Study on energy flow test of electric vehicle based on four-wheer drive powertrain bench

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Abstract. In order to obtain the internal energy conversion, transmission and loss, namely the distribution law of energy flow, a test platform for the energy flow of electric vehicle was built. The test bench is mainly composed of four-wheel drive powertrain bench, automatic driving system, a data acquisition system, sensor measurement system, charging system. It can monitor the operation parameters of the whole electric vehicle under different working conditions. Energy flow distribution can be obtained by processing the measured operation parameters. The energy flow of an electric vehicle under CLTC condition was tested. The energy distribution and energy consumption of each component of the vehicle were obtained, which provided guidance for the optimization of each component of the electric vehicle.

1. Introduction
Under the pressure of energy crisis and environmental pollution, new energy vehicles have been extensively researched and developed. Among them, electric vehicles have developed rapidly with their advantages of zero emission and zero pollution[1]. However, the current electric vehicle range is generally short problem making people discouraged. In the process of driving, the energy provided by the power battery is distributed to different parts of the vehicle in different working conditions. To fully understand the energy consumption of each component under different working conditions of the vehicle, analyze the matching of each component, and optimize the efficiency of each component, can reduce the energy consumption of the vehicle and improve the vehicle driving range. Therefore, it has become an important technical measure for automobile enterprises to improve vehicle economy and increase vehicle range by analyzing vehicle energy flow test and optimizing component energy consumption.

The so-called research on the energy flow of the whole electric vehicle is to analyze the effective power, heat loss and other losses of each component distributed by the energy provided by the power battery under different working conditions of the vehicle, and analyze the energy conversion and transfer process of the whole electric vehicle and the energy consumption of each component from the perspective of system integration[2].

In this paper, the energy flow test of electric vehicle is studied. This paper mainly studies the energy consumption of the whole vehicle, controller, powertrain and vehicle accessory system during the whole driving distance of the vehicle, and proposes the optimization direction, and proposes the test method for the energy flow of the whole electric vehicle. Aiming at the proposed test method, this paper conducts the energy flow test of a certain electric vehicle, conducts comparative analysis, proposes the optimization direction of each component, improves each operating efficiency, and provides guidance for the design of electric vehicles. Electric vehicle structure and energy flow test.
2. Electric vehicle structure and energy flow test

2.1. Basic structure of electric vehicles
The traditional internal combustion engine automobile is mainly composed of engine, chassis, body and electrical equipment. Compared with traditional cars, pure electric vehicles have no engine, and the transmission mechanism has changed. According to different driving modes, some parts have been simplified or cancelled, and new structure such as power system and driving motor have been added[3]. Due to the changes in the above system functions, pure electric vehicles are composed of four new parts: electric drive control system, chassis, body and auxiliary system[4].

2.2. Energy flow test of electric vehicles
The energy flow test of a complete vehicle is the transmission path, transmission efficiency and specific energy consumption of the vehicle. Based on the specific architecture cycle and working mode of the vehicle, the process of energy generation, transmission, transformation and consumption is studied and analyzed through practical test and analysis[5]. The energy test analysis of the vehicle is to test the energy consumption of each component and system, analyze its energy consumption sensitivity deeply through simulation technology and define the optimization and improvement direction of energy consumption, and determine specific plans and measures to reduce energy consumption, so as to improve the vehicle's driving range.

3. Construction of the vehicle energy flow test platform

3.1. Demand Analysis
The purpose of building this test platform is to test the energy flow distribution of the whole electric vehicle under different working conditions. Therefore, the requirements for the test platform are as follows: resistance loading and energy consumption, test platform control, data collection of relevant parameters, and automatic driving mechanism.

3.2. Test parameters
The energy exists in different forms in the transmission process from the battery to the wheel: the battery outputs DC high voltage to the vehicle high voltage distribution box, which distributes the electric energy. In order to obtain the energy consumption of each part of the vehicle, it is necessary to measure the input and output of each part. Mechanical parameters includes wheel speed, motor speed and torque, the electrical signals includes voltage and current of the battery, the motor controller, DC/DC, charger, pump motor, fan motor, air conditioning compressor and PTC.

3.3. Construction of test platform
According to test requirements, the test platform is composed of several parts. The test platform can be divided into four modules, namely vehicle road simulation system, automatic driving system, data acquisition system, sensor measurement system and charging system. The system composition of the test platform is shown in figure 1.
Figure 1. Test system structure diagram

4. Energy flow test of electric vehicles

4.1. Test Objects
A certain pure electric vehicle is taken as the research object of this energy flow test. Through the energy flow test, the component energy consumption and energy distribution of the vehicle are analyzed. The basic parameters of the vehicle are shown in Table 1.

| Parameter                  | Vehicle          |
|----------------------------|------------------|
| Vehicle type               | Pure electric    |
| Length × Width × height(mm) | 4678 * 1919 * 1618 |
| Reconditioning mass (kg)   | 1750             |
| Maximum speed (km/h)       | 180              |
| Maximum power (kW)         | 139              |
| Maximum torque (N.m)       | 415              |
| Battery type               | Ternary lithium battery |
| Battery Capacity (kWh)     | 57               |
| NEDC Range (km)            | 410              |

4.2. Test plan
During the test, the ambient temperature is 20±5°C, and the relative humidity is 40%~70%. This test includes two parts: discharging and charging. Before the discharge test, the car charger or Ac charging pile is used to charge the vehicle to an equilibrium state, so as to maintain the consistency of the test results. The specific process of the test is as follows:

1) First, each part of the vehicle is equipped with a corresponding type of sensor. After the completion of installation, carry out debugging to ensure that all sensors work normally and collect data correctly;

2) The vehicle is mounted on the four-wheel drive assembly bench, and the ride resistance is simulated on the bench. When running resistance simulation, other parts of the vehicle should be consistent with the state of running resistance measurement (such as air conditioning shutdown);

3) The vehicle travels at a speed of 60km/h for 15min.

4) Use the car charger or Ac charging pile to charge the power battery at room temperature until the charging device gives a clear signal indicating that the driver's power battery is fully charged;
5) This moment is recorded at the end of power battery charging, and the CLTC driving distance test of the vehicle is carried out on the platform within 12h thereafter. When the maximum vehicle speed in the test cycle is less than 118km/h, the test should be stopped.

6) At the end of the test cycle and when the vehicle stops, the distance D (km/h) traveled by the vehicle testing vehicle is recorded. The measurement results are rounded to the whole and the test time is also recorded.

7) After completing the continuous driving distance test, connect the vehicle to the power grid within 2h and charge the power battery of the vehicle according to the charging procedure of 4). Meanwhile, connect the energy measuring device between the power grid and the vehicle charger. During the charging period, measure the energy from the power grid and record the electric energy E.

4.3. Energy flow test and analysis of electric vehicles

Through the test, the driving distance, charging capacity and energy consumption rate of 100 kilometers of the vehicle under CLTC condition are shown in table 2.

| project results | Range D (km) | Charge E (kWh) | Energy consumption (kWh / 100 km) |
|-----------------|-------------|---------------|-----------------------------------|
| The test results | 347.8       | 57.2          | 16.4                              |

In the whole cycle test, 24 cycles were performed, with a total time of 13.3 hours. The SOC of the vehicle in full charge is about 98.2%, and the remaining power of the vehicle at the end of the test is about 4%. The total range is 347.8km, the total power consumption is 57.2kwh, and the comprehensive power consumption is 16.4 kwh /100km.

In order to more intuitively analyze the energy consumption of vehicles, cycles of SOC in 80%, 50% and 30% are selected to analyze the overall energy consumption and energy loss of each working condition and each component, and the average energy consumption of each cycle is analyzed.

Figure2. Energy consumption curve of power battery and drive motor system in a single cycle
Figure 3. Power consumption curves of DCDC and low-voltage accessories in a single cycle

Single driving cycles in the output power battery, drive motor system input, DCDC and low pressure accessory system energy consumption curve as shown in figure 2, figure 3, respectively, in the working condition of a single cycle, cell total energy output is 2.86 kWh, drive motor system input energy is 2.66 kWh, DCDC output is 0.12 kWh energy, low pressure accessory system power consumption is 0.11 kWh, drive motor system output on the vehicle axle shaft of machine for 2.33 kWh, the drive motor system in the working condition of a single cycle efficiency is about 87.6%. The energy consumption and share of each component in a single cycle are shown in Figure 4.

Figure 4. Distribution of vehicle energy consumption

It can be seen from the situation of vehicle energy consumption in Figure 4. The power consumption of the electric drive system is 2.66kWh, accounting for 92.8% of the total energy. The power consumption of DCDC is 0.12kWh, accounting for 4.1% of the total energy. Among them, the power consumption of low-voltage accessory system is 0.11kWh, accounting for 3.9% of the total energy. Other accessory systems consume 0.08kWh, accounting for 3.1% of the total energy. The total energy loss of the system was 0.34kWh, accounting for 11.75% of the total energy.

In order to compare the energy consumption of each component under different SOC, the energy consumption of each component under 80%, 50% and 30% SOC is listed in table 4. It can be seen from the table that under different SOC, the energy consumption of each component is not significantly different and basically remains unchanged.
Table 3. Energy flow in a single cycle under different SOC of the vehicle

| SOC | Power battery The output | Drive motor system input | DCDC The input | Low - voltage accessory system consumes power | Drive motor system The output |
|-----|--------------------------|--------------------------|----------------|-----------------------------------------------|-----------------------------|
| 80% | 2.7943                   | 2.6317                   | 0.1246         | 0.1153                                        | 2.227                       |
| 50% | 2.8261                   | 2.6662                   | 0.1208         | 0.1118                                        | 2.221                       |
| 30% | 2.974                    | 2.676                    | 0.1081         | 0.106                                         | 2.233                       |
| On average | 2.8648               | 2.658                    | 0.1178         | 0.111                                         | 2.228                       |

5. Conclusion

(1) The electric vehicle energy flow test platform is set up, including four motor vehicle test bench based on the four-wheel drive powertrain bench, the autopilot system, data acquisition system, sensor system, charging system, under different working conditions, which can realize the electric car vehicle running parameters monitoring.

(2) Relies on the building of the vehicle flow test platform vehicle energy flow test method is put forward, and put forward specific test scheme, and with some electric cars for example CLTC energy flow in the cases of test and analysis, get the vehicle state of energy distribution of the various components and the situation of energy consumption, for the enterprise to component optimization efficiency, reduce energy loss, travel distance increase.

(3) In the future test research, the simulation analysis will be combined with the test test to obtain the specific indicators of vehicle optimization through simulation, so as to provide data support and optimization direction for the enterprise's early research and development and later vehicle rectification.

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