Research on Test and Evaluation Technology of Hybrid Power Unit

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Abstract. With the adjustment of the strategic planning of China's automobile industry, the national policy strongly supports the development and large-scale application of hybrid power technology, but there is no guidance document on the testing and evaluation standards of hybrid power units. In this paper, the current situation of testing and evaluation technology of hybrid power units at home and abroad is analyzed in detail, and combined with the working characteristics of hybrid power units, the testing and evaluation methods that are more in line with the working characteristics of hybrid power units are put forward. They are the individual test of hybrid power unit parts, the test method of independent control of engine load and motor load, and the test method of total load control of hybrid power unit.

Keywords: Hybrid, testing, evaluation, new energy, hybrid power unit

1. Introduction
In order to promote the healthy and sustainable development of China's automobile industry and accelerate the transformation and upgrading of the automobile industry, in September 2019, the Ministry of Industry and Information Technology and other ministries and commissions jointly issued the Decision on Amending the Measures for Parallel Management of Average Fuel Consumption of Passenger Car Enterprises and Points of New Energy Vehicles (Consultation Draft), which reduced the points ratio of pure electric vehicles and fuel cells by about 50%, and introduced the concept of "low fuel consumption vehicles". The introduction of the new "integral method" means that the development of new energy vehicles returns to the essence of energy conservation and emission reduction. The national strategy for the development of new energy vehicles remains unchanged, but the requirements for energy consumption are increased [1]. From this point of view, the main way to encourage hybrid vehicles is to adopt the policy of low fuel consumption.

At present, the testing and evaluation standards for hybrid power units are all based on the whole vehicle, which tests the parameters such as vehicle dynamic performance, emission index and energy consumption. The engine and motor are tested and evaluated independently, referring to the traditional test standards for internal combustion engines and motors. This obviously violates the working logic of hybrid power unit, and does not reflect the overall working performance of hybrid power unit (engine and motor as a whole). The reason for this situation is that in the past, the national policy and industrial layout did not focus on the development of hybrid power technology, nor did it introduce a set of mature testing standards that met the working characteristics of hybrid power units.
Because of the various configuration styles of hybrid power units, it is difficult to test and evaluate hybrid power units, and there is no relevant unified test standard and method at home and abroad. At present, in the detection of hybrid power units, the method of testing each component separately is often adopted, and the original unified power output unit is decomposed into multiple components. Although this method is simple, it is contrary to the working logic of hybrid power unit, and can not reflect the overall working performance of hybrid power unit.

With the adjustment of the strategic planning of China's automobile industry, the national policy strongly supports the development and large-scale application of hybrid power technology, but there is no guidance document on the testing and evaluation standards of hybrid power units. Therefore, it is of great practical significance and promotion for the long-term development of China's automobile industry to carry out the construction of hybrid power unit test platform and the research of test methods.

In this paper, the current situation of test and evaluation technology of hybrid power unit at home and abroad is analyzed in detail. Combined with the working characteristics of hybrid power unit, the test and evaluation method which is more in line with the working characteristics of hybrid power unit is proposed.

2. Research status of hybrid power unit test and evaluation technology at home and abroad

Pure electrification is the best solution for the automotive industry to deal with energy security and climate change. However, due to the constraints of batteries and charging technologies, the climate cannot be formed in a short period of time. Therefore, OEMs are actively developing advanced engine technologies while developing alternative energy sources. Such as the use of supercharging, Miller cycle, lean burn, engine electrification and other technologies to improve engine performance and reduce energy consumption and exhaust emissions. As a low-cost, high-efficiency energy-saving and emission-reduction technical solution, hybrid technology is favored by major manufacturers [1-4]. At present, Changan, Geely, FAW and other major independent brand car companies have corresponding products on sale [5].

2.1. There is no guidance document for performance test and evaluation of hybrid power unit

There are relatively complete standards for testing and evaluation methods for hybrid vehicles, including 8 national standards including GB/T 19753-2013, GB/T 19755-2005, and GB/T 19752-2005. The standards related to the testing and evaluation of hybrid power units lag far behind the pace of development of hybrid technology. At present, only QC/T 926-2013 light-duty hybrid electric vehicles (ISG type) use power unit reliability test methods for reference. Completely unable to meet the requirements of the fast-developing hybrid technology for testing and evaluation standards that meet its own working characteristics. Moreover, referring to the traditional internal combustion engine and motor test standards, separate testing and evaluation of the engine and motor can not reflect the advantages of hybrid technology, which is contrary to the policies, regulations and the development trend of technology.

2.2. The test conditions and methods of hybrid power unit performance are not unified

Some institutions at home and abroad have built hybrid power unit test platforms according to their own conditions. Stuttgart University has built a comprehensive test platform for hybrid power units, which can complete the test of hybrid power units of various configurations. The platform also includes a battery environment bin for simulating various working environments of batteries [6]. However, the domestic hybrid power platform is mainly transformed from the engine bench [7-9]. On the basis of the original engine bench, modules such as battery simulator, power analyzer and motor cooling system are added, and some benches are equipped with inertia flywheels to simulate the inertia of the whole vehicle. Due to the performance limitation of dynamometer, it is necessary to add an accelerator box between hybrid power unit and dynamometer to meet the torque demand. Test contents, test methods, test equipment and test conditions are diversified, and there is no standard document for reference.
3. Introduction of hybrid power unit test platform

The structural style of hybrid power unit is varied, and the requirements of different hybrid structure forms on the platform are very different. Therefore, there is no fixed matching form for the hybrid power unit test platform. Hybrid power unit test platform can be defined as a modular, flexible and multifunctional test platform for hybrid power unit test.

3.1. Functional requirements of hybrid power unit test platform

It can provide engine, motor, controller and other parts with the same running environment as the whole vehicle, and carry out single test, debugging and calibration of key components of hybrid electric vehicle.

It can carry out debugging, calibration and performance test of hybrid electric vehicle powertrain system, comprehensively evaluate the performance of hybrid electric vehicle powertrain, and provide a verification platform for control strategy and control algorithm.

It can complete the whole vehicle dynamic test, simulate the road driving conditions of hybrid electric vehicles, and carry out the working condition tests specified in relevant national laws and regulations.

3.2. Basic structure of hybrid power test platform

The tested unit includes engine, motor, transmission, controller, power coupling device, etc.

Load simulation module, including dynamometer system, brake, etc.

Measurement and control module, including power analyzer, torque sensor, temperature and pressure sensor, vehicle control system, engine control system, motor control system, power battery control system, transmission control system, dynamometer control system.

Operation guarantee module, including temperature control system, compressed air, smoke exhaust system, fuel supply system, intake air conditioner, battery simulator.

4. Research on hybrid power unit test and evaluation method

At present, there are no specific test methods and national standards for hybrid power units to follow. According to the construction plan of hybrid power test platform and the experience accumulated in the test industry for many years, we can consider from three aspects: First, the single test of hybrid power unit components, which can be carried out according to the current regulations and test standards, and can fully understand the performance of single components of hybrid power units; The second is the test method of engine load and motor load independent control, which is to measure the universal characteristics of the whole power unit and provide detailed basis for the calibration of system control parameters and the formulation of control strategies; The third is the test method of total load control of hybrid power units, which can measure the joint operation characteristics of hybrid power units and confirm and optimize the control strategy.

4.1. Unit test of hybrid power unit components

Hybrid power unit components mainly refer to the engine, motor and power coupling mechanism. The purpose of the unit test is to fully understand the performance of the single component and determine whether its performance meets the design requirements. For engine unit test, please refer to GB/T 18297-2001 automobile engine performance test method and GB/T 19055-2003 automobile engine reliability test method and other test standards. Motor unit test can refer to GB/T 18488.2-2015 Electric Vehicle Drive Motor System Part 2: Test Method GB/T 29307-2012 Electric Vehicle Drive Motor System Reliability Test Method and QC/T 893-2011 Electric Vehicle Use Other test standards such as fault classification and judgment of the drive motor system. The dynamic coupling mechanism has various forms and does not have a fixed structure. The motor and engine of the P0 and P1 hybrid power units are integrated through a belt or shaft, and there is no separate power coupling mechanism. The motor and engine of the P2 hybrid power unit are dynamically coupled through the clutch. For the unit test of the clutch unit, please refer to the QC/T 27-2014 automobile dry friction clutch assembly bench.
test method; the P3 hybrid power unit the motor is arranged after the transmission, and there is a clutch and a transmission between the motor and the transmission. The transmission test can refer to the QC/T 568-1999 automotive mechanical transmission bench test method; there is no direct connection between the motor and the engine of the P4 hybrid power system mechanically connected, there is no power coupling mechanism; the motor of the Ps hybrid power unit is integrated with the transmission and cannot be separated. The transmission can be tested by referring to the QC/T 568-1999 automobile mechanical transmission bench test method, and the motor keeps rotating freely during the test. When the motor is tested, the transmission is maintained at a gear ratio of 1:1. The torque of the transmission can be obtained by multiplying the torque parameter measured at the output of the transmission by the transmission efficiency of the transmission.

4.2. Test method of separate control of engine load and motor load
The universal characteristics of the entire power unit can be measured through the individual control of the engine load and the motor load, and the universal characteristics can provide a detailed basis for the calibration of the control parameters of the hybrid power unit and the formulation of the control strategy. When carrying out the separate control test of the hybrid power unit engine and motor load, first keep the hybrid power unit at a certain constant speed and full load working state, and change the load distribution ratio of the engine and the motor in turn. Test the power performance, fuel economy and emission characteristics of the hybrid power unit at the load distribution ratio of the engine and the motor at this speed. After the test, adjust to the next speed and repeat the above test process. For specific test methods, please refer to GB/T 18297-2001 automobile engine performance test method 8.4 load characteristic test and 85,000 characteristic test and GB/T 18488.2-2015 electric vehicle drive motor system part 2: test method part 7 Part of the input and output characteristics test.

For the P0 type hybrid power unit, since the function of the motor is to complete the start and stop of the engine, the motor has no power output, so there is no need to conduct separate control tests of the engine load and the motor load. The test method can completely refer to GB/T 18297-2001 automobile engine performance test method. The P1 hybrid power unit can be tested directly according to the above method. If the motor of the P2 hybrid power unit can be separated from the transmission, it can be tested according to the above method. If the motor cannot be separated from the transmission, the transmission can be tested. The transmission maintains a 1:1 transmission ratio during the test, and the power performance test is performed through the output of the transmission. P3 and Ps hybrid power units need to be tested with a transmission. During the test, the transmission maintains a 1:1 transmission ratio, and the power performance test is carried out through the transmission output. The motor and engine of the P4 hybrid power system are arranged independently. During the test, the engine and the motor need to be connected to different dynamometers, and finally the test data is integrated and analyzed.

4.3. Test method for total load control of hybrid power unit
The total load control method of hybrid power units is mainly aimed at calibrated hybrid power units. Through this test, the joint operation characteristics of hybrid power units can be measured, and the control strategy and calibration parameters can be confirmed and optimized. During the test, the rotational speed and total load of the system are changed, and the hybrid power unit runs according to the pre-calibrated parameters and control strategy. The load distribution ratio of motor and engine is automatically distributed by the control unit, and the power performance, fuel economy and emission characteristics of the hybrid power unit are measured, and the test results are compared with the calibration data to explore possible optimization schemes.

5. Summary
The essence of hybrid power technology is engine electrification, which is an important measure to deal with increasingly strict emission regulations and increasingly severe environmental problems. Major automobile manufacturers at home and abroad are laying out hybrid vehicles. However, in the past
development process of automobile industry, the emphasis of industrial layout has not been placed on the development of hybrid technology, so a set of mature guidance documents for testing and evaluation conforming to the working characteristics of hybrid units has not been released. In this paper, combined with the structural characteristics and working characteristics of hybrid power units, aiming at different stages of development of hybrid power units, three test and evaluation methods of hybrid power units are proposed. They are the individual test of hybrid power unit parts, the test method of independent control of engine load and motor load, and the test method of total load control of hybrid power unit, which can provide technical support for the development and application of hybrid power technology.

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