An Overview of Electric Vehicle Concept and its Evolution

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Abstract:- *A growing concern in today's world is environmental protection and energy conservation. Automotive manufacturers are developing alternatives to existing fossil fuel-driven vehicles. This has paved way for the development of Electric Vehicles (EV) and Hybrid Electric Vehicles (HEV). In this paper an overview of basic concept of electric vehicle is explained. Also explained the all possible types of eclectic vehicle such as (1) Plug-in Hybrid Electric Vehicle, (2) Battery Electric Vehicle, (3) Fuel Cell Electric Vehicle and (4)Hybrid Electric Vehicle. At last we explained the brief evolution of electric vehicle.*

Key Words: Electric Vehicle, Hybrid Electric Vehicle, Plug-in Hybrid Electric Vehicle, Battery Electric Vehicle, Fuel Cell Electric Vehicle and Hybrid Electric Vehicle.

1. INTRODUCTION

In recent years, many existing automobile manufacturers and new dedicated companies have put a remarkable effort in transforming the conventional vehicle into an Electric Vehicle that provides green and reliable solution. In terms of market share, EV demand is raising [2]. It starts replacing conventional vehicle In USA, Europe and Asia. With revolutionized perspective and competitive price (Entry range), EV is a smart choice for any end user, however, an extra effort is required to enhance the range of autonomy and vary applications [3].

A vehicle which is propelled by one or more electric motors and draws power from onboard electric source is an electric vehicle. They are more durable and mechanically simpler than gasoline powered vehicles. They produce less pollution than gasoline-powered vehicles. While HEVs tend to reduce the emissions from internal combustion vehicles as a result of greater fuel efficiency, they do not completely solve the problem. Electric vehicles on the other hand are much more energy efficient, produce absolutely no tail pipe emissions and requires less maintenance as compared to the conventional internal combustion engine (ICE) vehicles [4]. However, the reason the automotive industry has not gone pure electric or able to compete favorably with existing gasoline cars, lies in the inherent problem of existing battery technologies.

The advantages of using electric vehicles over gasoline powered engines are as follows-

1. They do not create any pollution.
2. They are noise free.
3. They help us save fossil fuels.
4. They have high starting torque.
5. They can be charged at home without going to stations.

The above advantages have made electric cars popular in market and their numbers are increasing day by day.

The most common electrical energy storage device used in vehicles is a battery. Batteries have been the technology of choice for most applications, because they can store large amounts of energy in a relatively small volume and weight and provide suitable levels of power for many applications. Shelf and cycle life have been a problem/ concern with most types of batteries, but designers have learned to tolerate this shortcoming due to the lack of an alternative. In recent times, the power requirements in a number of applications have increased markedly and have exceeded the capability of batteries of standard design.

An electric vehicle stores its energy on board- typically in batteries, but alternatively with capacitors or flywheel storage devices. A more recent development is the hybrid electric vehicle (HEV), which uses both an electric motor or motors and a gasoline or diesel engine, which charges the batteries in order to extend the car's range and often to provide additional power [5]. Regardless of the energy source, an electric car needs a controller, which is connected to the accelerator pedal, for directing the flow of electricity from the energy source to the motor. This paper presents the brief overview on the concept of electrical vehicle with its types. In last section we discussed about the evolution of electric vehicle.

2. WORKING PRINCIPLE OF ELECTRIC VEHICLE

The basic motive of using electric vehicles is to save fossil fuels. To fulfill this energy sources used are batteries, capacitors, flywheels etc. energy can also be generated using fuel cells. Earlier in the starting era only 'pure' electric vehicles were in use which use only battery as a energy source and needs charging frequently. Nowadays electric vehicles use combination of energy sources and are called hybrid electric vehicles [6]. They are better than the pure electric vehicles as the auxiliary device used can support battery, increase range of vehicles and can help in transient operations. For e.g. when we use hybrid system of battery and super capacitor the super capacitor supports battery during high loads and transient loads which makes system efficient and maintains battery's health.

Most electric vehicles use lead-acid batteries, but new types of batteries, including zinc-chlorine, nickel metal hydride, and sodium-sulfur, are becoming more common . The motor of an electric car harnesses the battery's

electrical energy by converting it to kinetic energy. The driver simply switches on the power selects "Forward" or "Reverse" with another switch and steps on the accelerator pedal. While the internal-combustion engine of a conventional car has many moving parts and must convert the linear motion of pistons and rods into rotary motion at the wheels, an electric motor has only a single rotating element. Like a gasoline-powered car, an electric car has a system (called a power train) of gears, shafts, and joints that transmit motion from the motor to the vehicle wheels. Most electric vehicles do not have clutches or multispeed transmissions. In order to go backward, the flow of electricity through the motor is reversed, changing the rotation of the motor and causing the power train to make the wheels rotate in the other direction.

Most electric vehicles have a regenerative braking system which acts as a battery charger. When the vehicle slows down or when brakes are applied the motor starts working as generator and supply electricity to battery. This braking is called regenerative braking and it often works as a battery charger [7]. Converting the kinetic energy into electric energy slows the vehicle. Electric vehicles also have a brake pedal and a traditional braking system, which uses friction to slow the vehicle for quick and emergency stopping. These friction brakes convert kinetic energy to heat. In gasoline-powered vehicles this energy is wasted. The heat being dissipated into the surrounding air. However, is so important that engineers found a way to recover the heat and use it - for example, by heating the passenger compartment. The block diagram below shows the architecture of a simple battery powered electric vehicle

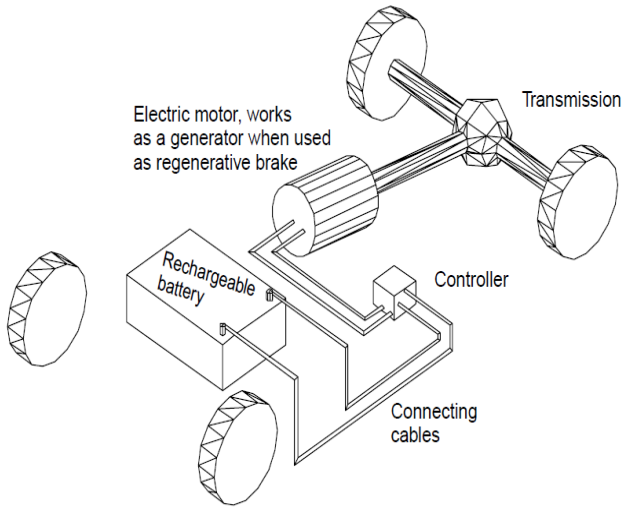

Fig -1: Architecture of a battery powered vehicle

As the above block diagram shows a battery powered vehicle consist of a battery, controller, motor and the transmission system. Battery is the energy source and the controller controls the flow of energy from energy source to the motor. The transmission system is for the transfer of energy.

3. TYPES OF ELECTRIC VEHICLE

Choosing a new vehicle can be difficult at the best of times, but it is even harder if you are trying to get to grips with all of the different types of hybrid vehicles that are on the market. The different types of vehicles are explained below-

3.1 Plug-in Hybrid Electric Vehicles (PHEV)

Plug-in Hybrid vehicles also combine an electric motor with a traditional internal combustion engine. However, plug-in electric motors are charged up by plugging the vehicle into a special power station. These vehicles can work as both electric as well as gasoline powered vehicles. When they are used for long range driver can switch it to fuel powered when motor stops giving power. The average range for these vehicles when they are being used in electric mode is around 35 miles. When the vehicle is being used in electric power mode, there are no tailpipe emissions; however emissions levels are standard when the car is being driven in traditional fuel mode. This type of vehicle is ideal of city driving, because they are most efficient when they are being driving in this environment.

3.2 Battery Electric Vehicles (BEV)

Battery electric vehicles (BEV) consist of an electric motor which is power by a battery connected to it. Battery is the internal source of energy in these vehicles. Battery gives these vehicles advantage of operating with zero emission. A technology named 'energy recovery' technology is used in them. In this electric motor works as both a propulsion source as well as a generator when braking and when vehicle moves down a slope and moves freely under gravity. This increases the efficiency of vehicle [8].

In traffic BEVs proves to be a good option because of high torque of the electric motor that is transmitted to the wheels and the smoother acceleration (and deceleration) compared to vehicles with internal combustion engines (ICE – Internal Combustion Engine). BEVs are noiseless while operating the electric motor and they don't produce pollutant emissions. These aspects make BEVs the ideal vehicles to be used in cities and/or urban areas. But besides the above advantages, there are some disadvantages to using BEVs:

1. High production costs.
2. Reduced overall size (compared to vehicles equipped with ICE).
3. Limited autonomy and top speed.
4. Large recharging time or the need for special charging places.
5. The lack of electric motor noise can cause traffic accidents (persons with hearing disabilities, pedestrians, cyclists, etc.).

The two types of battery electric vehicles classifies on the basis of the mode of transmission of electric power are as follows-

1. The internal combustion engine is replaced by the electric motor. The power produced by the electric motor is transmitted to the wheels via transmission (gearbox).

2. Each drive wheel is fitted with an electric motor (hub motor)

The use of a central electric motor design offers the advantage of using the same design as existing vehicles on the market. Also using the gearbox increases the efficiency of the usage of the power developed by the electric motor depending on load being placed on the vehicle based on traffic conditions. However, it should be mentioned that the use of a gear box lowers the overall efficiency due to inherent friction in the mechanisms that compose it.

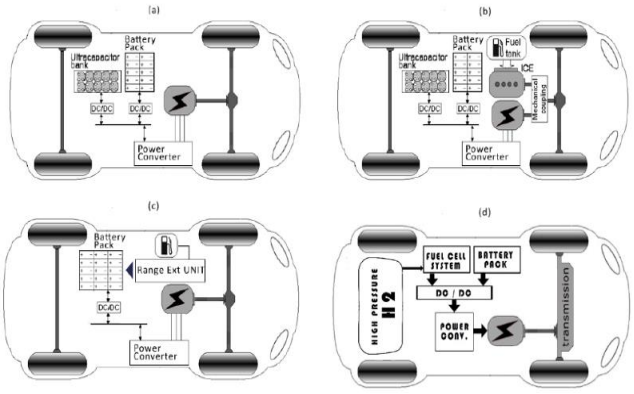

Fig -2: Simplified architecture of electric vehicle (a)Battery vehicle (b)Hybrid vehicle (c)Rang extended vehicle (d)Fuel cell vehicle

3.3 Fuel Cell Electric Vehicles (FCEV)

FHEV are powered by an electric motor which is charged-up by combining hydrogen and oxygen to create a chemical reaction. The fuel cell draws in oxygen from around the vehicle which reacts with stored hydrogen. Electricity is generated which powers the motor and moves the vehicle. There are zero harmful emissions from the vehicle during this reaction, although water is produced as a waste by-product [8].

The hydrogen cell must be topped-up in a similar way to the way that traditional fuel vehicles are topped-up, although the process of filling the cell does take a few minutes longer than it takes to top-up a fuel tank. The production of hydrogen for these fuel cells creates about the same emissions levels as charging a plug-in vehicle with fossil fuel electricity.

3.4 Hybrid vehicle

A Hybrid Electric Vehicle (HEV) is a vehicle that uses two or more sources of power. The two sources are electricity from batteries and mechanical power from an internal combustion engine or any auxiliary source. This combination offers very low emissions of vehicles with the power and range of gasoline vehicles. They also offer up to 30 more miles per gallon perform as well or better than any comparable gasoline powered vehicle and never have to be plugged in for recharging. A hybrid road vehicle is one in which the propulsion energy during specified operational missions is available from two or more kinds or types of energy stores, sources, or converters, of which at least one store or converter must be on board [9]. Using hybrid energy storage system improves the efficiency of main energy source as the auxiliary source can support it and can save it from high and varying loads.

4. EOLUTION OF ELECTRIC VEHICLE

The first electric vehicle was built by Thomas Davenport from Brandon, UK in 1834, he built a battery to supply an electric motor and he used it to drive a small vehicle that managed to go a short ride on rail. In 1881, Frenchman Gustave built EV includes a DC motor that fed by lead-acid batteries, the whole vehicle and its driver weighed approximately 160 kg. Two years later, a vehicle similar to this was built by two British professors. These early realizations did not attract much attention from the public because the technology was not mature enough to compete with horse carriages. Speeds of 15 km/h and a range of 16 km were not exciting for potential customers. The following 20 years were an era during which electric vehicles competed with their gasoline counterparts. This was particularly true in America, where there were not many paved roads outside few cities. The limited range of electric vehicles was not a problem. However, in Europe, the rapidly increasing number of paved roads called for extended ranges, thus favoring gasoline vehicles.

In 1894, the first commercial electric vehicle was Morris and Salom's Electroboat show. This vehicle was operated as a taxi in New York City by its inventors company. The Electroboat proved to be more profitable than horse cabs despite a higher purchase price (around 3000 vs. 1200$ in that era). It could be used for three shifts of 4h with 90-min recharging periods in between. It was powered by two 1.5 hp motors that allowed a maximum speed of 32 km/h and a 40-km range.

Fig -3: Morris and Salom's Electroboat used as cab in New York

The most significant technical advance of that era was the invention of regenerative braking by Frenchman M.A. Darracq on his 1897 coupe. This method allows recuperating the vehicle's kinetic energy while braking and recharging the batteries, which greatly enhances the driving range. It is one of the most significant contributions to electric and hybrid electric vehicle technology as it contributes to energy efficiency more than anything else in urban driving [10]. In addition, among the most significant electric vehicles of that era was the first vehicle ever to reach 100 km/h. It was "La Jamais Contente" built by Frenchman Camille Jenatzy in

1899. Electric vehicles started to disappear because of their limited driving range and performance that really impaired them unlike their gasoline counterparts, which became more powerful, more flexible, and above all, easier to handle. The last commercially significant electric vehicles were released around 1905. During nearly 60 years, the only electric vehicles sold were common golf carts and delivery vehicles.

In 1945, the innovation of the transistor and thyristor allowed switching high currents at high voltages. This made it possible to regulate the power fed to an electric motor without the very inefficient rheostats, and allowed the running of AC motors at variable frequency. During the 1960s and 1980s, about the environment triggered some researches on electric vehicles and many carmakers produced prototypes and small series of electric vehicles designed especially for specific markets.

However, despite advances in battery technology and power electronics, their range and performance were still an obstacle [11]. The modern electric vehicle era culminated during the 1980s and early 1990s with the release of a few realistic vehicles by firms such as GM with the EV1 and PSA. Although these vehicles represented a real achievement, especially when compared with early realizations, it became clear during the early 1990s that electric automobiles could never compete with gasoline automobiles for range and performance [12]. The reason is in batteries, the energy is stored in the metal of electrodes, which weigh far more than gasoline for the same energy content.

4.1 Development of commercial Electric Vehicle

Nissan Alliance reached 200,000 all-electric vehicles delivered globally, representing a 58% share of the global light-duty all-electric market segment.

The world's top selling all-electric cars in 2014 were the Nissan Leaf (61,507), Tesla Model S (31,655), BMW i3 (16,052), and the Renault Zoe (11,323). Accounting for plug-in hybrids, the Leaf and the Model S also ranked first and second correspondingly among the world's top 10 selling plug-in electric cars. All-electric models released to the retail customers in 2014 include the BMW Brilliance Zinoro 1E, Chery eQ, Geely-Kandi Panda EV, Zotye Zhidou E20, Kia Soul EV, Volkswagen e-Golf, Mercedes-Benz B-Class Electric Drive, and Venucia e30.

The world's top selling highway-capable electric car in history became the Nissan Leaf with over 200,000 units sold in 2015. The Tesla Model S, with global deliveries of more than 100,000 units, is the world's second best selling all-electric car of all-time. The Model S ranked as the world's best selling plug-in electric vehicle in 2015, up from second best in 2014.

Fig -4: Nissan Leaf Electric Car

Talking about the recent developments Tesla Model 3 was unveiled on 31 March 2016. With pricing starting at US$35,000 and an all-electric range of 215 mi (346 km), the Model 3 is Tesla Motors first vehicle aimed for the mass market. Retail deliveries of the Chevrolet Bolt EV began in the San Francisco Bay Area on 13 December 2016. In December 2016, Nissan reported that Leaf owners worldwide achieved the milestone of 3 billion km (1.9 billion miles) driven collectively through November 2016, saving the equivalent of nearly 500 million kg (1,100 million lb) of CO_2 emissions. Global Nissan Leaf sales passed 250,000 units delivered in December 2016. The Tesla Model S was the world's best-selling plug-in electric car in 2016 for the second year running, with 50,931 units delivered globally. In February 2017 Consumer Reports named Tesla as the top car brand in the United States and ranked it 8th among global carmakers. Global sales of the Nissan Leaf achieved the 300,000 unit milestone in January 2018.

5. CONCLUSION

This paper deals with the basics of electric vehicles. It gives introduction to electric vehicles and their needs. Types of electric vehicles are explained with the system of proposed electric vehicle and its topologies. Further studies can be done to improve the hybrid system. Various other energy sources like fuel cells, flywheels etc. Can be made to work with each other to form a efficient hybrid system.

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