Test Research on the Safety Performance of the Power System of EV

Libo Cao, Jiang Yang, Zhonghao Bai

College of Mechanical and Automotive Engineering, Hunan University, Changsha, China

Abstract: This paper analyzed the Safety Performance of the Power System of EV. Several road tests on the EV equipped with Li^+ battery had been performed. The discharge characteristic of the power battery system had been measured, and its possible influence to the safety performance of EV had been analyzed. This paper also introduced the vibration test, crash test, and turn over test on the H-Ni battery used by EV. The test results also had been analyzed.

Keywords: electric vehicle, crash, power battery, safety

Introduction

The power battery for electric vehicle needs high energy density. Most of them, such as excide battery、Li+ battery and MH-Ni battery, may cause some safety problems. It will result in disaster once the battery burns or explodes. Several local electric vehicle research institutes had taken place the disaster that whole vehicle or whole laboratory burned. These safety problems directly influence the practical prospect of electric vehicle. The reports made by ICTA compared EV with fuel burning vehicle and appraised the safety of electric vehicle [1], which show that the hydrogen accumulation and electrolyte leakiness of power battery are two very bad safety problems of electric vehicle. Therefore, researching the safety of the power system of electric vehicle is very important in both theory and practice.

1 Performance test on the electric vehicle with Li+ battery

1.1 The ECE circle test

The performance test of the electric vehicle with Li+ battery on the condition of simulating the ECE circle was finished. The discharge current of the power battery was obtained and shown as figure 1.

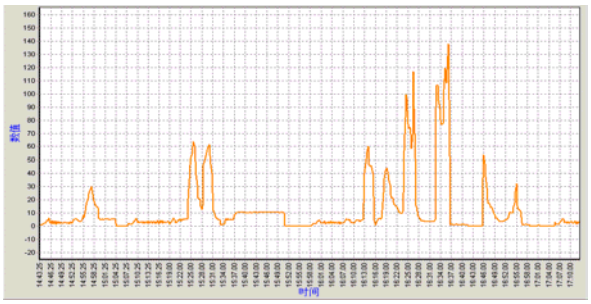


Figure 1 The current curve of the battery

Figure 1 illustrates that the current changed greatly, from 0A to 140A. Moreover, the current changed during a very short time, and the slope of the current curve was large. Because the power batteries continually discharged with large current, their temperatures were high. If they are often used in this

Contact: E-mail jqy_clb@hnu.cn

condition, they may result in some safety problems. At the same time, it also can cause the components of battery aging and shorten the battery's service life[2]. Therefore, advancing the discharge performance of Li+ battery may improve the safety of electric vehicle and prolong the battery's service life.

1.2 0～100km/h accelerating test of electric vehicle with Li+ battery

Figure 2 and figure 3 are the speed curve of the car and the current curve of the batteries in the course of the accelerating test . Figure 2 and figure 3 illustrate that the power batteries will discharge with big current when the car shifts and accelerates every time. The discharge time of the batteries is about 4s when the car accelerates with low-speed gear and is over 10s when the car accelerates with high-speed gear. It may aggravate the battery's inconsistent and influence the vehicle's drive and safety performance[3]. Therefore, it is necessary to make further research on the influence that the batteries discharge with big current will cause to its service life and the safety of electric vehicle.

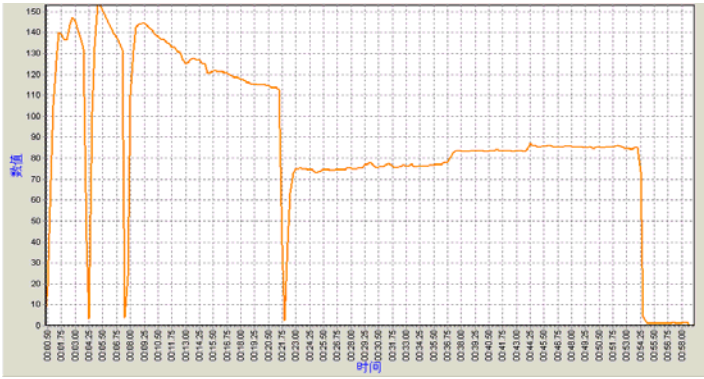


Figure 3 The current curve of the power battery in the test

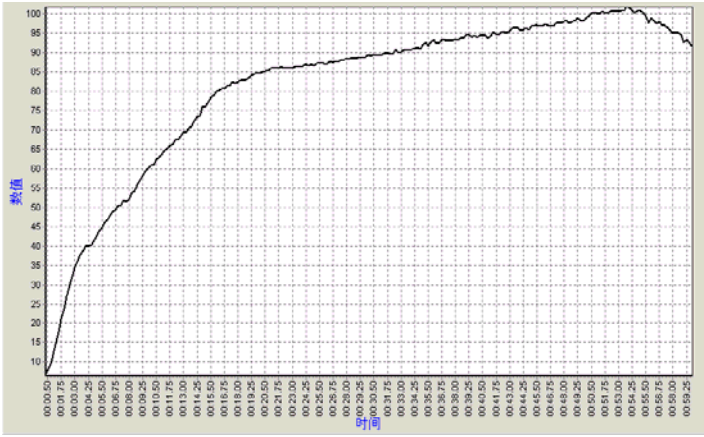


Figure 2 The speed curve of EV in the test

2 Performance test of excide battery and MH-Ni battery

2.1 The turning test of excide battery and MH-Ni battery

Fixed the excide battery or MH-Ni battery in the equipment, shown as figure 4. After the battery worked for 5 minutes, turned the battery over and remained it for 20 minutes. Then, let the battery worked for another 5 minutes. Recorded the voltage variety in the whole course. The MH-Ni battery group for test is composed of 10 cell batteries and their capacity is 80Ah. According to the GB/T18332.2-2001, the

batteries were charged before test. The MH-Ni battery for test is shown as figure 6. Figure 7 is the voltage curve of excide battery and MH-Ni battery in the course of the test. Figure 7 illustrates that the voltage of excide battery and MH-Ni battery does not have obvious change in the turning test.

Figure 4 The turning equipment

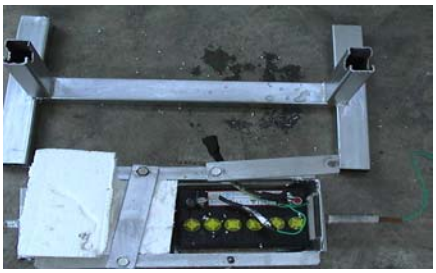


Figure 5 The leak electrolytes

After the test, there is some electrolytes leak from the excide batteries, as being shown in figure 5. The battery temperature does not go up in the test. Therefore, when electric vehicle turns over, the voltage and current of the power batteries may not have big varieties and their temperature may not go up. These benefit to the protection of passengers. However, the leak of the electrolyte of excide battery must be solved, because it can decay wires and car's body and make injury to the passengers[4].

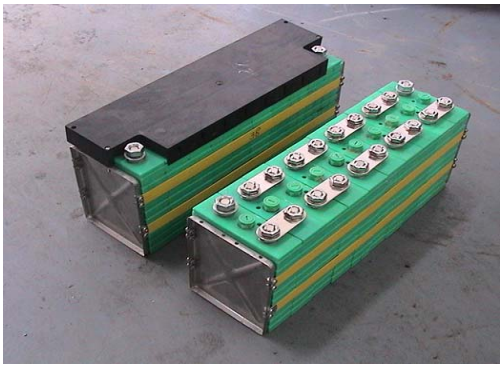
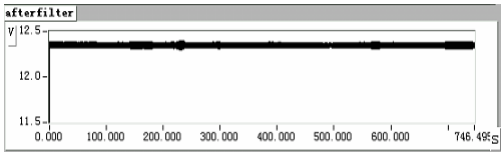
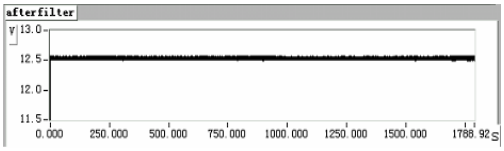


Figure 6 The MH-Ni batteries for test



A The voltage curve of excide battery



B The voltage curve of MH-Ni battery

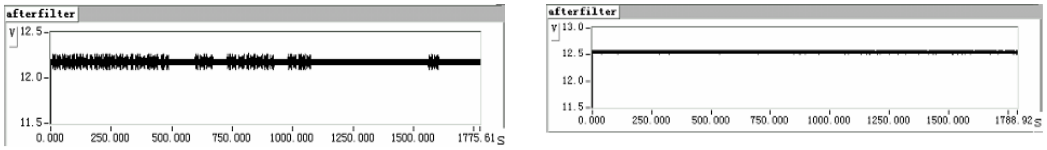
Figure 7 The voltage variety curve of the battery in the course of test

2.2 The vibration test on excide battery and MH-Ni battery

To simulate electric vehicle running on different road, the excide battery or MH-Ni battery was fixed on the vibration equipment and tested, as being shown on figure 8. The vibration tests are to simulate the electric vehicle run on uneven road with the speed of 40Km/h and on rugged road with the speed of 20 Km/h. The time of every test is 30 minutes.

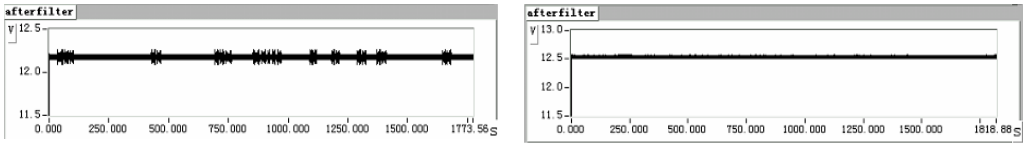
Figure 9 and figure 10 are the voltage curve of the battery in the test on different road. Two figures illustrate that voltage of the excide battery has about 0.2V change both on the uneven road and on the rugged road; the voltage of MH-Ni battery almost has no change in the course of the test. The temperature of the battery does not go up and there is not any electrolytes leak during the test. Because the ventilation condition is good and the batteries do not discharge with big current in the test, and the condition of the batteries in electric vehicle are worse than in the test, it is necessary to further research the vibration performance of power battery.

Figure 8 Excide battery fix on the test-bed



A The voltage curve of excide battery B The voltage curve of MH-Ni battery

Figure 9 The voltage curve of battery in the course of test simulating uneven road



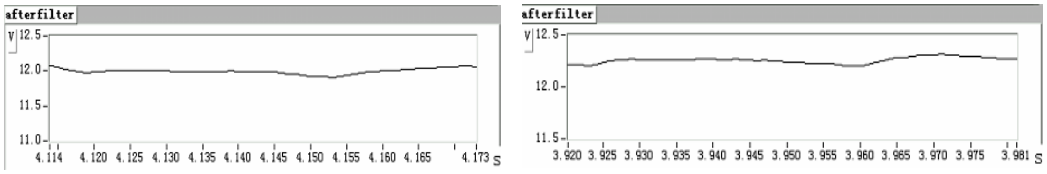
A The voltage curve of excide battery B The voltage curve of MH-Ni battery

Figure 10 The voltage curve of battery in the course of test simulating rugged road

2.3 The collision test of excide battery and MH-Ni battery

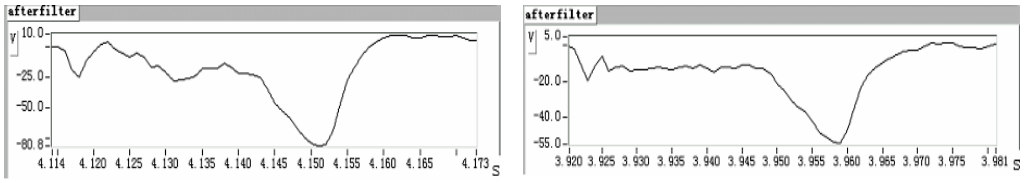
Figure 11 The trolley for test

According to SAE J1766:1998, the collision test regulations for power battery of electric vehicle and hybrid electric vehicle, and some other national standards[5], the batteries for test were fixed on the sled and the collision speed was set to 50Km/h, as being shown in figure 11. The energy-absorbing structure was installed on the sled in order to simulate the real car collision acceleration. The collision acceleration of sled and the voltage of the batteries were measured, as being shown in figure 12 and figure 13. The figures illustrate that the voltage of the batteries has only a little change.



A The work voltage curve of excide battery B The work voltage curve of MH-Ni battery

Figure 12 The work voltage curve of battery in the course of the collision



A Excide battery is fixed on the trolley B MH-Ni battery is fixed on the trolley

Figure 12 The acceleration curve of trolley in the course of the collision

There wasn't any damage that could be found on the batteries after the test and their temperature did not go up. A little electrolyte could be found on the excide battery, but it is less than 5L.

According to the above test results, if the power batteries can be fixed at the appropriate position of the car, the fixation can be strengthen, some safety structure and equipment, such as energy absorbing structure, current limit equipment, etc., can be used, the electric vehicle can be safe even when collision happened. Therefore, some serious accidents, such as fire and blast, can be escaped. If using seal batteries, the electrolyte of the batteries will not leak.

3 Conclusion

The safety performance of the power batteries used in electric vehicle has been studied by test method on the condition of collision, turning over, and so on. The influence of the power batteries to electric vehicle has been analyzed. It may be useful for the development of the safety protecting method used in electric vehicle.

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