REVIEW OF DIFFERENT TYPES OF BATTERIES USED IN ELECTRIC VEHICLES AND THEIR CHARGING METHODS

E Fantin Irudaya Raj
Assistant Professor, Department of Electrical and Electronics
Dr Sivanthi Aditanar College of Engineering, Tiruchendur

Abstract

With the rapid development of the automotive industry, the demand for gasoline increases sharply. The gasoline cars cause serious environmental pollution. The application of electric vehicles can solve these problems. In this paper, the significance for developing electric cars is stressed first. Then the recent progresses in developing electric car battery, charging technology, drive motor are summarized. Different type of batteries and charging methods are introduced and their feasibilities are analyzed. The future trend of electric vehicles has been discussed as well. With the development of key technologies in electric car manufacture, today's energy and environmental problems will be solved to a large extent.

Keywords: Electric vehicle, battery, charging mode, motor

I) Introduction

Electric vehicles are categorized as those powered by battery and driven by electric motor. They can be divided into pure electric vehicles, hybrid electric vehicles and fuel cell electric ones [1]. Under the double pressures from energy supply and environment protection, all countries in the world are intensely developing the electric car technology [2]. In China, a national nongovernment organization that composed voluntarily by electric vehicle industry and public institutions and workers, China Electric Vehicle Association (CEVA), was founded in 2004. Breakthroughs in some key technology in hybrid and pure electric vehicles have been made [3], and small batch production of pure electric vehicles has been achieved [1]. Japan has also attached great importance on the research and development of electric vehicles.

II) Battery

The power of electric vehicles is battery. The performance of battery determines the performance of electric vehicles. The battery develops very fast with the rapid development of electric vehicles [4]. Various kinds of cars and batteries have been developed in the whole developing process of electric vehicles. The lead-acid battery, nimh battery and lithium-ion battery are three of the batteries which are commercially used now and have a huge impact on the electric vehicle development.

Lead acid batteries. Lead acid battery is invented by Gaston Plante in 1859. Heavy metal lead works as negative electrode, lead oxide as positive plate, and sulfuric acid as electrolyte. The reaction between the electrodes and electrolyte is used to achieve the charging and discharging process [5].

Lead-acid battery has the advantages that it has a relatively mature technology and can be mass-produced. The raw materials are cheap and the production cost is low. One of its disadvantages is that the quality and volume are usually large. This increases the weight and power consumption of electric vehicles [6]. In addition, lead-acid battery has a short service life and pollutes the environment. However, lead-acid battery has a large market share in China and many vehicle manufacturers still use lead-acid batteries now.

Nimh batteries. Nimh batteries are not much used in electric vehicle market in China, but most hybrid cars use nimh batteries as auxiliary power supply. Nimh battery belongs

to alkaline batteries. Due to its high safety performance and no pollution, it has been hailed as “green energy”. The specific energy and specific of nimh batteries are high. Compared to the lead-acid battery, nickel metal hydride batteries increase three times in terms of volumetric energy density and is ten times higher in terms of power [5].

The electric car battery technology which based on nickel metal hydride batteries has some limitations [7]. The price of nickel is very high and it is a kind of insufficient resource, which are the main factors restricting the development of the Ni-MH battery. In addition, the capacity of Ni-MH batteries decreases at low temperature [8]. Compared to the lead-acid battery nickel metal hydride battery can store more energy, but over discharge will cause permanent damage. The study of nimh batteries should be made mainly for solving the problems in application. By improving the activity of catalyst on the surface of the metal hydride electrode, the rapid charge and discharge function and capacity of the nimh battery could be improved. The problems of nimh batteries can be solved through using suitable additives, conductive adhesives or optimizing the design of the battery or some other ways, and now nimh battery is still the preferred power for electric cars [9].

Lithium ion batteries. Lithium ion battery with the traditional structure includes graphite anode, lithium metal oxide cathode and electrolyte. Lithium ion batteries can be divided into lithium ion batteries and lithium polymer batteries. The cathode materials of lithium ion batteries mainly include lithium cobalt oxide, lithium nickel oxide, lithium manganese oxide, lithium iron phosphate, etc. And the anode materials mainly include graphite, lithium titanate, etc.

Table 1 represents the performance indicators of lithium ion battery in electric vehicles [10,11]. From the table we could see that compared to the nickel metal hydride batteries, lithium ion battery has relatively high operating voltage and larger specific energy. Lithium ion battery has also many other advantages such as small size, light weight, long cycle life, low self-discharge rate, high energy density, high power density, no memory effect and no pollution [13].

Table 1 Performance index of lithium ion battery in electric vehicles

NIMH battery	Specific energy/(W·h/kg)	Volumetric energy density (W·h/l)	specific power(W/kg)	cycle-index	monomer voltage/V
NIMH battery	30~110	140~490	250~1200	500~1500	1.2
Lithium-ion battery	Specific energy/(W·h/kg)	Volumetric energy density (W·h/l)	specific power(W/kg)	cycle-index	monomer voltage/V
Lithium-ion battery	100~250	250~360	250~340	400~2000	3.7

Note: The data of the electric car battery come from the literature [12].

There still exist some problems in the application of lithium-ion batteries in electric cars. The reason is that both the pure electric vehicle and hybrid electric vehicle need a big number of batteries, so the system is very complex and there are strict requirements for safety, reliability and consistency. There are restrictions on the safety, cycle life, cost, working temperature of lithium ion batteries.

III) Charging modes of electric cars

Based on the using features of batteries and

charging scheme, there exist four charging modes for electric cars.

Conventional charging. After discharging of a battery is over, it shall be re-charged immediately. The charging current is about 15A. This way is called conventional charging. Conventional battery charging methods are small current constant voltage and constant current charging, and the charging time is 5~8h [13]. Because the power and current rating is not the key, conventional charger and the installation cost are low. We can make full use of off-peak electricity for charging to reduce cost. This will improve efficiency and prolong the service life of the battery. The main disadvantage of conventional charging mode is that the charging time is too long. It is difficult to meet the demand when there is an emergency.

Quick charging. Quick charging can also be called rapid charging or emergency charging. This method uses 150 ~ 400 A high charge current for charging in a short time and makes the electric car a full charge in 20 min to 2h [8]. This way of charging has a short charging time, a long battery life, and no charging memory. It has a big charge and discharge capacity and will charge 70% to 80% of the electricity in a few minutes. Compared with normal charging patterns, quick charging also has certain disadvantages: charging efficiency is low, the corresponding work and installation cost are high [13]. Due to large charging current, quick charging puts forward higher request for technology and safety. At the same time, the metering standard also needs special consideration.

Mechanical charging. Mechanical charging is to change the battery. When the power of a battery runs out, put a fully charged battery for exchange [7]. There are strong professional requirements for replacing battery because the weight of a battery pack is very large. It requires the professionals to use specialized machines to complete the replacement. Electric car users can rent a fully charged battery to replace a used one. This can improve the efficiency of the electric cars. The users can be more convenient and expeditious when they use the car [13]. Making use of off-peak charging can reduce charging cost and improve operation efficiency. It can also bring many other benefits such as reducing the charging time, increasing running distance, etc. We can find the problem in a single battery and repair it in time. The reduction of battery discharge depth will also prolong the battery's life [14].

Wireless charging. No matter which kind of charging modes mentioned above are used, a fixed station is needed. Due to a lack of dedicated private parking space in today's city, street parking is very difficult. There will no places to build new fixed stations for charging. Wireless charging of electric cars will become the mainstream of future charging [15].

The government has two options to deal with such situations. One way is to build new charging stations which need to make the new street planning, but this may greatly damage the existing public facilities. The other way is to deploy wireless charging infrastructure, which will greatly reduce the damage to the area in the street [15]. In addition, the electric car drivers would like to choose a simple way of wireless charging. Because there is no trouble of fix charging cables, and people don't have to worry about leakage in rainy days. Using wireless charging has another big benefit: the electric car battery remains from 40% to 80%, which will extend the service life of the electric car battery.

IV) Electric drive and control technology

Performance analysis of electric car motors. Only the motor that meets some basic requirements can it be widely used in electric cars. First of all it should have sturdy construction, small volume, and light weight. Next, it must have good environment adaptability and high reliability. Finally, it must have low cost [16].

At present, the electric car motor mainly includes four classes: the direct current motor (DCM), induction motor (IM), permanent magnet brushless motor (PM - BLM), and switched reluctance motor (SRM). Electric vehicle drive motor belongs to the special motor and it is the key components in electric cars. To make the electric car have good using performance, drive motor should have a wide speed range and high speed, large enough starting torque, small volume, light quality, high efficiency,

and good dynamic braking and energy feedback performance [17].

Control system. With the development of the motor and driving system, the requirement for control system tends to be more intelligent and digital. Its application will make the car structure simpler, response more quickly, anti-interference stronger. Therefore, it can greatly improve the comprehensive performance of the whole vehicle [17].

Summary

India is one the biggest energy consumption country and the second largest oil importer in the world. With the increase of the number of vehicles, the demand for petroleum is increasing and environment pollution becomes more serious. The electric cars can just solve these problems. Using electric cars can reduce consumption of petroleum and improve energy structure of India.

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