Tskhinvali electric vehicle safety

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Usually, a high-quality review is able to not only broaden the horizons of readers but also provide guidelines for the future study. However, there is little review work concerning the safety of the high-voltage powertrain-based EVs in the crash conditions now.

Policies and ethics

Vehicle collision types usually include frontal impacts, side impacts, rolling and rear impacts. Statistics indicate that the probability of occurrence of vehicle rear impact is less than that of frontal and side impacts, but the probability of rear impact occurring in national highway traffic accidents is up to 44%, which is far higher than the corresponding probabilities of other types of impact [8,9,10].

The rear part of a typical electric vehicle body is equipped with a large number of high-voltage (HV) components, including the battery pack, the HV distribution box, the wire harness, the motor controller, the motor, and the on-board charger. Figure 1 shows the HV parts contained in the rear space of vehicle A. Vehicle A is a midsize sport utility vehicle (SUV) with five seats.

In this study, only the cutoff control signal, the body structure, the third row seat structure, and the wiring layout were optimized. Three rear impact tests were performed: two on vehicle A and one on vehicle B. The test conditions are described in detail in Table 2. The motor controller placement conditions are also shown in Fig. 2.

The most important factor in HV protection is the response time of the system to the crash or accident, i.e., shorter response times are more advantageous for the protection of the passengers and the HV system. The impact protection system must deal with the impact signals between the control modules. The theory of the high-voltage cutoff control signal in a rear impact scenario is illustrated schematically in Fig. 3. The function of the supplemental restraint system electronic control unit (SRS ECU) is to receive and process the collision signals.

When the rear impact occurs, the impact sensor transmits an impact alarm signal to the SRS ECU through a hard line. After the SRS ECU receives the impact signal, it determines whether the impact signal reaches the required threshold; if the answer is yes, then the SRS ECU sends an alarm signal to the battery management system (BMS) and the motor controller.

The SRS ECU can send the alarm signal to the front motor controller in two forms, via a pulse width modulation (PWM) signal and using the controller area network (CAN); however, the alarm signal is sent to the motor controllers in CAN form only. When the front and rear motor controllers receive their cutoff signals from the BMS, they would cut off the high-voltage supplied by the battery pack. In addition, at the time when they received their impact signals from SRS ECU, they would also reduce their own operating voltages immediately.

When a rear impact occurs, to ensure that the passengers are able to escape from the car in time, the door unlock signal must also be sent in addition to the HV impact signal to allow the doors to unlock in time after the crash or accident. The theory of the rear door unlocking signal process is illustrated schematically in Fig. 4. The function of the SRS ECU is again to receive and process the collision signals.

To provide a more in-depth understanding of the cutoff behavior of the HV parts and the discharge performance of the vehicle under actual impact conditions, three rear impact tests were arranged. In these tests, vehicle A was subject to 50 km/h and 80 km/h rear impacts, while vehicle B was subject to a 50 km/h rear impact. The 50 km/h rear impact preparation and tests were carried out with reference to the GB 20072 standard, and the 80 km/h rear impact preparation and test were carried out with reference to FMVSS 305. The tests are illustrated schematically in Figs. 5 and 6.

The high-voltage and low-voltage control signals must be connected to the pins of each control module to enable analysis of the transmission path and time and the execution strategy for the control signal. After screening, the important signals that must be detected were finally identified as shown in Table 3.