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Types of Batteries used in Electric Vehicles

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Abstract

As global automobile industry is developing rapidly there are many changes taking place in the vehicles we use, but electric vehicles are long way to go to compete with regular IC engine vehicles. In developing nations electric vehicles are still not a good choice for consumers as they are too expensive and also due to their constraints. At present times mostly Li-ion batteries are used in the EV's but, Li-ion also has its own limitation. Hence, we are reviewing about the technological status and limitations of various kinds of batteries and electrochemical devices that can be used in EV's. And also, we are discussing briefly about the future of powering the electric vehicles.

Keywords*: - Automobile, constraints, limitation, electrochemical.*

INTRODUCTION

Electrical vehicles are using rarely in this polluted world even though they are invented in 1800s,it has been crossed nearly 200 years, since they are invented but there is not as much as development like IC engines vehicles which are using rapidly in nowadays because of the availability of fuels like petrol, diesel and CNG whereas electric vehicles (EVs) doesn‟t have more availability of charging station [1]. Due to recent technology development, EVs can challenge to fuel cars with improvement in battery technology and charging stations. Electric vehicles have to improve in long range transportation and battery charging capacity. Many companies looking forward to reduce charging time like tesla motors. The batteries used in EVs are specifically designed for high KW/h. In major cities 40% of pollution is occurred due to usage of fuel combustion vehicles. Hence, use of electric energy vehicles is important to reduce the environmental impact. The batteries used in electric vehicles are rechargeable batteries and 100% recovered and reusable.

There are different types of batteries such as lead-acid, Ni-cd, Ni-Zn, Zn-air, Nickel-metal hydrate, li-po, Lithium-ion, Lithium-sulphur, lithium-air, Graphene, Ultra-capacitors batteries, etc., are used in EVs. These batteries can also be recharged through solar energy. The current study focuses on major batteries used in electric vehicles, the different technologies used in batteries and the possibility of implementation in EVs are reviewed with suitable research articles.

Li-ion batteries are most used batteries in the electric vehicles now a day. Li-ion battery is an advanced rechargeable battery. First commercially developed by Sony in the early 1990"s. Li-ion batteries have unmatchable combination of high energy and power density. It is significantly reducing greenhouse gas emissions if the EV"s are well used. But it is economical and there is a shortage of Lithium and some transition metals in the near future. Commercial Li-ion cells uses various cathode materials especially LiMn2O4, due to its ease of production, thermal safety, easily available and economical [2-5]. Based on the Life Cycle Assessment (LCA) of NiMH, NCM and iron phosphate lithium-ion batteries, on a storage basis, NiMH gives more environmental impact, followed by NCM and then LFP, irrespective of ozone layer depletion [6].

High energy of Li-ion batteries may also allow their use in various electric grids including improving the quality of the energy harvested from the renewable sources like wind, solar, geo-thermal etc. Li-ion is the third lightest element and has one of the smallest ionic radii and also has high gravimetric, volumetric capacity and power density.

During charging, Li-ions are inserted into and deinserted from negative electrode and positive electrode, respectively also during charging Li+ is deintercalated from cathode oxide compound and inserted into lattice oxyanode. The cathode has high potential and pure alloy state, where as the anode has low potential and rich alloy state, the process is reversed during discharge, as shown in figure 1 [taking as an example an anode with graphite and a cathode with layered oxide compound].

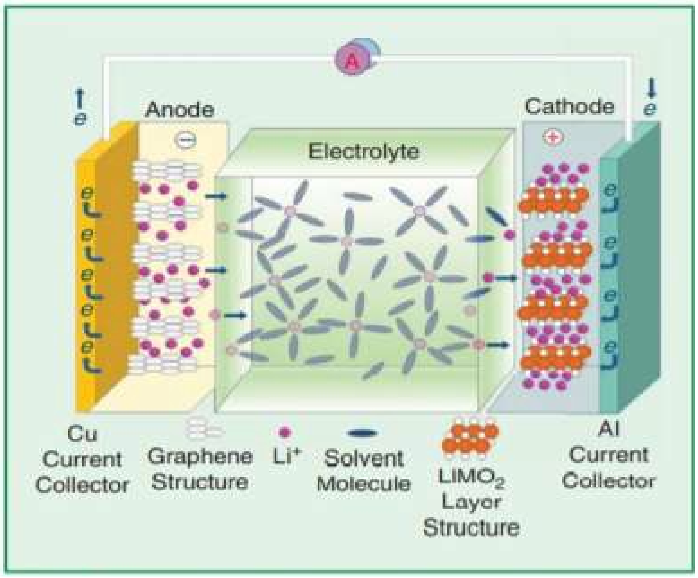

Figure 1: Li-ion battery [source: US department of energy]

Most of the Li-ion batteries use a negative electrode principally made from carbon (graphite) or lithium titanate (Li4Ti5O12) with some other novel materials. The electrolyte typically composes of mixture of lithium salts (LiPF6) and an organic solvent (diethyl carbonate). The electrolyte must offer the highest possible lithium ion transport under use conditions. [7].

ULTRA CAPACITORS

Ultra-capacitors are super capacitors and it is a device for storing electrical energy which is growing rapidly in popularity. In 1950s general electrical engineers started experimenting components using porous carbon electrodes for fuel cells and rechargeable batteries. In 1957 H.Becker developed a electrolytic capacitors with porous carbon electrode [8]. that capacitor known as super capacitor as it stored high amount of energy.

An ultracapacitor unit in a vehicle consists of many cells in series and possibly also in parallel much as is the case for batteries. In most cases, a number of cells are combined into modules for convenience of assembling the ultracapacitor pack for the vehicle. The cell characteristics are the key factors in determining the ultracapacitor unit performance. [9]

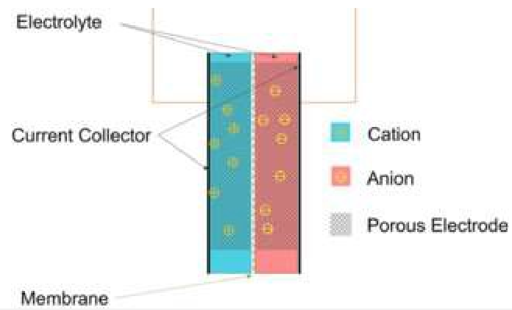

Figure 2: Schematic diagram of ultra-capacitor

Working of Ultracapacitor

Basically, the ultracapacitor has ability to quickly accumulate power and can provide an uninterrupted energy. Here the working of ultracapacitor is we know that energy is stored in ultra-capacitor by polarising the electrolytic solution. The charges are separated through electrode-electrolyte interference. This is the main working principle of ultracapacitor. It has unlimited life cycle compared to electro chemical battery. It has quick charge time compared other batteries [10]. The ultra-capacitor has some of major disadvantages that constricted the use of ultracapacitors in market. It has low voltage compared to convention batteries hence voltage drops this was the considerable loss in ultra-capacitors. The ultracapacitors cells have low voltage equate to other batteries and series connections are needed for high voltages [11].

(NIMH)

It is a type of rechargeable battery. NiMH was patented in 1986 by Stanford Ovshinsky, founder of Ovonics. The electrolyte used in this battery is alkine solution and positive (+) electrode is hydroxide & negative (-) electrode is alloy of nickel, titanium, vanadium [12]. NiMH has double energy density compared to lead acid batteries. The batteries used in our daily applications are harmful to environment. But this battery is harmless to environment. This battery is used for high voltages with safety measures [13]. The major advantage with this battery is it can resist to cover charge and discharge cycles. Even though it is a good electric battery, it has some of disadvantages like it has limited life cycle i.e., 200-300 if discharged on high load current. It is difficult to access and it has a pretty much cost. When we notice temperature in this battery it is not that much good compared to other batteries [14].

This Ni/MH battery has high performances for the specific power, the energy density and the charge efficiency. In particular their ampere-hour (Ah) efficiency is 100% and Watt-hour (WH) efficiency is 90–95% in the intermediate state of charge (SOC), this battery is very suitable for HEV application. This battery module is very safe due to its excellent resistance to over-charging and over discharging. In addition, it has favorable durability in the HEV application [15].

There are some few models of Ni/MH batteries are shown in **figure 4.** The EV-95 (95 Ah) and the EV-28 (28 Ah) units developed for Electric vehicles.

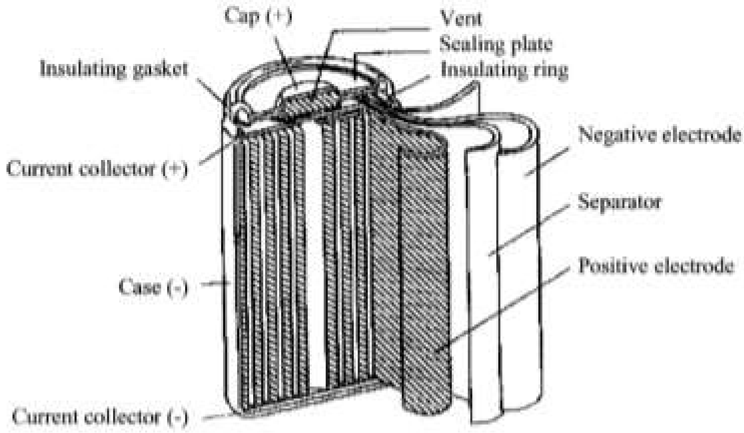

Figure 3: Structure of cylindrical battery cell [15].

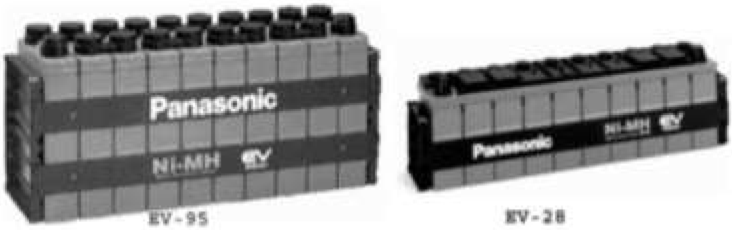

Figure 4: Ni/MH battery modules for EV application

EV-95, these are some of models of Ni/MH which has long life characteristics of more than 1000 cycles and 4-year on-board driving, shows excellent total performance for vehicle driving. They need to control hydrogen loss and these are actively pressing ahead with mass production of these batteries, and they are on sale and being leased for EVs [16].

Although these are cheaper than li-ion batteries, performance degraded if stored at elevated temperatures, need more complex charge algorithm and generates more heat during charge makes the Ni/MHs away from EV applications [17].

It is a type of secondary battery i.e., rechargeable battery, despite having a very low energy-to-weight ratio and a low energy-to-volume ratio, its ability to supply high surge currents means that the cells have a relatively large power-to-weight ratio. It was invented in 1859 by French physicist Gaston Planté. In this battery the electrolyte is made of sulphuric acid and it has lead acid as positive (+) electrode and spongy lead as (-) negative electrode. Compared to other batteries it has low cost. In the fully charged state, the negative plate consists of lead, and the positive plate is lead dioxide. The electrolyte solution has a higher concentration of aqueous sulfuric acid, which stores most of the chemical energy [18].

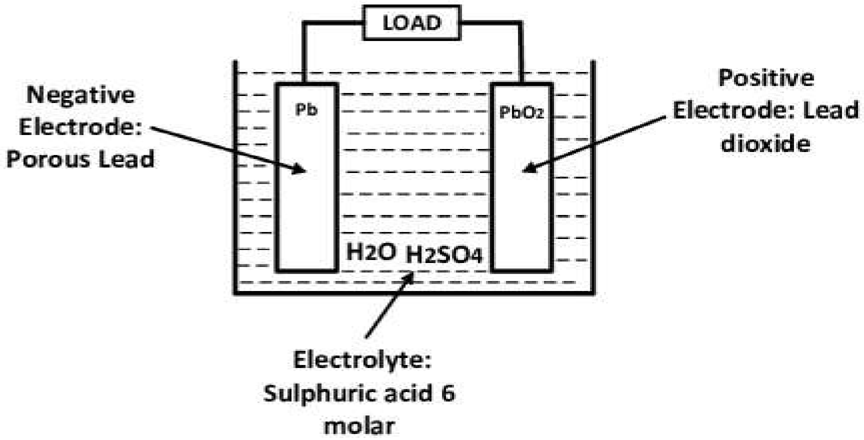

Figure 5: Lead acid battery

Lead acid batteries (shown in **figure 5**) are easy to manufacture and available in all shapes and size, best value for power and energy per kilo-watt hour, around 97% of lead is recycled and reused in new batteries and less cost when compared to other batteries. But it is not much used in cars because it is used as secondary battery to generate 12V power. Being a good battery lead is itself a toxic especially to children. Regarding to this it can"t be discharged more than 20% of capacity. Also, these batteries also have limited life cycle [19].

Nickel cadmium

Nickel cadmium batteries are invented in 1899 but are gradually lost its value to its competitors which are lead acid batteries and nickel metal hydride due to its high cost. But it has many advantages which are it can be used at very low temperatures and it offers good life cycles than the other batteries. In the Ni-Cd batteries Nickel oxide hydroxide as positive electrode and cadmium as negative electrode and potassium hydroxide as an electrolyte [20].

Hydrogen fuel cells

Some automaker like Nissan, Ford, Volkswagen and some other companies developing hydrogen fuel cells. Fuel cell cars and trucks combine hydrogen and oxygen to produce electricity which runs a motor. Hydrogen is the most common element on the earth and it is lightest element approximately 14 times lighter than air. It can be refilled easily like fuel cars.

Many automakers have been trying to produce their first fuel cell car but here comes with „Hundai". It was the first company to lunch fuel cell car in the market in 2015, i.e., Tucson fuel cell car. The fuel cell stacks are designed to last the life time of vehicle that is around 150,000-miles. The fuel cell car model is shown in figure 6. There's no carbon added to the by-products of combustion in a hydrogen engine [21]. See below **figure 6**.

Due to lack of hydrogen stations, fuel cell cars are not being in use. Hydrogen behaves differently from gasoline & fuel cars, and it is not flammable than gasoline and petrol. Also, fuel cells are expensive especially material such as catalyst.

Lithium Sulphur

Lithium sulphur batteries have gathered so much attention in recent years. They recognised as the most promising next generation batteries for the future of EVs. Lithium sulphur battery pack is configured with 61.3KW/h to power a mid-sized EV for a range of 320km [22]. Unfortunately in Lithium Sulphur batteries, sulphur have some challenging characteristics such as high volume change upon cycling, low conductivity and high solubility towards the electrolyte and also the lithium metal anode has the low coulombic efficiency due to the formation of the dendrites due to this it effects the battery life cycle and also causes safety hazard. Through the intensive research and technical developments these problems can be addressed with certain solutions. [23]. And the Lithium metal anode can be addressed by the formation of a passivation layer which can be artificially produced by treating with chemicals such as Tetraethoxysilane, chlorosilane, nitrogen etc., to isolate the anode from undesired side reactions to supress the dendrite growth and improve the coloumbic efficiency. So, thus by improving efficiency through these methods Li-S may take over the Li-ion batteries in future.

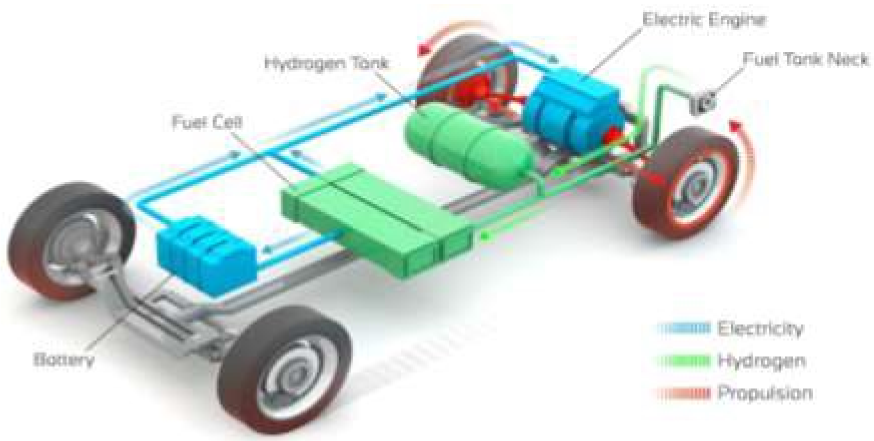

Figure 6: Fuel cell car model

As we all know that by adding graphene to the conventional batteries improve their efficiency and capacity proving it is good potent conductor of electrical and thermal energy. So use of the graphene battery may increase the electric vehicle efficiency and also driving range. Graphene batteries have not reached the widespread commercialization yet but some breakthroughs are reporting around the world about these batteries. Graphene batteries have high capacity, faster charging, light weight, flexibility, high temp range. These batteries have all the qualities that can be used in the EV"s. Graphene batteries have promising future in battery technology [24].

Solar panels

Generally, we use solar panels to create electricity. Technology is developing rapidly; these solar panels are used to run vehicles. It is the one of the sources for EVs to power up battery of electric vehicle. No greenhouse gas emissions are released into the atmosphere while using solar panels to produce electricity. Photovoltaic cells are contained in solar panels convert the sun energy directly into electrical energy.

The term „solar vehicles" usually imply that solar energy is used to power all the parts of vehicles propulsion. The **figure 7** shows the solar panel based electric car. Generally, 2kW of solar panels should be enough to provide power equal to or greater than the consumption of average electric car. A 250W solar panel will produce around 30-42.5kW of AC per month [25].

Figure 7: Solar panel based electric car

CONCLUSION

In this paper different types of power sources for electric vehicles and future scope on batteries are discussed. The different types of batteries i.e., lithium-ion, nickel-metal hydrate. Lead-acid, ultra-capacitors, fuel cells and solar panels there are different types of sources used to run vehicles. The electric vehicles can create a friendly environment. Out of all these batteries discussed above, mostly preferable battery is lithium- ion and in future graphene and lithium-sulphur can have much competition to Lithium-ion. Solar panel based electric vehicles also lead a major role in future due easy source of energy.

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