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Detection and Fault Diagnosis of High-Voltage System of New Energy Vehicles

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Abstract. With the development of new energy vehicles, the detection and fault diagnosis of high voltage system of new energy vehicles are becoming more and more important. The leakage of high-voltage system of new energy vehicles will lead to the failure of power on and normal operation of vehicles. At the same time, it is very important for the safety protection of the whole vehicle. Taking the leakage detection of byd-qin hybrid high-voltage system as an example, this paper analyzes the fault generation mechanism and puts forward the detection technology of new energy vehicles, so as to help maintenance personnel better grasp the diagnosis technology of new energy vehicles.

Keywords. New energy vehicle, high-voltage system, detection, fault diagnosis.

1. Introduction

In recent years, the production and sales of new energy vehicles have been greatly improved, but the leakage of high-voltage system of new energy vehicles also occurs from time to time. This phenomenon leads to the failure of power on and normal operation of vehicles, and also threatens the life safety of passengers. In order to better deal with the leakage of high-voltage system of new energy vehicles, it is necessary to fully understand the cause of the failure, develop detection methods, and timely deal with the leakage of high-voltage system of new energy vehicles.

2. Composition of High Voltage System of New Energy Vehicles

The new energy vehicle is equipped with high-voltage equipment, mainly including power battery, high-voltage wire, electric compressor, PTC heater, junction box, charging system, DC/DC converter and drive motor (including inverter). The relationship is shown in figure 1.

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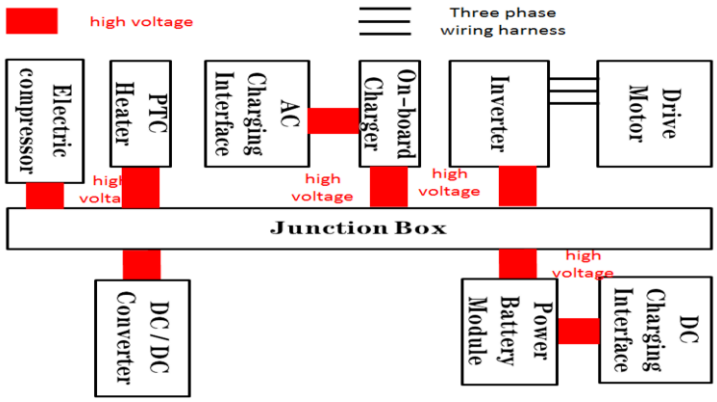

Figure 1. Composition of high voltage equipment for new energy vehicles

2.1. Power Battery Pack.

The power battery pack is composed of many power battery modules, including battery management system (BMS), power battery box and auxiliary components, etc., which are connected to the vehicle through high and low voltage plug-ins. The power battery pack provides energy for each system. At the same time, the battery management system in the power battery pack can monitor the status of the battery pack in real time, judge whether the power battery pack is abnormal according to the monitoring results, conduct comprehensive management on the power battery pack in time, and upload the battery status and fault conditions to ensure the working state of the power battery pack and extend its service life.

2.2. High Voltage Control Box.

The high-voltage control box is a "distribution hub", which is used to complete the output and distribution of high-voltage power supply of power battery and realize the protection and cut-off of branch electrical appliances. Its internal parts include PTC fuse, compressor fuse, DC / DC fuse, on-board charger fuse and other components, as shown in figure 1.

2.3. Drive Motor and Motor Controller.

The drive motor is a compact, lightweight, high power output and high efficiency permanent magnet synchronous motor (PMSM). The permanent magnet is inserted into the rotor, and the rotating magnetic field and the stator coil work together to produce torque; the motor resolver is coaxial installed on the electric machine to detect the rotor rotation angle, which is sent to the motor controller; the motor temperature The temperature sensor detects the temperature inside the motor stator, and the temperature information is also sent to the motor controller. The power battery produces direct current, while the driving motor needs alternating current. Therefore, the motor controller is needed to realize the conversion from DC to AC. At the same time, the motor controller will collect the position signal and other information of the motor to realize the precise

control of the motor. The drive motor controller is mainly composed of IGBT module, drive board, control board and other components[1-2].

2.4. DC / DC Converter.

In new energy vehicles, the power supply includes the main power supply (power battery pack) and the auxiliary power supply (LV battery). Among them, the power battery pack acts as the driving force of the car, while the auxiliary power supply supplies power for the instrument system. For the auxiliary power supply, the traditional vehicle uses the generator to generate electricity to charge it, while in the new energy vehicle, it completes the charging process of the low-voltage battery through the voltage conversion of the DC / DC converter, which avoids the problem of insufficient power supply of the generator caused by the excessive access of the electrical equipment in the traditional automobile. Therefore, DC / DC converter is a very important component in new energy vehicles. It converts the high-voltage direct current of the power battery pack into 12V low-voltage direct current, which not only supplies power to the electric equipment of the whole vehicle, but also charges the battery.

2.5. The Power Battery Pack of New Energy Vehicle.

The power battery pack of new energy vehicle for on-board charging is high-voltage DC power supply, which can not be directly charged by AC power supply. Therefore, it is necessary to convert AC power into DC power by on-board charger to complete the supplement of power battery.

3. Analysis of Diagnosis Technology for High Voltage Equipment

The detection and judgment of high-voltage equipment is basically the same as that of electronic control system. The difference lies in safety protection and special detection for high-voltage equipment.

3.1. Voltage Measurement Method.

High voltage system is mainly used to judge whether the performance of power battery, junction box, charging system, inverter and DC / DC converter is normal. The measuring principle and method are the same as those of traditional vehicle low-voltage circuit, but it must be based on insulation function multimeter and high-voltage safety operation specification.

3.2. Resistance Measurement.

High voltage system uses resistance method to determine whether the performance of high-voltage interlock device, PTC heater and drive motor is normal, and the use process also needs to comply with the specification requirements.

3.3. Other Measurement Methods.

In order to determine whether there is leakage in the vehicle, clamp on ammeter can be used for detection.

Megger is used to judge the insulation of the high-voltage system. As shown in figure 2, the connection between the high-voltage system and the low-voltage system of the vehicle and the vehicle body is shown. The insulation status of any part of the high-voltage system and the vehicle body is required.

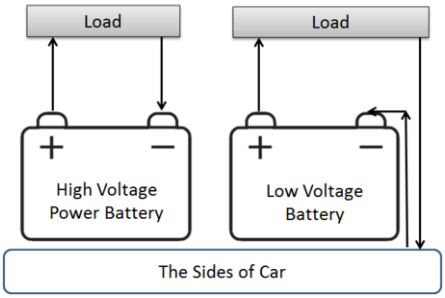

Figure 2. Relationship between high and low voltage system and body of new energy vehicle

4. Fault Diagnosis Case

4.1. High Voltage Leakage Fault

The driver of a byd-qin hybrid new energy vehicle found that the power displayed on the dashboard was 83% when the vehicle was powered on OK. The vehicle automatically switched to HEV, and the engine started and ev mode could not be used. At the same time, the fault light of the power system was on, and the instrument panel indicated that please check the power system[3].

4.2. High Voltage Leakage Detection Principle

The high voltage system of new energy vehicle is equipped with leakage sensor, which is mainly used to detect the insulation impedance between the main line of DC power supply of electric vehicle and its shell and chassis. By detecting the insulation resistance between the negative lead connected with the power battery output and the chassis of the vehicle body, the leakage degree of the high-voltage components can be judged. Different models have different installation positions of the leakage sensors. The leakage sensors of byd-qin are installed on the front reinforcing beam of the rear surround shelf of the vehicle body. As shown in figure 3 and figure 4.When the power battery pack or high voltage components have leakage, the sensor will send a signal to the battery management controller. After receiving the leakage signal, the battery management controller will take the relevant protection operation such as charging and discharging and alarm, so as to prevent the high-voltage leakage of the power battery pack and high-voltage components, causing injury and loss of people or objects. As shown in figure 1, the leakage sensor mainly detects the insulation resistance between the lead connected

to the negative pole of the power battery pack and the chassis of the vehicle body, and judges the leakage degree of the power battery pack and high-voltage components of the system by the resistance value. When the insulation resistance between the negative pole and the vehicle body is less than or equal to 100-120 K Ω, it is general leakage; when it is less than or equal to 20 K Ω, it is serious leakage[4].

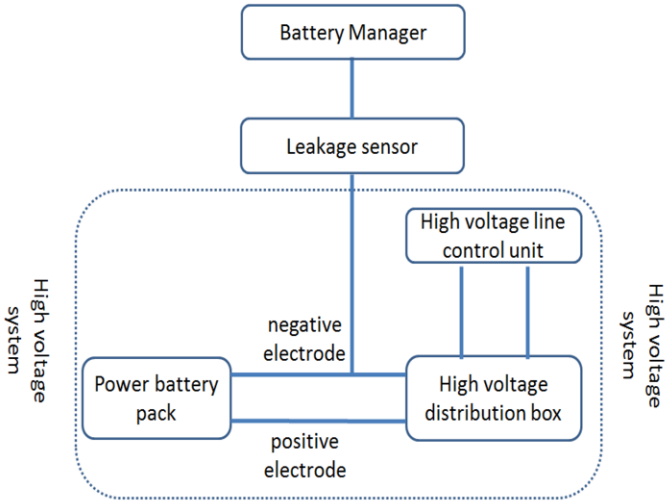

Figure 3. Leakage management system

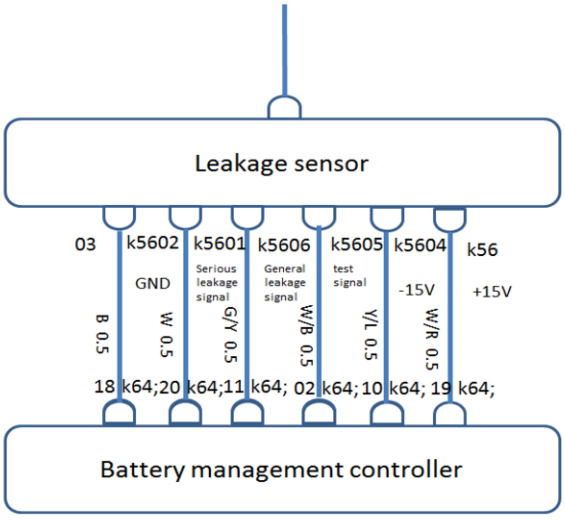

Figure 4 . Leakage management system

4.3. Cause Analysis of High Voltage Leakage Fault

When the high-voltage battery manager (BMS) system reports a leakage fault, the fault may be caused by all the high-voltage control units (power battery pack, maintenance switch, high-voltage distribution box, motor controller and DC assembly, electric air-conditioning compressor, PTC heater and on-board charger), orange high-voltage harness, leakage sensor and connecting harness. Leakage of these components may cause high voltage leakage fault and report leakage fault code. But in the actual production, the leakage parts usually include No.2, No.4, No.6 and No.8 battery modules of power battery pack, electric compressor body leakage, PTC water heater leakage, high-voltage distribution box leakage, drive motor controller and DC assembly leakage.

5. High Voltage Leakage Fault Diagnosis Process

In the diagnosis of high-voltage leakage of new energy vehicles, the problem of leakage sensor circuit should be initially eliminated, and then confirm whether the leakage fault is in on gear or OK gear. If the leakage occurs in on gear, it can be preliminarily judged that the power battery pack is leaking; if it is in the OK position, it can be preliminarily determined that the leakage is caused by the high-voltage components of the system. The self diagnosis function of the diagnostic instrument should be fully used in the detection. The leakage can be quickly determined by consulting the fault code and data flow. Then, the power battery pack, high-voltage components and wiring harness that may have leakage can be checked respectively.

5.1. To Confirm the High-voltage Leakage Fault

First connect the diagnostic instrument to make the vehicle in the OK gear, and the instrument OK light is on. But after starting the engine, ev mode cannot be used. Use the diagnostic instrument to read the BMS, and there is a fault code of leakage.

5.2. Leakage Sensor Inspection

- After clearing the fault code of the whole vehicle, power on the vehicle again, read the BMS data stream with the diagnostic instrument, and display the battery pack leakage status as serious leakage.
  - In the on status, read the battery manager data with the diagnostic instrument, and display the status of the voltage divider contactor is off.
  - In the off position, pull out the low-voltage connector of the leakage sensor, and the diagnostic instrument detects and eliminates the leakage fault, and the leakage fault occurs after the plug-in.
  - Disconnect the insulation wire lead out terminal of leakage sensor, and still report "serious leakage" fault.
  - Determine the leakage sensor fault, replace the leakage sensor, the vehicle returned to normal.

5.3. After Clearing the Fault Code, Make The Vehicle in the on Gear State

Using the diagnostic instrument to check whether the BMS battery manager has leakage fault code, and then read the data stream. If it shows that four voltage dividing contactors are closed, it indicates that the power battery does not leak; if it shows that the four partial voltage contactors are disconnected, and BMS also reports the leakage fault code p1a0000 or p1a0100, it can be preliminarily judged that the power battery pack is leaking, and the high-voltage leakage inspection of the power battery pack is required. During the operation, the vehicle should be kept in the on gear state repeatedly, so as to confirm whether the leakage fault will be reported every time the vehicle is in the on gear state.

5.4. Check the Electric Leakage in the OK Gear

Step on the brake pedal and press the start button to make the vehicle in the OK gear state, and then carry out the leakage detection. The instrument shows that pleased check the power system. At this time, connect the diagnostic instrument and consult the BMS system. If the fault code p1a0000 is reported, it is a serious leakage fault; if p1a0100 is reported, it is a general leakage fault. After clearing the fault code, put the vehicle in the OK position again. If the fault code reappears, check the data flow in BMS. Once the four voltage divider contactors are disconnected, it can be confirmed that the vehicle is unable to use EV mode due to leakage fault. And because the vehicle is in the OK gear state, leakage fault can be determined as the high-voltage components outside the power battery pack have leakage risk. The specific high-voltage control unit leakage can be checked according to the leakage flow of high-voltage components in 5.6[5].

5.5. When the Power Battery Pack Leakage Check is in on Position, the High Voltage Leakage Fault Can Be Preliminarily Determined as the Power Battery Pack Leakage

The specific battery module leakage can be checked according to the following process.

- In the off position, first pull out the No.8 battery module connector, and then switch to the on position, and read the system fault code and data flow with the diagnostic instrument. If there is no leakage, it can be judged that No. 8, No. 9 and No. 10 battery modules may have leakage. However, in actual production practice, the failure probability of No. 8 battery module is the highest; if there is still leakage after maintenance, the fault of No. 8, No. 9 and No. 10 battery modules shall be eliminated, and No. 1-7 battery modules shall be inspected.
- Also in the off position, pull out the connector of No. 6 battery module, and then switch to the on position, and read the fault with the diagnostic instrument. If there is no leakage, it can be judged that No. 6 and No. 7 battery modules have leakage. In actual production, the probability of failure of No. 6 battery module is high; if there is still leakage, remove the fault of No. 6 and No. 7 battery modules, and check No. 1-5 battery modules.
- If it is still in the off position, pull out the No.4 battery module connector, and then switch to the on position, and read the fault with the diagnostic instrument. If there is no leakage, it can be judged that No. 4 and No. 5 battery modules have leakage. In actual production, the failure probability of No. 4 battery module is high; if there is still leakage, remove the fault of No. 4 and No. 5 battery modules, and check No. 1-3 battery modules.

- If it is still in the off position, pull out the connector of No. 2 battery module, and then switch to the on position, and read the fault with the diagnostic instrument. If there is no leakage, the leakage of No.2 and No.3 battery modules can be judged. In actual production, the failure probability of No.
- Iron battery pack: 1, 3 and 5 can be interchanged; 2 and 4 can be interchanged; 6 and 8 can be interchanged; 7 and 9 can be interchanged.

5.6. Leakage Inspection of High Voltage Components

- In the off position, first disconnect the emergency maintenance switch, then disconnect the high-voltage harness connector of the electric compressor; install the emergency maintenance switch and check it in the OK position. Read the fault with the diagnostic instrument. If there is no leakage, it is judged as the leakage of the electric compressor; if there is still leakage, it is judged that the electric compressor is normal, and then continue to disconnect other high-voltage control units for detection.
  - In the off position, first disconnect the emergency maintenance switch, and then disconnect the PTC heater high-voltage harness connector; install the emergency maintenance switch and check it in the OK position. If there is no leakage, it can be judged as PTC heater high-voltage leakage; if there is still leakage, it is judged that PTC is normal, and then continue to disconnect other high-voltage control units for detection.
  - In the off position, first disconnect the emergency maintenance switch, and then disconnect the high voltage harness connector at the input end of the air conditioning distribution box; install the emergency maintenance switch, and check it in the OK position. Read the fault with the diagnostic instrument. If there is no leakage, the leakage of the air conditioning distribution box and wiring harness will be judged; if there is still leakage, it will be judged that PTC and wiring harness are normal.
  - In the off position, first disconnect the emergency maintenance switch, and then disconnect the DC side connector of the on-board charger; install the emergency maintenance switch and put it in the OK position for inspection. If there is no leakage, it is the fault of the on-board charger. If there is leakage, continue to disconnect the DC input connector (short circuit of interlock switch). When it is in the OK position, no leakage will be reported immediately, then the motor and motor controller may have leakage. In order to eliminate the motor problem, connect the DC input and disconnect the three-phase output of the motor controller at the same time. If the leakage is still reported when the motor is in the OK gear, it is determined that the motor controller and DC assembly are leaking; if the leakage is reported for a long time, continue to disconnect other high-voltage control units.
  - According to the above methods, disconnect the remaining high-voltage control units in turn, and check the leakage of control units or high-voltage wiring harness one by one. During the inspection, repeat the operation several times as much as possible to confirm whether the fault phenomenon occurs again, so as to avoid misjudgment.
  - For the vehicle with high-voltage interlock, after disconnecting the high-voltage components with high-voltage interlock, it is necessary to short-circuit the

interlock switch at the high-voltage control unit end, and then check it in the OK state, and finally judge the leakage situation.

- After the leakage of high-voltage components are determined, the insulation resistance of high-voltage components is detected with a multimeter, so as to confirm the specific leakage position. If the insulation resistance is greater than or equal to 50 m Ω, it is normal; if it is less than this value, it is leakage.

5.7. High Voltage Harness Inspection

- Read and record the software and hardware version numbers of each control unit and the vehicle fault code with the diagnostic instrument.
    - After clearing the fault code of the whole vehicle with the diagnostic instrument, power on the vehicle again, read the BMS data stream with the diagnostic instrument, and the battery pack leakage state shows serious leakage, and the fault code is p1a0000.
    - When the vehicle is in on gear, read the BMS data stream with the diagnostic instrument, and the status of the voltage divider contactor is displayed as pull in.
    - Disconnect the high-voltage input of each high-voltage control unit one by one from the high-voltage load end. If the leakage fault is still reported, carry out the next step inspection.

6. Conclusion

The popularization of new energy vehicles has put forward new requirements for the knowledge structure, standard consciousness and diagnosis technology of after-sales service personnel, especially maintenance technicians. This paper analyzes the application of new energy vehicle detection technology, so as to provide help for maintenance technicians to solve new energy vehicle fault. We believe that the diagnosis method of electronic control system is still the basis of new energy vehicle diagnosis technology, including experience method, instrument measurement method, voltage method, resistance method, lamp test method, data flow method, action test method, replacement method, etc. mastering this law can help maintenance personnel to better transition to new energy vehicle diagnosis technology. The voltage method and resistance method are still applicable to the detection and judgment of high-voltage equipment of new energy vehicles. In addition, due to the characteristics of high-voltage leakage and high insulation requirements, compared with the diagnosis of traditional vehicles, leakage detection and insulation detection become important detection contents, and are the basic maintenance skills that maintenance personnel need to master.

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