle space [5]. Overall, the electric vehicle has more advantages than disadvantages. Advantages include no tailpipe emissions, which leads to a reduction in global warming and unhealthy people. Table 2 summarizes the advantages and disadvantages of the EV.

G. Power Management:

Control strategies for hybrid-electric vehicles generally target several simultaneous objectives. The primary one is the minimization of the vehicle fuel consumption, while also attempting to minimize emissions and to maintain or enhance drivability. To date, the power management (PM) system in EVs is basically formed by two layers; High level software-based supervision and low level hardware-based control which can be divided into two control layers low level component and low level control. Both hardware and software control layers works together to optimize PM system in EVs [9,10].

Major challenge of energy management system (EMS) in an electric vehicle is to assure optimal use and regeneration of the total energy in the vehicle. Regardless of number of sources, the powertrain configuration, at any time and for any vehicle speed, the control strategy has to determine the power distribution between different energies. When two storage systems or two fuel converters are available additional power distribution between the RESSs and between the fuel converters has to be determined. These decisions are constrained by two factors. First of all, the motive power requested by the driver must always be satisfied up to a maximum power demand already known. Then, charge status must be maintained within, allowing the vehicle to be charge continuously. [11]

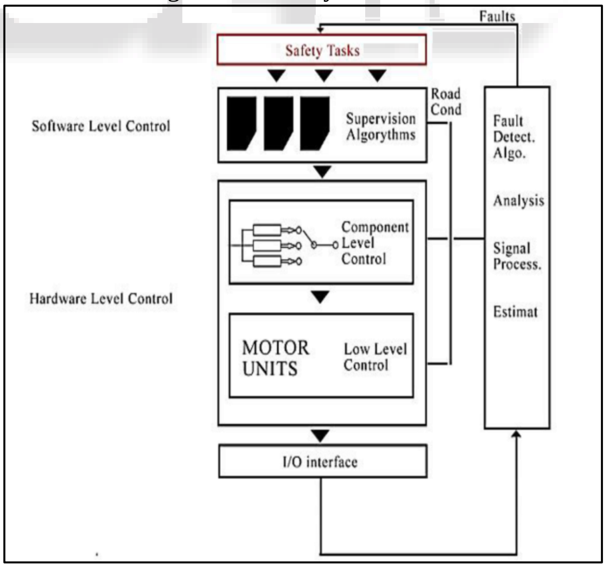

Fig. 4: Power management control layers in EV

H. Advantages and Disadvantages of the EV

Advantages	Disadvantages
Fuel can be harnessed from any source of electricity, which is available in most homes and businesses.	Limited in the distance that can be driven before the complete failure of the battery.
It reduces hydrocarbon and	Accessories, such as air

carbon monoxide, responsible for many environmental problems, by 98%.	conditioning and radios drain the battery.
Also reduces pollution.	Heavier car due to the electric motors, batteries, chargers, and controllers.
Does not produce emissions. Important in urban cities, where cleaner air is much needed.	More expensive because of cost of the parts.

Table 2: Advantages and Disadvantages of the EV

1) Emissions

Compared to gasoline powered vehicles, electric vehicles are considered to be ninety-seven percent cleaner, producing no tailpipe emissions that can place particulate matter into the air [1].

2) Global Warming: Ozone Layer

The process of carbon dioxide emitted into the atmosphere, also known as global warming, diminishes the Earth's ozone layer, which is what occurs at this time. A factor that makes electric vehicles clean is their ability to use half the number of parts a gasoline powered vehicle does, including gasoline and oil.

3) Affected People: Sickness

Particulate matter, carcinogens released into the atmosphere by gas-powered vehicles, "can increase asthma conditions, as well as irritate respiratory systems" [1]. The carbon dioxide released into the atmosphere by internal combustion vehicles reduces the ozone layer, which absorbs ninety-seven to ninety-nine percent of the sun's high frequency ultraviolet light [7]. According to *Ozone Layer*, "Every one percent decrease in the earths ozone shield is projected to increase the amount of UV light exposure to the lower atmosphere by two percent" [7]. Ultraviolet light, produced by the sun, is extremely harmful to life on Earth. UV light damages the skin, causing skin cancer. It also hurts the eyes and the marine life.

V. FUTURE OF THE EV

Future electric cars will most likely carry lithium-ion phosphate (LiFePO4) batteries that are now becoming popular in other countries. The LiFePO4 batteries are rechargeable and powerful and are being used in electric bikes and scooters. Electric cars will most likely adopt this technology in the future.

Another technology that is likely for future electric cars is the increased use of supercapacitors and ultracapacitors for storing and delivering electrical charge. Many of these batteries are currently being used in conjunction with hybrid car prototypes, so these are expected in the electric car future markets as well.

If the developers of future electric cars can create vehicles with a range of 300 miles per charge, a charging time of five to ten minutes, and safety in operating the vehicles, the market is wide open for them. Researchers are working on improved battery technologies to increase driving range and decrease recharging time, weight, and cost. These factors will ultimately determine the future of EVs [8].

VI. CONCLUSION

As seen in this report, the electric vehicle has many advantages and benefits over the internal combustion engine and hybrid vehicle. It is cleaner and much more efficient; however, it also has disadvantages. It is heavier, limited to the distance it can travel before recharge, and costs more. The future of the EV relies on its battery. If researchers can produce or find the "super battery", the EV's future is promising. As of today, each vehicle has its own characteristic that makes it better than the other. Only time and technological improvements will tell which vehicle will excel in the future.

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