

Battery group parameter selection and dynamic simulation of pure electric vehicle

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Abstract. The battery pack is one of the core components of pure electric vehicle, dynamic performance of the whole vehicle is closely related to the matching design of the battery, and is affected by the air resistance coefficient and the windward area of the whole vehicle. The dynamic indicators include maximum driving speed, 0-100km/h acceleration time and climbing grade, the battery parameters are designed and matched before the vehicle design, mainly analyze influence on the vehicle dynamic performance of the types of batteries, air resistance coefficient, windward area by the simulation software ADVISOR, and optimize the combination of these parameters. The results show that the dynamic performance of the vehicle reaches the initial design index and the dynamic performance of the vehicle is improved significantly.

1 The introduction

In 2015, Chinese new energy automobile production become the first, the direction of the development of auto technology will be safe, energy-saving, environmental protection, new energy vehicles will be the future development trend, this pointed out the direction of the investment and the development of new energy vehicles industry[1]. However, the research on pure electric vehicles in China is not comprehensive enough, especially in battery technology. The data shows that the investment of domestic battery industry is about 100 billion RMB in 2016[2]. The battery types used in electric vehicles are lead-acid batteries, nickel-series batteries, lithium ion battery, fuel cell, etc. China's electric vehicle technology development "12th five-year plan" has pointed out that the development of vehicle powered batteries with lithium ion batteries as the focus will be promoted. BYD K9A use lithium iron phosphate battery, which is nearly 2/3 of the cost of driving 300 km compared to fuel bus, and can run more than 270 kilometers on a single charge, with a maximum speed of 80Km/h[3]. The Nissan Leaf entered the Chinese auto market in 2011, using the latest lithium battery pack, with a nominal voltage of 345V and a maximum speed of 144km. Tesla is electric sports car brand established by Musk, Tesla Model 3 adopted more than 7000 section 18650 lithium-ion battery pack with a voltage of about 400V DC and accelerates in less than 6 seconds in a hundred kilometers in 2016[4]. The current status of the use of battery packs at home and abroad shows that there is still a certain gap between the domestic battery pack technology and foreign countries, especially in terms of the vehicle's driving force, such as the maximum travel speed and the

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acceleration time of 100 km[5]. However, battery technology research and breakthroughs for vehicle power to improve is essential. As the core component of pure electric vehicle, how to design and select battery packs, shorten the development cycle and make it meet and exceed the design requirements is the key to the development of pure electric vehicles.

2 Battery pack parameter selection

Power battery is the only device to provide energy vehicle, the role is very important. Electric vehicle battery pack must have a higher power density, in order to achieve vehicle power performance requirements. At the same time should have a higher energy density in order to achieve adequate driving range. In addition, the power battery should have more charge and discharge times, high enough cost performance, ease of maintenance, high discharge efficiency and other characteristics. Battery parameters include the choice of type, voltage, capacity and battery number and a series of parameters.

2.1 Choice of battery type

Lithium iron phosphate battery use lithium iron phosphate as the cathode material. due to its better safety performance, there has been no explosion, high reliability, long cycle life, it can discharge with high current, starting current up to 2C, lead-acid batteries now do not have this performance, nickel-based battery larger environmental pollution, energy density of lithium-ion battery is about 100 ~ 150Wh / kg about 2 to 3 times higher than lead-acid batteries, and high temperature performance, large single cell capacity, no memory effect, light weight, environmental protection, so lithium iron phosphate battery is chose.

2.2 Selection of battery voltage

Battery voltage is mainly according to the rated voltage of the motor to determine the size, in addition to consider power consumption of lighting device, instrument accessories, so the total voltage of the battery should be slightly greater than the rated voltage of the driven motor. It is the series relationship between the individual lithium iron phosphate battery, which can improve the working voltage of the whole vehicle and prevent the shortage of battery voltage and affect the driving distance of the electric vehicle.

Table 1. Technical parameters of lithium iron phosphate battery

Number	Parameters	Values
1	Single battery capacity (Ah)	70
2	Single rated voltage (V)	3.2
3	Single battery internal resistance.	1
4	Single maximum voltage (V)	3.9
5	Single minimum voltage (V)	2
6	Battery voltage (V)	270
7	Number of battery	81

2.3 Selection of battery number

Combined with automobile design and automobile theory knowledge, the number of batteries is calculated by the continuous mileage calculation, the other parameters of the vehicle are well matched, and the parameters of the lithium iron phosphate battery pack are shown in Table 1.

3 Simulation analysis of vehicle power performance

The ADVISOR is a software for simulation analysis of traditional internal combustion engines, fuel cell vehicles, hybrid electric vehicles and pure electric vehicles, by ADVISOR software to simulate the dynamic performance of the vehicle, analyze the factors affecting the dynamic performance, thus reduce the development cycle of electric vehicle.

Based on inputting the vehicle technical parameters, firstly set up the initial capacity of the battery pack, minimum quantity, the quality of the car, shift delay time, the simulation parameters such as mileage, climbing on the constant speed. In this paper, the initial battery charge is 100%, the minimum charge is 30%, the shift delay time is 0.2s, and the simulated driving range is 0.402km. After these initial conditions are determined, simulation of the dynamic performance of the vehicle load of 130 kg (about two people) is carried out. This is shown in Table 2.

Table 2. Simulation of vehicle dynamic performance under different load quality

Number	Dynamic performance	The simulation results
1	Maximum driving speed (km/h)	133.3
2	0-100km/h acceleration time (s)	18.8
3	Climbing grade	16.7%

The dynamic performance is influenced by a variety of factors, which type of battery is selected, how the wind resistance coefficient and the windward area can be obtained through the simulation analysis below.

4 Simulation analysis and comparison of results

The dynamism of electric vehicles is the most important and basic performance of all kinds of vehicles. There are many factors affecting the dynamic performance of electric vehicles, such as the type of battery, air resistance coefficient, the windward area, the structure of the vehicle, the external force suffered, the quality of electric vehicles, motor performance, etc. The impact of the first three factors is analyzed in this paper.

(1) Maintain the same capacity of battery pack, respectively, using lead-acid batteries, nickel-metal hydride batteries, lithium-ion battery vehicle performance simulation of the vehicle, the simulation results in Table 3.

Table 3. The dynamic performance simulation results under different types of battery

Battery type	Maximum travel speed (km / h)	0-100km /h acceleration time(S)	Climbing grade
Lead-acid battery	128.5	31.9	10.6%
Ni-MH battery	131.3	22.6	13.5%

Lithium-ion battery	134.0	15.9	20.7%
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According to the above simulation results, select the type of battery as abscissa, the vertical axis of Figure 1 is the maximum speed, the vertical axis of Figure 2 is 0-100km / h acceleration time, draw different simulation comparison chart.

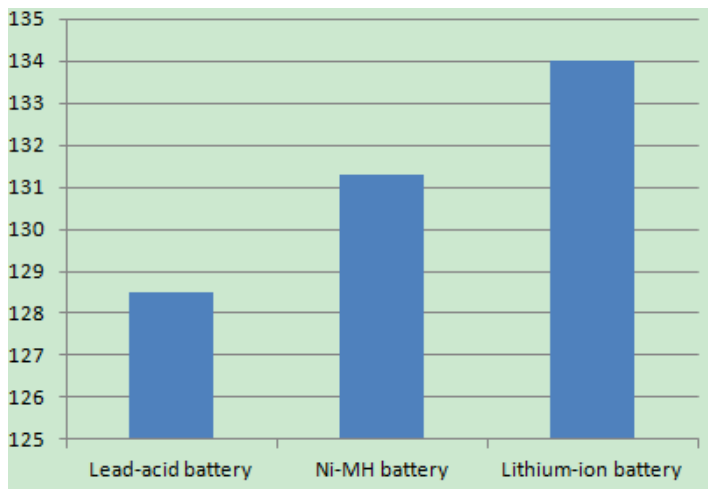


Figure 1. Comparison of maximum speed simulation (unit: km / h)

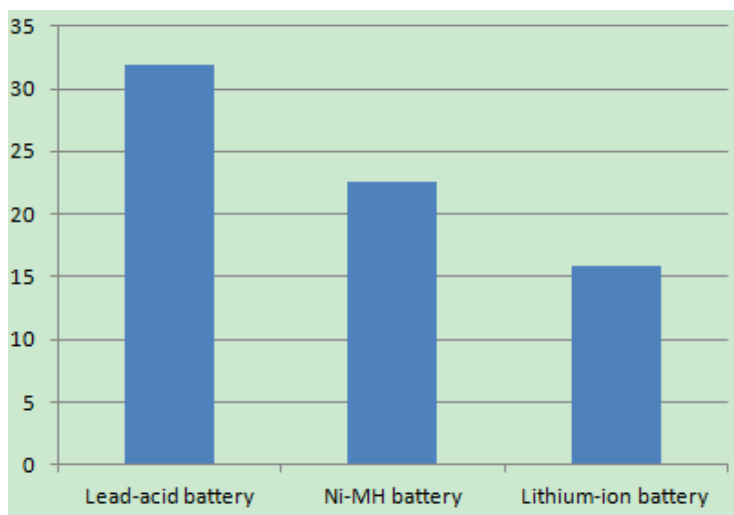


Figure 2. 0-100km / h acceleration time simulation comparison (unit: s)

From figure 1 and figure 2, it can be obtained that different types of battery are selected, and the dynamic performance of the vehicle is very different. The performance of li-ion battery in the maximum driving speed, 0-100km/h acceleration time and 40km / h is obviously better than that of lead-acid battery and ni-mh battery. In figure 1 ,the maximum speed of using lithium ion batteries increased by 4.3% than the lead-acid battery. In figure 2, the acceleration time of using lithium ion battery reduced by 16s than lead-acid batteries, by 6.7s than ni-mh battery. So the lithium-ion battery is increasingly widespread in the electric vehicle.

(2) Battery parameters remain unchanged, change the different air resistance coefficient, the selection of air resistance coefficient is 0.3, 0.35 and 0.4, and the simulation results of vehicle power performance are obtained, as shown in Table 4.

Table 4. The dynamic performance simulation results under different air resistance coefficients

Air resistance coefficients	Maximum travel speed (km/h)	0-100km /h acceleration time(s)	Climbing grade
0.3	137.2	15.7	20.2%
0.35	124.1	16.9	18.3%
0.4	118.3	17.3	16.8%

The larger the air drag coefficient, the smaller the maximum traveling speed, the longer the acceleration time, the smaller the climb grade. The maximum driving speed of air resistance coefficient is 0.3, which increases by 15.9% compared with the wind resistance coefficient as 0.4, the climb grade of 40km /h increases by 3.4%, while the dynamic performance of the air resistance coefficient as 0.35 is at a medium level. The car's surface and bottom can be machined as smooth as possible, and the air resistance coefficient can be optimized to reduce the coefficient of wind resistance.

(3) The impact of different windward area on the vehicle dynamic performance, as shown in Table 5:

Table 5. The dynamic performance simulation results under different air resistance coefficients

Windward area (m ²)	Maximum travel speed (km/h)	0-100km /h acceleration time(s)	Climbing grade
2.0	134.0	15.9	20.0%
2.3	129.8	16.3	18.9%
2.6	126.1	16.7	17.8%

From the analysis of Table 5, it can be seen that the dynamic performance of the vehicle decreases as the windward area increases. Especially the maximum driving speed, the impact of the windward area is more prominent. The maximum driving speed of windward area of 2.0m² is 3.2% higher than the windward area of 2.3m², and the climbing speed is increased by 1.1%. When the windward area is 2.0m², the maximum driving speed is 6.3% higher than the windward area of 2.6m², and the climbing speed is increased by 2.2%, taking into account the windward area by the space constraints, generally not easy to reduce. However, it should be kept to a minimum to ensure the best dynamic performance.

The initial design specifications of the pure electric vehicle dynamic performance are as follows: the maximum speed $v_{max} \geq 100$ km/h, 0-100km/h acceleration time $t \leq 20$ s, when the vehicle is at 40km/h uniform speed, the climbing grade $\alpha \geq 15\%$. The above three kinds of parameters are optimized combination, the selected battery type of iron phosphate battery, the drag coefficient of 0.3, the windward area of 2.0m², the simulation results in Table 2, indicate that the dynamic performance to meet the design requirements, the battery parameters of the pure electric car match reasonably, and the dynamic performance is remarkably improved.

5 Conclusion

This article focuses on analysis and comparison of different battery types, drag coefficient, the wind area for the dynamic performance simulation. After optimization, the simulation results of dynamic

performance are obtained, which meet the requirements of dynamic performance index and significantly improve the dynamic performance.

References

1. Yuan Xiaodong, Power battery recycling, New economic guide (2016)
2. Zhao Guiliang, Status and performance analysis of urban pure electric buses(2016)
3. Hu Hua,Song Hui, *Electric car*(2012)
4. Li Zhe, Pure electric car's lithium iron phosphate battery performance research(2011)
5. Wang Guoqiang,Wang Zhixin. Research on optimization of new electric vehicle frame structure (2016)