Powertrain modeling and performance simulation for Electric vehicle

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Abstract. According to the dynamic performance evaluation indexes of the vehicle, combining the performance requirements of the electric vehicle which paper studied, choosing the motor parameters, transmission ratio and the battery parameters respectively.The vehicle model is established in the ADVISOR software, simulation analysis is carried out on the dynamic performance. Results show that the selected parameters conform to the requirements of the dynamic performance, matching is feasible.

Introduction

At present, the global vehicle industry is currently faced with the financial crisis and the great challenge of energy and environment problem, so, developing the electric vehicle, realizing vehicle power energy system electrification, promoting the strategic transformation of traditional vehicle industry, have formed a broad consensus in the world. The electric vehicle is provided energy by vehicle power, and is driven by the vehicle motor . Pure electric vehicle is with motor instead of fuel oil machine and is driven by the motor without automatic transmission. At present, the development of the electric vehicles still dose not have the conditions of industrialization and scale, battery system and dynamic integrated system are two technical bottleneck of restricting its development[1,1]. The parameter selection and matching of the electric vehicle power transmission system are researched in the paper, the dynamic performance simulation is studied, the simulation results verify the rationality of parameter matching.

Vehicle model and dynamic performance requirements

In this paper, the electric vehicle is modified by sedan xiali, it is equipped with independent double motor drive mode, the front wheel steering, rear wheel driving. The power transmission system structure is shown in figure 1. The main parameters and dynamic performance requirements of independent double motor drive electric vehicle are shown in table 1[3].

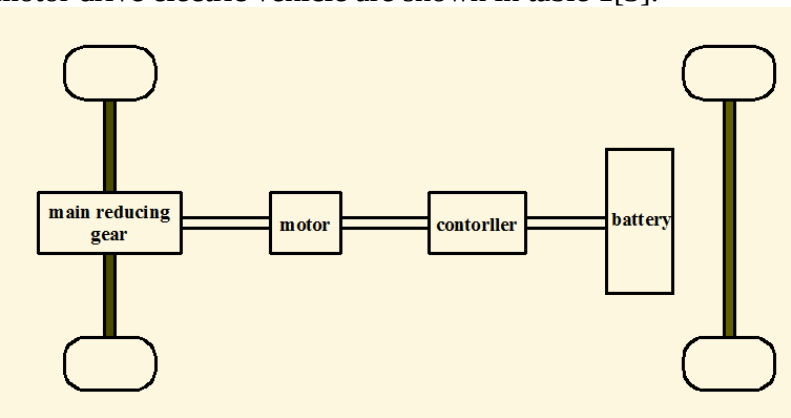

Fig. 1 Independent double motor drive electric vehicle power transmission system structure

Table 1 The main parameters and performance requirements of the independent motor drive electric vehicle

Vehicle parameter name	The parameter value
the before and after wheel track/mm	1380
the wheel base/mm	2340
radius of the driving tire/mm	260
the vehicle mass/kg	1200
the minimum bending radius/mm	4800
the height of mass center /mm	550
the motor	Permanent magnet motor
the maximum speed/km·h-1	the lithium battery
the driving range km	⩾80
the accelerating ability/s	⩾100
the maximum grade %	0~50km/h:≤10 50~80km/h:≤15
the rolling resistance coefficient	0.016
the air drag coefficient	0.34
the windward area/m2	2

The parameters selection of dynamic power transmission system

The selection of motor parameters

The motor characteristic curve is shown in figure 2, the output characteristic formula is

$$T = \begin{cases} 9549P_n / n_o & n \le n_o \\ 9549P_n / n & n > n_o \end{cases} \tag{1}$$

Among them: T is the motor torque; P_n is the motor rated power; n is the actual motor speed; n_o is the rated motor speed .

When the motor actual speed is less than rated speed, output torque keeps constant , the power is proportional to the speed; When the actual speed is higher than the rated speed, the output torque decreases with the increase of rotational speed, the output power keeps constant.

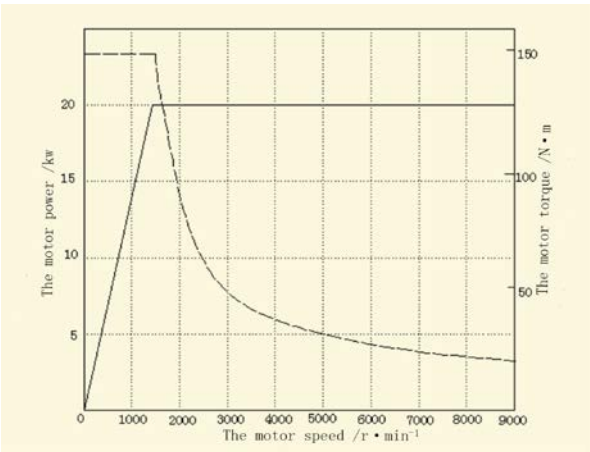

Fig. 2 Motor characteristic curve

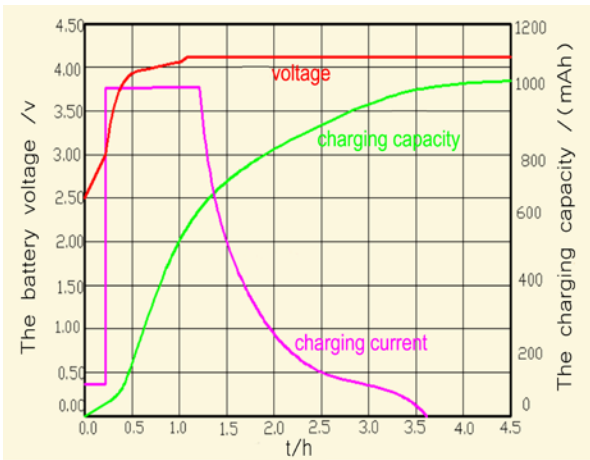

Fig. 3 Battery charging curve

There are three main evaluation indexes for the electric vehicle dynamic properties: maximum speed, acceleration time and grade ability[4,5]. The motor of electric vehicle is as power source, the rated power of the motor is calculated by 90% of the vehicle maximum speed. The expression of the rated power is

$$P_n \ge \left(mgf + \frac{C_D A V_{\max}^2}{21.15} \right) \cdot \frac{V_{\max}^2}{3600\eta_T} \tag{2}$$

Among them: P_n is the motor rated power, m is the vehicle mass, g is the gravity acceleration , f is the rolling resistance coefficient, C_D is the wind resistance coefficient, A is the windward area, $V_{\max}$ is the vehicle maximum speed, η_T is the mechanical transmission efficiency and its value is 0.9.

According to the electric vehicle design parameters in table 1, the value of rated is 15kw.

In this paper, design of electric vehicle uses fixed gear, the peak power of the motor is measured as in situ accelerate the power required to measure. The expression of the peak power is

$$P_a = \left(\delta \cdot m \frac{V}{2\sqrt{T}} + m \cdot g \cdot f(v) \cdot \frac{T}{1.5} + \frac{C_D \cdot A \cdot V^2}{21.15 \times 2.5} \cdot T \right) \cdot \frac{V}{3600 \cdot \eta_T \cdot T} \tag{3}$$

Among them: P_a is the need power at the end of the acceleration, V is the need speed at the end of the acceleration, T is the acceleration time, its value is 10s. According to the calculation, the values of P_a is 30kw.

The parameter selection of transmission ratio

The choice of transmission ratio must satisfy the performance requirements of the vehicle, which should not only guarantee the maximum grade ability of electric vehicles, but also to ensure the maximum speed[6]. The expression is

$$\begin{cases} i \le \dfrac{0.377 n_{\max} r}{V_{\max}} \\ i \ge \dfrac{F_{V\max} r}{\eta_T T_{n\max}} \\ i \ge \dfrac{F_{i\max} r}{\eta_T T_{n\max}} \end{cases} \tag{4}$$

Among them: i is the transmission ratio, $n_{\max}$ is the motor maximum revolving speed , $F_{v\max}$ is the resistance in the maximum speed, $F_{i\max}$ is the resistance in the maximum grade ability. According to calculation , the values of i is 7.

The selection of the battery

Battery energy determines the range of electric vehicles. It is the most important parameters reflect the battery value, and is also one of the major factors restricting the development of the electric vehicle industry. Lithium battery is the best choice because of its long service life, high energy density, light weight, small volume, green environmental protection and a series of advantages and popularity. The lithium battery parameters of the electric vehicle in the paper are as follows: battery capacity160 ah, rated voltage 96 v, the battery number 1, the battery quality200 kg. Battery charging curve is as shown in figure 3.

The establishment of the whole vehicle model

The electric vehicle is modeled by Advisor software, it contains the motor model, battery model, transmission model, driver model, the parameters involved the motor torque, rotational speed, transmission ratio and other vehicle module are input into the system. The construction of the model is as shown in figure 4.

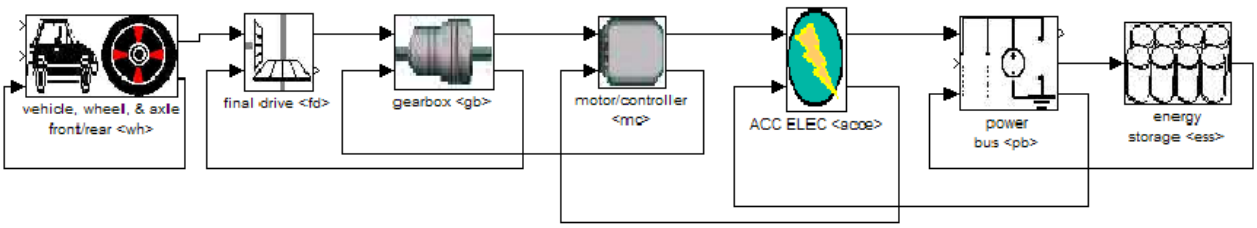

Fig. 4 Electric vehicle simulation model

The simulation analysis of the vehicle dynamic performance

According to the dynamic power system transmission parameters of the vehicle , as well as the simulation model which is set up in the simulation software ADVISOR2002. The vehicle is required to work in ECE typical conditions.The dynamic simulation results are shown in table 2. The results in the table verify the performance requirements.

Table 2 Dynamic simulation results

Dynamic performance parameters	The parameter value
Maximum speed（km·h-1)	118
Maximum grade ability%	25%
0-50（km·h-1）acceleration time(s)	7.6
50-80（km·h-1）acceleration time(s)	11.2

Under the condition of the maximum acceleration, speed change curve is as shown in figure 5. From the chart , the maximum speed of the electric vehicle can reach 180 km/h, the result meets the original performance requirements .

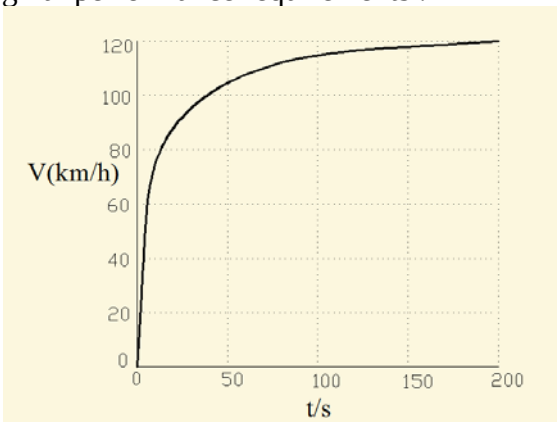

Fig. 5 Speed change curve

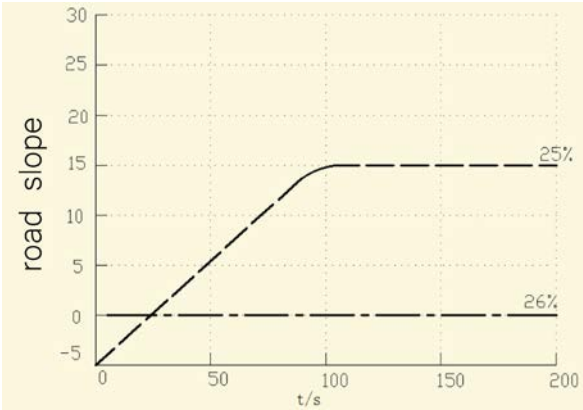

Fig.6 Slope curve of the electric vehicle

The slope curve of the electric vehicle is as shown in figure 6, from the figure we can see that the maximum grade ability is 25%, the time is nearly 100s. When the slope is up to 26%, the vehicle almost cannot work. The result meets the grade ability requirements.

The maximum output power curve of battery is as shown in figure 7. According to the formula of maximum output power, the lithium battery is tested under the condition of different temperature and SOC, the maximum output power curve as follow.

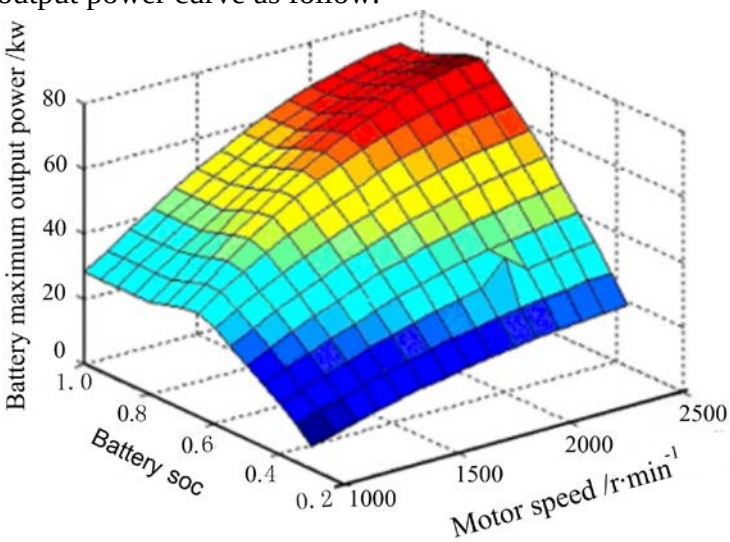

Fig. 7 Maximum output power curve of battery

Summary

The electric vehicle modeling is simulated in the paper using ADVISOR software , the dynamic performance is simulated and analyzed , the result shows that the parameter designs meet performance requirements. In addition, in this paper, the study was conducted under the condition of fixed transmission ratio, the different transmission ratio also has a great influence to power performance.

References

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