Development of hybrid electric vehicle powertrain test system based on virtue instrument

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Abstract. Hybrid powertrain has become the standard configuration of some automobile models. The test system of hybrid vehicle powertrain was developed based on virtual instrument, using electric dynamometer to simulate the work of engines, to test the motor and control unit of the powertrain. The test conditions include starting, acceleration, and deceleration. The results show that the test system can simulate the working conditions of the hybrid electric vehicle powertrain under various conditions.

1. Introduction
Hybrid electric vehicles, which combine the advantages of traditional fuel vehicles and electric vehicles, can meet the requirements of low emission, low fuel consumption and low cost, and so on [1]. Based on the degree of mixing, hybrid electric vehicles can be divided into three categories such as weak mixing (Micro Hybrid), light mixing (Mild Hybrid) and the whole mixture (Full Hybrid) [2]. In consideration of low investment and relatively high economy and power, hybrid vehicles have obvious advantages comparing to the traditional internal combustion engine vehicles.

The key assemblies of hybrid vehicle powertrain consist of power supply module, motor and motor controller, engine and engine control unit. The verification test of key assemblies’ performance and function is conducive to enhance the design goal of hybrid vehicles. The team of author developed a hybrid powertrain test system which can verify the function of integrated starter-generator (ISG), power supply module, motor and motor controller, engine and engine control unit based on virtual instrument.

2. System hardware design
The test system is composed of ISG motor module, dynamometer module, power supply module, auxiliary electric system load simulation module and host computer module, as shown in figure 1. The ISG motor module contains ISG motor and motor controller. The dynamometer module includes power dynamometer, converter / inverter, measuring and controlling instrument, the speed and torque sensor. The power supply module includes a power battery, battery management system, programmable power source. The electric system load simulation module includes DC/DC converter, electric air conditioning compressor and other affiliated electrical system. The host PC module includes data acquisition card, data processing unit, display output unit. BSG motor module,
dynamometer module and power supply module communicate respectively with host computer module through CAN bus.

The dynamometer module adopts the AC electric dynamometer which has the characteristics of low inertia moment, good regeneration performance, high precision to control and fast response [3]. The dynamometer can be used as the load of the engine to test the performance of the engine, or used as load of the ISG motor to test the performance of the motor. The dynamometer can work in driving mode, taking electric energy from the power grid by the converter, or work in load mode, generating electric energy and feeding to the power grid by the inverter. The control of different working modes is realized by the measuring and controlling instrument. Speed and torque sensor was installed on the output shaft of dynamometer for real-time monitoring. The ISG motor or engine is connected with the dynamometer as the object to be measured.

Power supply module is used to supply power for test system. The power battery is connected with the programmable power source through the common DC bus; the controller of programmable power source is used to control the output voltage and the current of the programmable power source, simulating all kinds of power battery with different specifications. During the test, the programmable power source and the power battery can be used as the power supply of the test system respectively. Programmable power source is integrated with programmable electric load, which consists of discharge modules. The host computer module obtains the working state, voltage and current of the programmable power source. The host computer obtains the working state of the power battery through the battery management system, and sets the terminate condition of charging and discharging, the limit conditions of voltage, current and temperature of the battery.

Figure 1. The system hardware block diagram.
3. System software design

Virtual instrument technology is a program development environment, it can give full play to the computer's ability to create a stronger function of the instrument, and users can define and develop a variety of instruments according to their own needs [4]. The test system software of hybrid vehicle powertrain was developed based on virtual instrument, using electric dynamometer to simulate the work of engines, to test the motor and control unit of the powertrain. The test conditions include starting, acceleration, and deceleration. Take ISG motor starting engine condition as an example, the test flow chart and human-computer interaction interface design as follows.

3.1. Test flow chart design

The test flow chart of starting condition design is shown in Figure 2.

The initialization parameters can be set in the host computer, and transmit to the controller of programmable power source, measuring and controlling instrument, the battery management system by CAN bus. Simulate torque of the engine using dynamometer; electrify the motor to drive dynamometer. The host computer sends out the control command to measuring and controlling instrument to control the dynamometer according to the feedback of test results and data processing to adjust the power dynamometer through the inverter. If the measured resistance torque is consistent with the set resistance torque, sent the speed feedback to host computer, then the engine is start successfully.

Other condition such as acceleration, deceleration, and so on can deduce the rest from the starting condition.

3.2. Human-computer interaction interface design

Human-computer interaction interface of the system was developed based on virtual instrument, which adopted the form of the tab to realize the intuitive and friendly man-machine interactive function. It contains the user login interface, the initial setup interface, the main control program interface, etc..

The initial setup interface, as shown in figure 3, can be used to set and adjust the test parameters of the test system. The set of objects mainly include engine parameters, starting and stopping motor parameters, communication system parameters, cycle test times, power supply parameters, report output path, etc.

Figure 2. The test flow of starting condition.

Figure 3. The initial setup interface.
The main control program interface of the test system is mainly composed of the working status indicator, the running parameter output display area and the system control command input area, as shown in figure 4.

Figure 4. The main control program interface.

4. Conclusion
Hybrid powertrain as the key to improve the automobile's economy, it is necessary to carry out the relevant operation test. After repeated testing and debugging, the developed system has been able to run stably, and achieve the design goal of hybrid powertrain test. Login the test system to verify the system. First set the relevant parameters in the initial settings tab. The result of working condition test of 5 cycles is shown in Figure 5.

Figure 5. The test result of 5 cycles working condition.

The test system developed in this paper realizes the test function of hybrid powertrain, which can not only test according to the specified conditions, but also be used in cycle testing.

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