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Overview of Energy Storage Devices Use in Electric Vehicle

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ABSTRACT

This paper mainly illustrates about the energy storage devices mainly used in electric vehicle and shows the comparison of the different storage devices according to the present need of electric vehicle. It consists of various batteries, ultra-capacitor, fuel cell and fly wheel used in electric vehicle. After comparative analysis of various energy storage devices final selection of energy storage is finalized as per the merits in the Electric Vehicle application.

KEYWORDS: *Energy storage devices, batteries, ultra capacitors, fly wheel, fuel cell.*

I. INTRODUCTION

In present scenario electric vehicles are in demand.so it mainly involves of various energy storage devices like batteries, ultra-capacitors and fuel cells. There are a number of supplies for energy storage applied in a motorized application, such as specific energy, specific power, efficiency, cost, environmental alteration, safety and maintenance requirement. For allocation on an electric vehicle, specific energy is the first concern since it limits the vehicle range. The energy storage system through high specific energy and high specific power which permits rapid charge to moderate the long charging time required nowadays.

This paper comprehensively reviews knowledge of energy storage system, its classification, characteristics, construction with advantages and disadvantages for electric vehicle application.

II. BATTERIES FOR ELECTRIC VEHICLE

Batteries have been the major energy source for electric vehicle for a long time. Dissimilar battery tools have been designed and implemented and this process still going on to accomplish the preferred performance aims. Battery is electrochemical cell also known as galvanic cell consist of three primary elements which is two electrodes one positive and another is negative immersed in an electrolyte.

A. Lead acid batteries

The lead acid batteries are the most widely used battery in electric vehicles. In lead acid cells the spongy lead act as a negative active material and the lead oxide act as a positive active material. The plates are deep in an electrolyte of diluted sulphuric acid. The benefit of battery is that it is low in cost, mature technology, high power capability, high specific energy, high specific power long cycle life, maintenance free, rapid recharge

capability. Also it has some disadvantages also because of low energy density and poor temperature characteristics.

B. Nickel Based Batteries

1. Nickel –Iron battery

Nickel iron battery employs the nickel oxyhydroxide as positive electrode and the metallic iron as negative electrode, which is to be uses the electrolyte of potassium hydroxide solution mixed with lithium hydroxide.

It has open circuit voltage 1. 37v.The advantage of this battery high power density, capability to withstand,2000 deep discharge. Disadvantages of this battery gassing, corrosion, self-discharge, is so complex, low temperature than lead acid battery, high cost. This battery is mainly used in fork lift trucks, mine locomotive, shunt vehicle, railway locomotive, motorized hand truck.

2. Nickel –cadmium battery

It has open circuit voltage 1.3v. The advantage of this battery is high specific power, high tolerance, long cycle life, small voltage drops, rapid charge capability, wide operating temperature, long term storage. Disadvantages are high initial cost, low cell voltage, because of cadmium it causes environmental hazard.

3. Nickel –metal hydride battery

The Ni-MH battery composed of nickel hydroxide as positive electrode and alloy of vanadium, titanium and nickel as negative electrode. The alkaline solution used as electrolyte. Features of this battery are like it has flexible size ranging, high specific energy, high specific power, simple and inexpensive, no maintenance, excellent thermal properties, it has capability to use regenerative braking energy. The main challenges with this battery is high self-discharge and heat generation at high temperature and the need to control hydrogen losses.

C. Lithium Based Batteries

1. Lithium polymer battery

The lithium polymer battery uses lithium metal for negative electrode and a transition metal intercalation oxide for the positive electrode.it has capability of fabrication in variety shapes and sizes. Its nominal voltage is 3v.it has low discharge rate up to 0.5% per month. Drawback of this battery is it has weak low temperature.

2. Lithium Ion battery

The lithium ion battery is rechargeable battery. The lithium ion battery employs oxidized cobalt material as positive electrode and carbon material as negative electrode which is Tobe placed in electrolyte of lithium salt in an organic solvent.it has energy density twice of the nickel metal hydride battery. Advantages of this battery are like it is light in weight, high volume capacity, high specific energy, it has good high temperature performance, low maintenance, low self-discharge. Disadvantages are like it has moderate discharge current, it requires protection circuit and also subject to aging and transportation regulation, and it is expensive. The main challenge is that it has possibility of over discharge which can be dangerous and may lead to the explosion.

TABLE I: -Comparative Analysis of Energy Storage Batteries [1,2]

Parameters	Lead Acid Battery	Ni-Ion Battery	Ni-Cd Battery	Ni-Mh Battery	Li-Polymer Battery	Li-Ion Battery
Specific Energy	High	Low	Low	Low	High	High
Cost	Low	High	High	Low	High	High
Energy Efficient	Yes	Yes	Yes	Yes	Yes	Yes
Charging Capability	Rapid Recharge	Self-Discharge	Rapid Charging	High Self-Discharge	Low Self-Discharge	Low Self-Discharge
Life Cycle	Long	Long	Long	Short	Long	Long
Weight	3x Weight Of Li-Ion Battery	Less	Less	Less	Less	Less
Temperature Performance	Poor	Poor	Poor	Poor	Good	Good
Maintenance	No	Yes	Yes	No	No	No
Environmental Hazard	No	No	Yes	No	No	Yes
No Of Recharging Cycle	500	1000	1350	1350	1000	1000

III. ULTRA-CAPACITOR USED IN ELECTRIC VEHICLE

Capacitors are the devices in which two conducting plates are separated by an insulator. The opposite charges on the plates attract and hence store energy (Q = C*V). The large energy storing capacitors with large plate areas are called as ultra-capacitor.it also known as super capacitor. Energy stored in capacitor is can be given as,

$E = ½ (C * V^2)$

The ultra-capacitor is an electrochemical capacitor which having relatively high density. The energy density of ultra-capacitor is hundred times greater than the conventional capacitor. The ultra-capacitor is mainly having three parts which are two electrodes, an electrolyte and a separator. The ultra-capacitor stores energy by separating positive and negative charges. The positive electrode attracts the negative ions and the negative electrode attract the positive ions. The power density of ultra-capacitor is higher than the battery.

Advantages of ultra-capacitor is that it has low internal resistance, high efficiency and low Soc.There are mainly three types of ultra-capacitor technologies available 1. Double layer capacitor 2. Pseudo capacitor 3. Hybrid capacitor

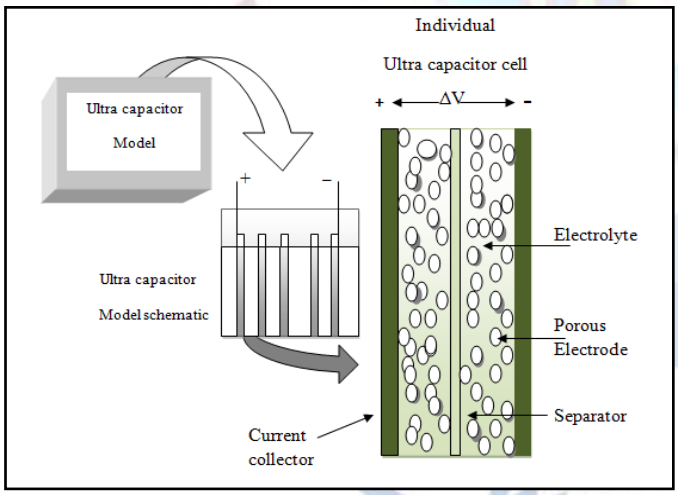

Fig. ultra-capacitor module [5]

IV. FLYWHEEL FOR ELECTRIC VEHICLE

A flywheel is an electromechanical method to energy storage. for collection of electricity, a motor is used to exchange the electrical energy from an external source into the rotational energy of a flywheel. Using the motor as a generator and extracting energy regains the stored energy and slows the flywheel. A complete flywheel battery system consists of the flywheel, magnetic hearings, a motor generator. power electronics and control electronics. Flywheel systems with high energy density are prepared of composite material for the demands for high strength. The necessity for high strength is fundamental for minor flywheels.

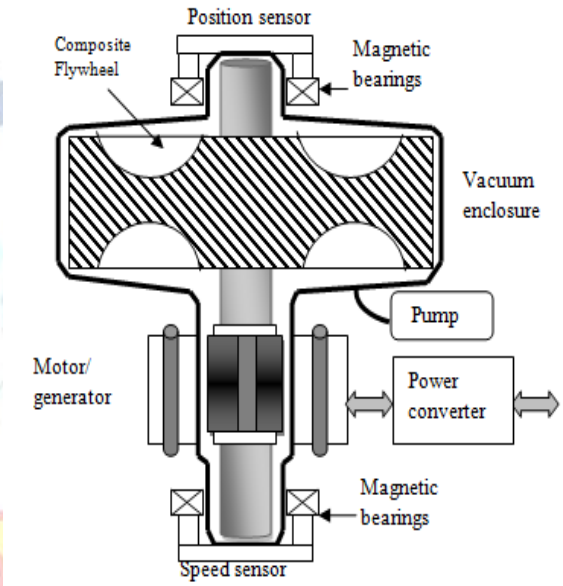

Fig. layout of High speed rated flywheel [6]

V. FUEL CELL FOR ELECTRIC VEHICLE

The Fuel Cell creates electricity from the fuel on the anode and the oxidant on the cathode and reacts in the electrolyte. Throughout the generation process, the reactants flow into the cell, whereas the products of reaction flow out. The Fuel cell is able to reduce electricity as long as the reactant flows are sustained. Benefits of the Fuel cell contain high conversion efficiency of fuel to electrical energy, quiet operation, zero or very low emission, waste heat recoverability, fuel flexibility, durability, and reliability. Different arrangements of fuels and oxidants are likely for Fuel cells. Hydrogen Is an ideal non-polluting fuel for FCs, since it has the highest energy density than any other fuel, and the product of cell reaction is just water. Other fuels include hydrocarbons and alcohols Unlike electrochemical batteries, the reactants of FCs must be refilled before they are used up. In vehicular uses, a specific fuel tank should be involved on board. Due to the relatively low energy density (2.6 kWh/L for liquid hydrogen compared with 6 kWh/L for petrol), large fuel tanks are required. The efficiency of the Fuel cell is in need of on the amount of power drawn from it. Usually, the more power drawn, the lower the efficiency. Utmost losses manifest as a voltage drop on internal resistances. The response time of fuel

cells is relatively longer related with that of batteries and Ultra capacitors. Another problem of Fuel Cells is that they are costly. FCs currently cost five times more than ICEs, the major cost components being the membrane, the electro catalyst, and the bipolar plates. New research is in progress to develop hydrocarbon membranes to replace the current per fluorinated membrane.

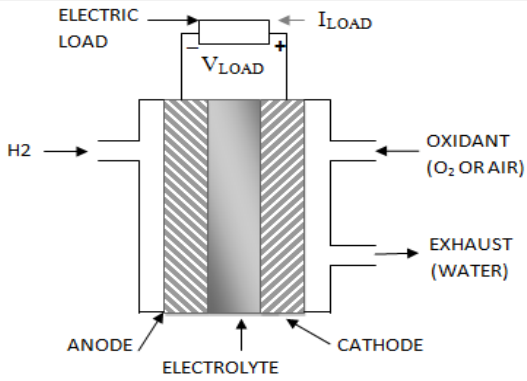

Fig. configuration of hydrogen fuel cell [2]

TABLE II: - Comparative analysis of the energy sources used in electric vehicles [2,3,5]

Parameters	Battery	Ultra Capacitor	Flywheel	Fuel Cell
Specific Energy	High	High	Low	Low
Cost	High	High	Low	High
Energy Storage	High(30 To 40 Wh/Kg)	Low (3 To 5 Wh/Kg)	High	High
Life Span	Long	Long	Long	Long
Efficiency	80% To 85%	>95%	90-95%	In Need Of Amount Of Power Drawn Form It
Environmental Hazard	Subject To Aging	Eco Friendly	Safety Concerns	Highly Flammable
Charging Capability	Low Self Discharge	High Self Discharge	High Charging And Discharging Rate	High charge and discharge time
Reliability	High	High	High	Low
Maintenance	No	No	No	Yes

VI. CONCLUSION

In this study, energy storage systems like batteries, ultra-capacitor, flywheel, fuel cell are mentioned with their features like specific energy, specific power, cost, weight, reliability, efficiency, maintenance, etc. Therefore, as per given aspects ultra-capacitors are more preferably is Tobe used because of high efficiency, no maintenance, high specific energy and more reliability but the storage capacity is low than battery. In present scenario combination of batteries and ultra-capacitor to improve the storage capacity. So in all batteries lithium ion battery is used because of its good features and it more efficient to use.

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