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TYPES OF POWER STORAGE USED IN ELECTRIC VEHICLES

Arpita Waikar[1], Bhumika Kaswate[2], Aachal Jaiswal[3]

[1]*Arpita Vinodrao Waikar, Dept Of EE, J.D.I.E.T Yavatmal, Maharashtra, India,* ***arpitawaikar22@gmail.com***
[2]*Bhumika Sunil Kaswate, Dept Of EE, J.D.I.E.T Yavatmal, Maharashtra, India,* ***kaswatebhumika@gmail.com***
[3]*Aachal Shailendra Jaiswal, Dept Of EE, J.D.I.E.T Yavatmal, Maharashtra, India,* ***aachaljaiswal8421@gmail.com***

Abstract

Due to the decrease in petroleum resources and declining the air quality, global warming ,electric vehicle are becoming more commonplace in the transportation sector in recent times .On one time charging electric motors can travel up to 150-180 km. It can be recharge whenever is convenient to user. It is more cost effective than regular vehicles or cars due to the long lasting battery use. An electric vehicle (EV) is a vehicle energized by an electric motor, rather than an internal combustion engine (ICE). This power is supplied to EVS by the power storage devices such as batteries, ultra-capacitors and flywheels which are overviewed in this paper. The battery is main energy storage device in the electric vehicle. The electric vehicle marketing is dependent on significant advancement in the battery technology . There are various different parameters of batteries and types of batteries available today are mentioned in this paper. Ultra-capacitors are basically static component. Its charging and discharging speeds are very fast. It has excellent life cycle .Flywheel is another energy storage .It acts as a motor during the storage state.

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INTRODUCTION

The development of automobiles with heat engines is one of the greatest achievements of modern technology. However, the large use of automobiles creates serious problems for society and human life. Decline in air quality, global warming, and decrease in petroleum resources are becoming the major threats to human beings. More and more severe emissions and fuel consumption regulations are stimulating an interest in development of safe, clean, and high efficiency transportation. It has been well recognized that electric technologies are the most promising solution to the problem of land transportation in the future.

An electric vehicle (EV) is a vehicle energized by an electric motor, instead of an internal combustion engine (ICE), the power stored in the batteries runs the electric motors.

The batteries have to be charged regularly by supplying any main (120 V or 240 V) supply.

WORKING OF ELECTRIC VEHICLE

An electric vehicle mainly consist of three main components :

- Battery
- Controller
- Electric motor

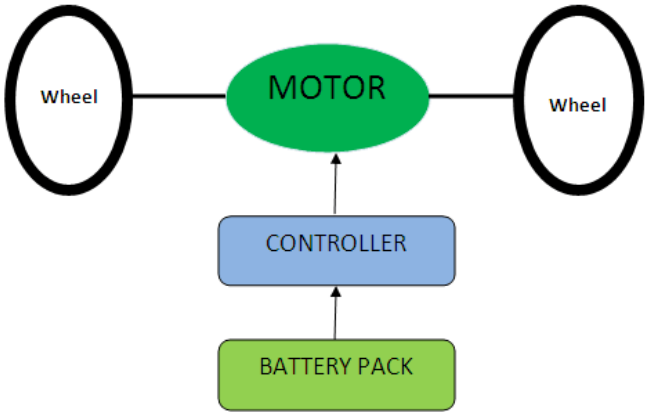

Fig 1 Block diagram of Electric Vehicle

Electric motor : The electric vehicle can be work on AC as well as DC motor. If we use DC motor of rating 20 kw, the car may run between the voltage 96v to 192v. Motor works on the principle of electromagnetic induction where change in the magnetiv flux causes the central shaft to rotate. In case of 3 phase AC motor it runs at 220 to 240 v along with300v battery packs. AC motor are easily available in various size, shapes nd power rating in contrast to DC motor. AC motor also uses regenerative braking which act as agenerator to charge the batteries while braking.

Motor-controller : It controls the amount of current supplied to motor which is depends on amount of pressure on accelator pedal. To provide the signal, on how much power to deliver the accelerator is connected to variable resistor . When there is no pressure on accelerator, no power is deliver and vice versa.The controller takes power from battery and delivers power to motor. In case of 3-phase AC motor we required 3 sets of MOSFET . This is more complicated than DC motor.

Battery : Batteries store the energy and convert to electrical energy from chemical energy when required. Battery must be designed with high ampere-hour capacity.
TYPES OF POWER STORAGE USED IN EV'S

- Batteries
- Flywheels
- Ultra-capacitors

BATTERIES :

The electric vehicle marketing is growing globally . However it is dependent on the significant advancement in the battery technology. Consumers want to feel more confident in a way that their electric vehicle will have long range and quick charge capabilities. The battery is the main energy stored device in the electric vehicle. The battery in fact administered the success of electric vehicles. The amount of electricity stored in the battery is measured in ampere- hours or in coulombs, the total energy measured in watt –hour.

CHARACTERSTICS OF BATTERIES

For studying characteristics of battery some important parameters needed to be study. The characteristics are as given below-

1. VOLTAGE

The approximate value of EMF is nearly about 2.0 v per cell. This value varies as their is change in specific gravity of electrolyte, temperature and time from where it is charged. The EMF of cell is directly proportional to specific gravity but with increase in specific gravity of electrolyte cause effect on internal resistance (i.e. increases). The terminal voltage while charging is high whereas it is low at the time of discharging.

2. CAPACITY

Capacity is the quantity of electricity mixed with electrochemical reaction. Capacity is symbolically given by 'Q' and can be understood by-

$$Q = x*n*f$$

Where,
x- No. of moles of reaction
n- no. of electrons transferred per mole of reaction
F-Faraday's Constant

Capacity of cell depends upon various parameters. The capacity of cell varies infinitely as surface area quantity used of active material. The capacity of cell also depends upon concentration of electrolyte. This electrolyte affects the internal resistance which further affects the life span of battery. It is directly proportional to specific gravity of electrolyte.
Capacity of battery can also be given by

Ampere-hour (at 12 volt)= watt hour / 12

For example: if a battery is providing 6 amp of current for 15 hours then battery is rated 190 AH. The power obtained is directly proportional to ampere hour rating.

3. DISCHARGE CURVE

It gives the relationship between voltage and percentage of capacity discharge. It is desirable characteristics, which describe voltage is constant while battery is used up.

4. TEMPERATURE DEPENDANCE

Temperature is inversely proportional to the internal resistance. As temperature increases, it's internal resistance decreases and vice versa.

5. SERVICE LIFE

The life of battery lies between 500to 1200 cycles .Battery can be permanently damaged by-

- Short circuiting
- Over discharging
- Over charging
- Drawing large current than rated
- By extreme temperature

TYPES OF BATTERIES AVAILABLE TODAY:

1. Lead Acid

Lead acid batteries are the cheapest batteries. There are two types of main lead acid batteries: automobile engine starter batteries, and deep cycle batteries. Lead acid batteries are highly available, low costly and have mature technology. The component used are spongy lead, lead oxide, electrolyte, diluted sulfuric acid. It cannot discharge more than 20% of its capacity also it has a limited life cycle. Low energy and power density, Heavier and may be needs maintenance.

Fig 2 Lead acid battery

2. Nickel Cadmium /Nickel Iron

Nickel cadmium/ nickel iron batteries are more expensive than lead-acid batteries because nickel is costly. Ni-Cd has higher energy density and it has long life. Although they can be recharged very quickly, they have a tendency to overheat. Cadmium is highly toxic, so recycling efforts have to be managed very carefully. Although cadmium supplies are not very high. It is made up of copper, lead, zinc, and cadmium recycling. Ni-F. The battery have high energy density and can discharge fully without being damaged. They need to be 11% overcharged to be charged. This results in water loss and increase of hydrogen, which is a safety concern.

Fig 3 Nickel-cadmium battery

3.Nickel-Metal Hydride

A nickel-metal hydride battery is composed of electrolyte such as alkaline solution, positive electrode like nickel hydroxide and negative hydroxide like nickel, titanium, vanadium and other metals . it is environmentally friendly. The Ni MH has twice the range and cycle life is longer. . It is sealed, is maintenance free, and can be charged as quickly as 15 minutes. It can withstand overcharging and over-discharge abuse. It can stored volumetric power and energy.

Fig 4 Nickel metal hydride battery

4 . Sodium Sulfur

The NaS battery uses a ceramic beta-alumina electrolyte tube with sodium negative electrodes and molten sulfur positive electrodes within a sealed insulated container. Presently, this type of batteries have high energy density, high efficiency of charge / discharge and long cycle life , and is fabricated from inexpensive materials . The operating tempreture of 300 to 350 c and the highly corrosive nature of the sodium polysulfides, primarily make them suitable for stationary energy storage applications. The main disadvantage of the

NaS battery is the high temperature, which has raised safety hazards. Also, the battery must be charged every 24 hours to keep the sodium and sulfur from solidifying.

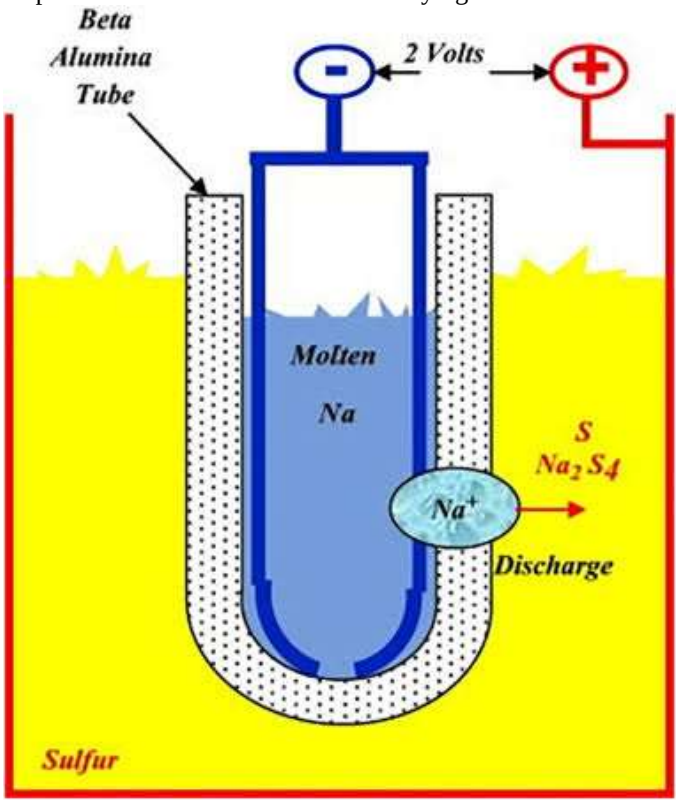

Fig 5 sodium sulfur battery

5. *Sodium Nickel Chloride*

Sodium nickel chloride (NaNiCl2) batteries are under development by AEG Anglo Batteries GmbH (Ulm, Germany). The battery operates at a temperature of 300°C and is claimed by its manufacturer to be safe in accidents and will operate even if one of its cells fails.The battery can be cooled down and reheated without damage; however, no current can be drawn from the battery if the temperature is below 270°C. Costs to produce the battery are very high. BMW and Mercedes Benz are testing EVs with NaNiCl2 batteries.

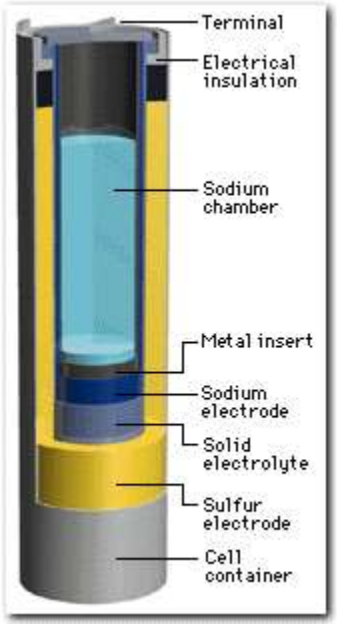

Fig 6 sodium nickel chloride

6 .Lithium –Ion

The lithium ion battery is made up of positive electrode such as oxidized cobalt material , negative electrode like carbon material and the electrolyte such as lithium salt solution in an organic solvent. and the ventilation system required to keep the batteries cool .It is costly because the battery uses an oxidized cobalt material for the anode, a highly purified organic material for the electrolyte, and a complex cell control system. The recharging of batteries take long time. This yields cells with an impressive 200+ W h/kg specific energy and a good specific power, 80 to 90% charge/discharge efficiency .It has long battery life around 1000 cycles.

Fig 7 Lithium ion battery

*7.*Lithium Metal Sulfide

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The lithium metal sulfide battery is an elevated-temperature battery based on a lithium alloy/molten salt/metal-sulfide electrochemical system. This system provides high specific

power for better acceleration. Other advantages include its small size, low weight, and low cost per kilowatt hour. The battery is composed of iron disulfide and a lithium aluminum alloy that is completely recyclable. SAFT America Cockeysville is currently researching this type of battery.

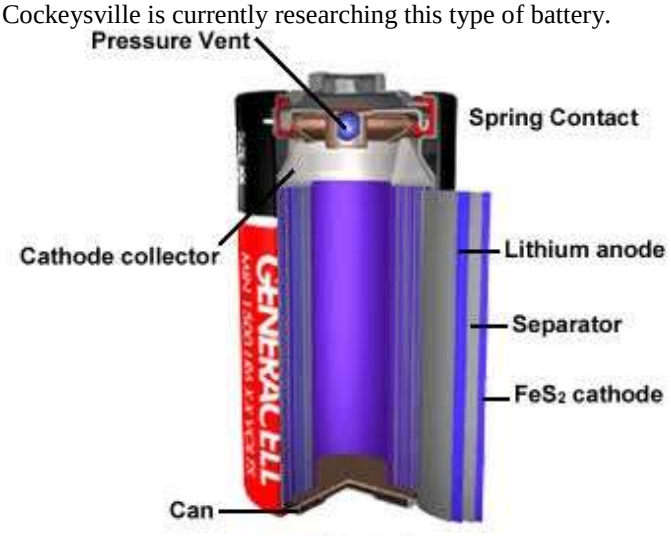

Fig 8 Lithium metal sulfide

8. Lithium-Polymer

The lithium-polymer battery is based on thin film technology. The battery worth the cost 20% more than lead-acid but deliver twice the energy, with a life span of 50,000 miles. It has an operating temperature between 65 and 120°C. It can be charged very fastly in less than 90 minutes but can be damaged by overcharging. The major challenge infront of this technology is scaling up its size to properly power an EV.

Fig 9 Lithium polymer

Table 1 Main battery types comparison

Parameter / Battery Type	Acid-Lead	NiCd	NiMH	Li	UltraCapacitor
Voltage / cell (nom.)	2	1.2	1.2	3.6	2.7
Density of energy	High	Low	Medium	High	High
Fast charge / discharge	No	Yes	Yes	Yes	Yes
Operating temperature	-20÷40 °C	-40÷60 °C	-20÷60 °C	-30÷60 °C	-40÷65 °C
Internal resistance	Low	High	Medium	Low	Low
Memory	No	Yes	No	No	No
Lifetime (cycles)	1,000	>3,000	>3,000	>1,000	>200,000
Cost	Medium	Low	Medium	High	High

Fig 10 Comparison of battery

ULTRA-CAPACITOR

Capacitor is basically a static component**.** Ultra-capacitors behave like very high-power, low-capacity batteries but store electric energy by accumulating and separating unlike-charges physically, as opposed to batteries, which store energy chemically in reversible chemical reactions. There is no chemical reaction in the components. Its charging and discharging speeds are very fast. It has excellent life cycle. However, the energy storage is limited. Its energy storage density is less than 20% of the lead –acid battery. It also has unique feature that their voltage is directly proportional to its state of charge.

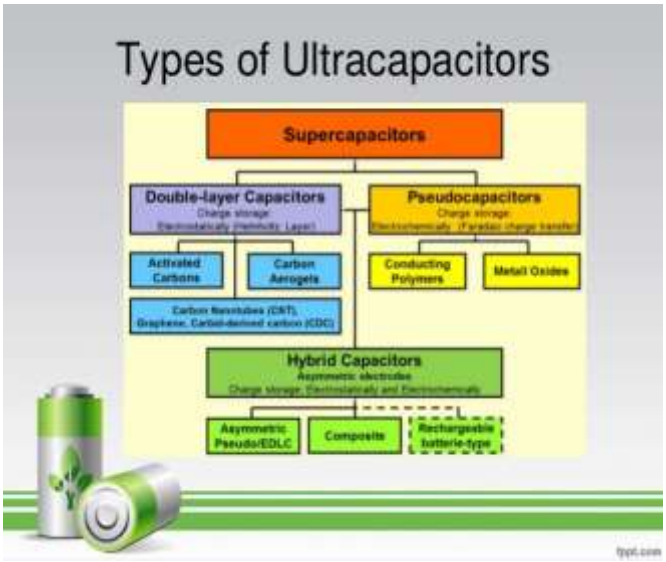

Fig 11 Types of ultra capacitor.

FLYWHEELS

Flywheels are used as energy storage by using the energy to spin the flywheel which keeps on spinning because of inertia .The flywheel acts as a motor during the storage stage. When the energy is needed to be recovered , the flywheel's kinetic energy can be used to rotate a genertor to produce power. Advance flywheels can have their rotors made out of sophisticated materials like carbon composites And to keep the flywheel spinning in a frictionless environment, each flywheel spins on an axle with magnetic bearings in a vacuum-sealed aluminum box.

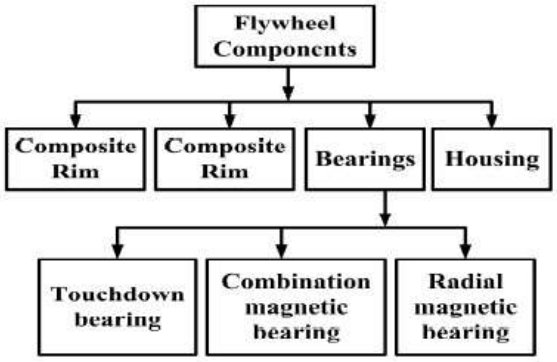

Fig.12 Basic Flywheel Components.

CONCLUSION

The analysis of context is to point the potentialities and features of electric vehicles. Electric vehicles are more efficient , environment friendly, option to the cars or vehicles available today. Lithium ion battery has impressive specific energy and specific power. It has 80 to 90% charge discharge efficiency, it has long battery life. Hence lithium ion battery are more suitable also ultra capacitor have excellent life cycle.

ACKNOWLEGDEMENT

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