Study on Power Battery Model Simulation and Life Characteristics of Electric Vehicle

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Abstract: With the development of new energy vehicles, electric vehicles have placed an important position in the future development. However, there are still many deficiencies in the process of power battery model simulation and the research of life characteristics of electric vehicles. This paper matches the parameters of the power battery and motor of the electric vehicle by giving the electric vehicle sufficient power performance and driving range, establishes electric vehicle model, proves that the power system parameters of electric vehicle can meet the vehicle performance, and analyzes the service life by simulation analysis.

1. Introduction

Electric vehicle is one of the development trends of automobile industry, and has been widely praised by consumers since it was put into production. For electric vehicles, the power of battery is the most important and whether the power performance and driving range of the vehicle can be guaranteed is the key. At the same time, the research on its life characteristics has become the top priority.

2. Overview of Electric Vehicles

With the shortage of energy and the impact of fuel vehicles on environmental pollution, the development and production of electric vehicles has achieved an important strategic height from the national strategic planning. Electric vehicles and other new energy vehicles will gradually replace fuel vehicles. From the “12th Five-Year” National Plan for Science and Technology Development jointly formulated by the Ministry of Science and Technology, the pure electric drive vehicle transformation strategy has been clearly implemented, and the industrialization engineering construction of new energy vehicles has been comprehensively carried out. In the “13th Five-Year” National Plan for Science and Technology Development, the industrialization of new energy vehicles will put forward higher requirements. As of December 2019, the number of new energy vehicles in China has reached 3.81 million, including 3.1 million pure electric vehicles [1]. From the perspective of the types of electric vehicles, they are mainly divided into pure electric vehicles, hybrid electric vehicles and fuel cell electric vehicles. This paper mainly discusses the electric vehicle that only takes the battery as the energy storage, with the motor power supply as core component and driven by its operation. Then through the role of the transmission device, the kinetic energy of the driving wheel is converted into vehicle power. The motor itself has good traction characteristics, and the transmission system of electric vehicle does not need clutch and speed transmission to complete, but mainly through the speed control system, which is formed by the controller changing the speed of the motor.

3. Power Performance of Electric Vehicles

For electric vehicles, the main thing is the kinetic energy of the battery, otherwise the speed of the car will not meet the requirements. Similarly, for the use of electric vehicles as a means of transport, transport efficiency largely depends on the dynamic performance of transport. Therefore, dynamic performance is one of the most important performance of electric vehicles. There are three

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indexes to evaluate the dynamic performance of automobile, which are high-speed driving, acceleration time and climbing ability. High-speed driving refers to the highest speed that the car can reach on a good and smooth road surface. The acceleration time refers to a kind of ability to quickly improve the vehicle speed under the unified conditions, which is mainly expressed by the starting acceleration time and overtaking acceleration time. Starting acceleration time is the time required for electric vehicles to reach high speed from starting in place and overtaking acceleration time refers to the process or time of electric vehicles accelerating from low speed to high speed. Short acceleration time means fast overtaking and safe driving. Climbing gradient refers to the ability of electric vehicles to climb steep slopes on a good windless road, which directly tests the torque of electric vehicles, so the completion rate on steep slopes is very important. The maximum climbing gradient represents the ultimate climbing ability of the vehicle. In fact, when the car goes uphill, it will be affected by wind resistance and soft uneven road resistance. From this point of view, the theoretical capacity of climbing gradient is often greater than the actual value [2].

4. Mathematical Model of Dynamic System

From the structure of electric vehicle power system, the main components include battery, motor and control system. Battery is the power supply, and its main performance indexes include specific energy, specific power and cycle life. In order to make the automobile have higher energy utilization rate, longer service life and higher competitiveness under normal conditions, it is necessary to make it have a higher power ratio. At present, valve regulated lead-acid batteries have been widely used. In contrast, some alkaline batteries, such as MH Ni batteries and lithium batteries, are superior to lead-acid batteries in the main performance indicators, which is limited by the high manufacturing costs. The power battery mainly outputs and obtains energy by charging and discharging. Voltage and internal resistance have great influence on it.

4.1 Vehicle Parameters and Performance

The specific parameters of pure electric vehicle are shown in Table 1.

Table 1 Parameters of Pure Electric Vehicle

Name of Parameters	Numerical Value	Name of Parameters	Numerical Value
Vehicle Full Load Mass(KG)	1550	Rolling Resistance Coefficient of Pavement f	0.03
Air Drag Coefficient (CD)	0.3	Frontal Area A(m^2)	2.0
Wheel Radius(mm)	305	Transmission Efficiency	0.93

4.1.1 Performance Requirements

Acceleration time is (from 0km / h to 100km / h) 12s ± 1s.
Maximum climbing gradient is (V_0 = 15km / h) > 30%.
Maximum speed is 150km / h and the driving range is more than 200km.

4.1.2 Selection of Traction Motor

Electric drive system is the core component of an electric vehicle. The motor converts electrical energy into mechanical energy to drive the vehicle, or vice versa, converts mechanical energy into electrical energy for regenerative braking and charging on-board energy storage device. The power consumed by electric vehicle driving at the highest speed on horizontal road surface is as follows:

$$p_r = \frac{1}{\eta}\left(\frac{mgfv_{\max}}{3600} + \frac{C_d A v^3}{76130}\right)$$

The power consumed by electric vehicles during limited climbing is as follows:

$$p_r = \frac{1}{\eta}(\frac{mgf_{\cos\alpha}}{3600}v_0 + \frac{C_d A v^3{}_0}{76130} + \frac{mg\sin\alpha}{3600}v_0)$$

The power consumption of electric vehicle in the process of accelerating from 0 km / h to 100 km / h is estimated as follows:

$$p_a = \frac{1}{1000\eta}(\frac{\delta m(v_t{}^2 + v_b{}^2)}{2t} + \frac{2}{3}mgfv_t + \frac{1}{5}pc_d A v_t{}^3)$$

In this formula, δ is the rotating mass coefficient and Vt means the final acceleration speed of the vehicle. Substituting the given data, we can get that P_v = 42.23kw, P_α= 20.21kw, P_a = 62.3kw.

The rated power of the motor is P_m [P_v, P, P_a]. From the obtained data, it can be concluded that P_m = 65kw can meet the requirements of vehicle performance. The specific parameters of the motor are shown in Table 2.

4.1.3 Selection of Power Battery

At present, lithium battery is the main choice for electric vehicle battery, which is determined by its own advantages of industrialization, such as good performance, environmental protection, and strong endurance, so it is widely used in the electric vehicle industry.

Assuming that the vehicle runs at constant speed v = 60km / h, the consumed power is as follows:

$$p_r = \frac{1}{\eta}(\frac{mgfv_{\max}}{3600} + \frac{C_d A v^3}{76130})$$

$$p_m = \frac{p_1}{\eta_m}$$

$$w_R = p_m * t = p_m * (s / v)$$

The actual total energy of the battery is:

$$w_b = {}^{w_R}\!/\!{}_{\lambda_{soc}} = U_b * {}^{c}\!/\!{}_{1000}$$

Table 2 Parameters of Motor

Type	Rated Power(KW)	Maximum Power (KW)	Maximum Torque(Nm)	Maximum Speed(r/min)	Rated Speed(r/min)	Rated Voltage(V)
Direct-current Electromotor	70	90	190	8500	2500	220

S is the driving range, SOC is the effective capacitance coefficient of battery pack, which is taken as 0.8. U_b is the average operating voltage of the battery pack and C is the total capacity of the battery pack.

Substituting formula (7) and formula (8) into informula (9), we can get the following results:

$$c = \frac{1000 p_1 s}{Ub\lambda_{soc} V}$$

By substituting the data, we can further get the minimum battery capacity C = 135.98Ah for the range of 200km, and finally select the power battery capacity of C = 150Ah, and adopt the domestic mainstream lithium iron phosphate power battery with the capacity of 150Ah and the nominal voltage of (3.2 × 100) v.

4.1.4 Mathematical Model Analysis of Ultra-Long Capacitor

The ultra-long capacitance C is related to the working current and temperature.

$C = f(T, I)$

If Q (n) is the energy stored by the ultra-long capacitor at the n_{th} moment, then the energy stored by the ultra-long capacitor at the (n + 1)th moment is:

$Q(n+1) = Q(n) - I\Delta t$

The discharge power is

$P = U_0 \cdot I = (U - U_R)I$

If the working voltage of the ultra-long capacitor is V (n) at one time and V (n + 1) at the next moment, then:

$$V(n+1) = V(n) - \frac{\Delta t}{c}$$

The life characteristics of ultra-long capacitor should be considered in the working state, so it should be made to work in a reasonable voltage range$[V_{\min}, V_{\max}]$. SOC can reflect the amount of electricity stored in the ultra-long capacitor, that is, the degree of charge and discharge, which is defined as:

$$soc = \frac{V - V_{\min}}{V_{\max} - V_{\min}}$$

The energy output of ultra-long capacitor is as follows:

$$E = \frac{1}{2}CU_{\max}^2 - \frac{1}{2}CU_{\min}^2$$

The equivalent internal resistance R_0 of ultra-long capacitor refers to the equivalent series impedance of ultra-long capacitor. It is related to working current and temperature, that is:

$R_0 = f(T, I)$

The efficiency η of ultra-long capacitor is defined as the ratio of charge energy to discharge energy in charge-discharge process, that is:

$$\eta = \frac{\int_0^t I_d \times u(t)dt}{\int_0^t I_c \times u(t)dt}$$

The charging efficiency η_c is defined as the ratio of stored energy to charged energy of ultra-long capacitor, that is:

$$\eta_c = \frac{\frac{1}{2}C(U_{c\max}^2 - U_{c\min}^2)}{\int_0^t I_c \times u(t)dt}$$

The discharge efficiency η_d is defined as the ratio of the output energy of the ultra-long capacitor to the stored energy of the ultra-long capacitor, that is:

$$\eta_d = \frac{\int_0^t I \times u(t)dt}{\frac{1}{2}C(U_{d\max}^2 - U_{d\min}^2)}$$

Assuming that the working temperature of the model is set at 25 ℃, then the upper limit of the working voltage of the capacitor is 1.4V, the lower limit is 0.8V, and the initial SOC value of the capacitor is 0.8. A cycle of equal power charge and discharge is input to the model.

4.2 Analysis of Life Characteristic through the Above Mathematical Model

To some extent, the voltage of ultra-long capacitor decreases from the initial 1.28V to about 0.96V with discharge. And with the continuous charging, the vehicle voltage gradually reaches the original value, and finally returns to 1.25-1.28V. It can be seen that the change of voltage presents a linear relationship. The SOC value of the ultra-long capacitor decreases with the discharge and increases with the charging, showing a linear relationship. The SOC decreases from the initial value of 0.8 to 0.25-0.28. When the internal resistance of ultra-long capacitor has resistance loss, the SOC value finally returns to 0.76-0.78. At the same time, with the continuous discharge, the SOC value decreases gradually, and the voltage also decreases. In addition, due to the equal power charge and discharge, the current will show a gradual increase in the discharge. When charging, the situation is just the opposite. With the increase of SOC value, the voltage increases, the current gradually decreases, and the current change of super capacitor also changes linearly [3].

According to the demonstration of charging and discharging efficiency and discharge capacity of ultra-long capacitor by establishing mathematical model, the battery life of electric vehicle can be combined with power battery as the power system of electric vehicle to increase the endurance and service life of electric vehicle.

5. Conclusion

In this paper, the study on battery model simulation and life characteristics of electric vehicles proves that lithium batteries are of great value in the power system of electric vehicles at present. At the same time, for the service life of electric vehicles, power combination is still needed to achieve better endurance and prolong battery life.

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