Study on Control Strategy for Composite Power Supply System of EV

Liyuan Tian¹, Xiaofei Liu¹
¹Changchun University of Technology. ChangChun, China
tianliyuan@ccut.edu.cn

Abstract: At present, countries all over the world are vigorously developing new energy vehicles. Many countries and regions have introduced policies to stop the production and sales of traditional energy vehicles. However, the large-scale industrialization of pure electric vehicles has encountered the constraints of power batteries, and its main problems are reflected in the specific power of the power battery is low. This paper analyzes the current situation of electric vehicle composite power supply, points out the problems and solutions of electric vehicle energy storage system, in order to obtain the expected development and test results.

1. Introduction
In recent years, under the background of the scarcity of petroleum resources and serious environmental pollution, people are committed to the development of efficient, clean and safe means of transportation. Electric vehicles have become an inevitable trend in the development of the automotive industry with their inherent advantages of energy saving and environmental protection. However, the shortcomings of vehicle power batteries such as low specific power and short endurance have hindered the further development of electric vehicles. In order to solve the above problems, the current better solution is to use a composite power supply that combines batteries and super-capacitors to give full play to their respective advantages, so that the overall performance of electric vehicles has been greatly improved.

2. Discussion of compound power supply

2.1 The history of electric vehicles
The Frenchman Gustave Trouve made the world's first electric car in 1881. It is powered by a lead-acid battery and driven by a 0.1hp DC motor. Two British professors built a similar electric car in 1883. The following 20 years were an era in which electric cars competed with their gasoline counterparts. The first commercial electric car was Salom and Morris' Electric Boat. Modern electric vehicles reached their peak during the 1980s, and in the early 1990s several actual electric vehicles were displayed by manufacturers, such as GM's Saturn EV1, logo (Citroen) 106 Electric [1]. In the research and development of electric vehicles, the application technology of batteries appears to be the most inadequate, hindering the further development of electric vehicles.

2.2 Classification of electric vehicles
Electric vehicles (EV) are divided into pure electric vehicles (PEV), hybrid electric vehicles (HEV) and fuel cell electric vehicles (FCEV) [2]. Pure electric vehicles are powered by batteries and driven by electric motors. A car driven by an internal combustion engine and one (or more) electric motors
becomes a hybrid car. Fuel cell vehicles are driven by electrical energy generated by vehicle fuel.

2.3 The development of super capacitors

Super-capacitor is known as electrochemical capacitor or electric double layer capacitor. The main way of realizing its working principle is the electric double layer capacitor technology. Super-capacitors do not have a chemical reaction during their charging and discharging process, but a reversible physical reaction. Since the internal resistance of the super capacitor is very small, it can be charged and discharged with a large current and realize ultra-fast charge and discharge; the cycle life is long, the average number of charge and discharge times can reach hundreds of thousands of times, and there is no "memory effect" of the battery; its specific power is high, up to 20000W/Kg, which is more than ten times that of lithium-ion batteries; the raw materials of the product are pollution-free green environmental protection materials; the temperature characteristics are excellent, and it can work between -40°C-70°C; basically no maintenance fees. The safety factor is high. But compared with batteries, its specific energy is much lower. Therefore, in the future, the composite energy storage system structure combining batteries and super-capacitors can give full play to the advantages of both and meet the power source requirements of high-performance electric vehicles [3].

2.4 The development of composite power

From the above introduction, it can be analyzed that there are some shortcomings of on-board power supplies, and solutions are urgently needed. At present, due to technical problems of storage batteries, the design and selection of storage batteries must be a compromise between specific energy, specific power and cycle life. In terms of the difficulty of giving high-value specific energy, specific power and cycle life at the same time, it is better to combine an energy source with a power source. At present, super-capacitors are often used as power sources.

Based on a model of a certain company, Yangbo Ye of Jiangsu University compared and analyzed the advantages and disadvantages of different structures of DC/DC converters, proposed simple logic thresholds and fuzzy logic control strategies, and carried out control strategies and power on MATLAB/Simulink software. Modeling of batteries, super capacitors, and DC/DC converters, using ADVISOR to simulate the composite power supply model, and it is verified through experiments that the super capacitors in the composite power supply can reduce the high-power output of the battery and the battery SOC, and reduce the battery consumption rate by 8.6% [4].

Jifeng Feng of Harbin University of Science and Technology adds super capacitors and DC/DC converter to the power system of pure electric buses to forms a composite power supply system. The super capacitor is subjected to constant current charging and discharging experiments and temperature characteristic experiments. A simulation model is built in AVL CRUISE and joint simulated with MATLAB. The simulation results show that the model can greatly reduce the charging and discharging current of the lithium-based batteries and improve the efficiency of braking energy recovery. A test bench for the drive system of a pure electric passenger car is built and the experiment is carried out. The experimental results are consistent with the simulation results [5].

Zhuo Kong of Shandong University analyzed the voltage characteristics, capacity characteristics, aging characteristics and self-discharge characteristics of lithium batteries and super-capacitors at different rates, and established the second-order RC model of lithium batteries, super-capacitor RC models and hybrid electric vehicle models to reduce The work load of the lithium battery is reduced, the power loss of the lithium battery is reduced, and the vehicle loss per 100 kilometers is reduced by more than 10%[6].

Tani A, Camara MB, Dakyo B and others added super-capacitors and lithium batteries to the energy storage system of fuel cell electric vehicles to form a composite power system, and built a vehicle model of composite power fuel cell electric vehicles, and simulated under driving cycle of NEDC. The simulation results show that the composite power supply with super capacitor is more economical than the original energy storage system and has lower energy loss [7].

Qiao Zhang, Weiwen Deng, Gang Li and others proposed a hybrid energy storage system that
combines a battery and a super capacitor, and a real-time predictive energy management control strategy for electric vehicles. Optimize the power distribution between power sources to minimize battery life and system loss, and voltage-drop of battery decreased by 27.14% (from 70V to 51V), its energy consumption and temperature are reduced by 28.57% (from 7 to 5) and 16.67% (from 18°C to 15°C), and the system cost is reduced by as much as 43.03% (From 2.761 $ / km down to 1.573 $ / km) [8].

Karel Fleurbaey, Noshin Omar and others from the Free University of Brussels, Belgium, aimed at a plug-in hybrid electric vehicle (PHEV), replacing its power battery (Li-ion battery) with a composite power system composed of a power battery and a super capacitor. In the study, three different power supply forms were compared under three different operating conditions: NEDC, FEP-75 and HWFET, which use independent batteries, a composite power supply combined with a power battery and a super capacitor, and a composite power supply combined with an energy battery and a super capacitor. The power consumption of the vehicle. The study found that the energy-based battery and super-capacitor combined power system has the lowest power consumption in three driving cycles. Compared with the independent battery system, its power consumption is reduced by 6.0%, 10.3% and 6.8%, respectively. However, due to the large internal resistance of the power battery, the overall energy efficiency of the composite power system combined with the power battery and the super capacitor is lower [9, 10].

Various automobile companies are also studying the application of composite power supplies and put them into production use. A type of Fabbrica Italiana Automobili Torino (F.I.A.T.), Cinquecento to Eletra, uses a composite power storage system and a simulation experiment under driving cycle of ECE. The simulation results show that its energy-saving performance has been well improved [11]. The BYD E6 produced by BYD adopts a composite power supply with a maximum power of 90kw, a maximum torque of 450N.m, and a maximum speed of 140km/h or more. Without air conditioning, the driving range is the longest under comprehensive conditions 300~400km [12]. In 2015, the French Bolloré Group launched a BlueCar car that uses a composite power supply that combines super-capacitors and lithium-ion batteries. The car has a driving range of up to 241 kilometers under NEDC (New European Driving Cycle) conditions [13].

3. Energy distribution strategy
The energy distribution strategy of the composite power supply system should be formulated to meet the following requirements: Under the premise of ensuring the dynamic performance of the vehicle, the required power of the vehicle should be reasonably allocated to the battery and super capacitor, so that the battery and super capacitor in the composite power system can give full play to each other. The advantage of this is to make full use of the peak-shaving and valley-filling effect of super-capacitors to reduce the impact of high current on the battery and increase the battery life [4, 14].

There are three main types of power allocation strategies for composite energy storage systems: deterministic strategies, non-deterministic strategies and heuristic strategies.

Based on the analysis of the known road condition information, the deterministic control strategy is the more optimized control strategy parameter. The most typical of this strategy is the simple logic threshold control strategy and the logic threshold control strategy with filtering ideas. The methods are all based on obtaining the average power of the driving road conditions. During the normal driving of the car, the battery provides the average power, and the super capacitor provides the peak or excess power.

The heuristic control strategy is based on the assumptions or formulas that reflect the basic principles, and the corresponding values are derived from these assumptions or formulas. The biggest advantage of this control method is that it is simple to implement, and only needs to know the general information (such as the maximum allowable charge and discharge current of batteries and super-capacitors, etc.), without the need to know the driving road condition information in advance. The most typical heuristic control method is to use a power distribution control strategy based on the current vehicle speed. The steady-state power of the car at this speed is provided by the battery, and the transient power is provided by the super capacitor.

The non-deterministic control strategy is based on algorithms such as stochastic methods, fuzzy logic
or neural networks to realize the real-time optimization of power distribution during the driving process of the bus. Although the non-deterministic control strategy is very suitable for solving complex optimization problems that are difficult to express in mathematical expressions, there is no guarantee that a car using this control strategy can be applied to every driving condition. In addition, this method is very complicated to implement. The most typical of this control strategy is to use a fuzzy logic control strategy to blur the required power and the state of charge of the battery and super capacitor to achieve a reasonable distribution of the required power.

4. Conclusion
At present, for new energy vehicles, the characteristics of a single energy storage element determine that there will be a variety of problems in its application. Under the existing technical conditions, a single energy storage element is difficult to meet the power and energy of the electric vehicle power system at the same time. The double requirement of energy. In order to give full play to the advantages of each energy storage element, a composite energy system composed of two or more energy storage elements is proposed, which can solve the above problems well.

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