Research on Measurement and Control System of New Energy Vehicle Test Bench

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Abstract. New energy vehicles can alleviate the environment and energy pressure, promote the rapid upgrading and transformation of the automobile industry, and have a major impact on China's technological economy and environmental improvement. However, at present, China's new energy vehicle technology is still in its infancy, and there are still bottlenecks in the development of complete vehicles and parts. How to break through technical barriers and research new technologies has become a key factor in the introduction of new energy vehicles into the market. Based on this, the paper builds a new energy vehicle experimental platform, and develops a real-time online multi-channel data acquisition and analysis system based on Lab VIEW. Combined with the D2P Moto Hawk development platform, the electronic control of the test platform is realized. The final development of the measurement and control system enables dynamic monitoring of the test bench, fault alarms and control of key components.

1. Introduction
The generation of new energy vehicles has greatly improved the efficiency of the use of clean energy and effectively protected the environment. According to relevant surveys, under normal circumstances, the fuel efficiency of internal combustion engines is 38%, and the generation of new energy vehicles effectively changes the problem of low energy utilization. Taking electric motor vehicles as an example, its emergence has developed battery energy into automobiles. Power, which effectively improves distribution efficiency, discharge efficiency, and energy utilization. At present, China's research on new energy vehicles is still in its infancy, and new energy vehicle technology is not advanced, and a set of high-level completely new energy vehicle test bed system is established, whether it is theoretical research on new energy vehicle technology or new energy vehicles. The promotion of technological achievements is of great significance. The research and development of the new energy vehicle test bed is conducive to improving the overall test level of new energy vehicles and key components in China, formulating and improving the test standards for new energy vehicles, and establishing a relatively complete test of new energy vehicles and parts. Evaluation System. The final establishment of the new energy vehicle test bench can directly debug and test the key components and vehicle performance of new energy vehicles, reduce the risks and costs of research and development of new energy vehicles, and promote the development strategy of new energy vehicles in China to solve energy problems. Environmental and climate issues are important [1]. This
paper takes the electric vehicle as a new energy vehicle as an example, and analyzes and expounds the research and development of the new energy vehicle test bed measurement and control system.

2. Basic structure of new energy vehicle test bench

The new energy vehicle test bed system consists of two parts: mechanical components and measurement and control systems. The new energy vehicle test bed is a complex system that not only needs to simulate different operating conditions and working modes of new energy vehicles, but also can test key components of new energy vehicles. The goal of the test bed construction is a platform that can fully realize the testing of new energy vehicles, including the development and testing of core chassis control technologies such as hybrid drive systems and hybrid brake systems for hybrid vehicles such as hybrid electric vehicles, pure electric vehicles and fuel cells. The test bench consists of a controller, an engine, a switched reluctance motor, a power supply, an electromagnetic clutch, an automatic transmission, a wheel, an ABS brake, a gear reducer, a DC power dynamometer, an inertia flywheel, and a sensor. The specific arrangement of the mechanical components is shown in Figure 1 [2-3].

![Fig. 1 New energy vehicle test bench structure](image)

LabVIEW [4] is used to call DLL (Dynamic Link Library) to realize CAN communication between DC power dynamometer and industrial computer, and realize bench simulation of vehicle driving load. Refer to SAE J1939 [5], electric vehicle non-vehicle conductive charger and battery management system communication protocol [6], and combined with the actual situation of the test bench controller, the test station node source address definition is shown in Table 1. Among them, the newly defined node address is reserved from the SAE J1939 standard as the self-configuring node address space for future road devices. Each device of the test bench adopts different communication modes such as CAN bus, 485 bus and 232 bus, and in the running process of the test bench, in addition to obtaining the real-time running data of each device through communication, it is necessary to collect the motor speed and motor turn in real time. Information such as moment, drive motor input voltage, input current, and motor stator temperature. To this end, an information acquisition and communication conversion information unit based on the CAN bus was developed. Wherein, the dynamometer control system (485 communication) and the motor controller test power supply (232 communication) share
one information unit; the battery management system (485 communication) and the intelligent discharge meter (232 communication) share one information unit; Instrument (232 communication) and test bench data acquisition unit use one information unit; vehicle controller, motor controller and charger and other equipment have been controlled by CAN bus communication, can be used directly; industrial computer through CAN card as CAN node to achieve Centralized collection of data and control of the test bed system.

**Tab. 1 Test station CAN network node address allocation table**

| Test bench controller definition                                      | address  |
|-----------------------------------------------------------------------|----------|
| Vehicle controller                                                    | 36 (0x24) |
| Motor Controller                                                      | 130 (0x82) |
| Battery management system                                            | 244 (0xF4) |
| Charger control system                                               | 229 (0xE5) |
| New definition                                                        |          |
| Dynamometer control system                                           | 131(0x83) |
| Motor controller test power supply                                    | 132(0x84) |
| Industrial computer 1 (for test bench control)                       | 133(0x85) |
| Smart discharge meter                                                | 134(0x86) |
| Test bench data acquisition system                                    | 135(0x87) |
| Industrial computer 2 (for test bench monitoring display)            | 136(0x88) |

3. **Test bench working principle**

Power sources for new energy vehicle test stands include switched reluctance motors, power supplies and engines. The power drive system achieves a separate output of the power source or a composite output of the two power sources through the control of two electromagnetic clutches. The transmission system is an automatic transmission and a speed reducer, and its controller is arranged on the measuring console. The brake system is implemented by ABS and motor brakes. The driving load is achieved by the loading of the DC power dynamometer. The inertia of the whole vehicle is simulated by two sets of inertia flywheels. The control system sends control commands to each controller through the industrial computer and D2P, and the controller completes the control of the actuator. During the test, the data acquisition system displays the operating status of each component online and stores the data. The simulated vehicle test is shown in Figure 2.

![Fig. 2 Working principle of the new energy vehicle test bench](image-url)
The driver inputs the driver's signal through the electronic accelerator pedal and the brake pedal according to the test requirements. After the control system receives the signal, the torque distribution is performed. The throttle actuator and the motor throttle are used to control the torque output of the engine and the motor. The power is transmitted to the wheel through the transmission system such as the transmission and the reducer. The measurement and control system collect the wheel speed to calculate the required driving. The resistance is transmitted to the DC power dynamometer controller via the USBCAN card for automatic loading of the driving resistance, and the vehicle inertia is simulated by different combinations of the flywheels. When braking, the brake pedal and the motor regenerative braking are realized together, and the motor recovers the braking energy to feed back the power supply, and so on until the end.

4. Test bench control system design

4.1. Engine throttle control

The throttle actuator adopts the PID control scheme. The position signal of the analog input channel acquisition throttle actuator is converted into a 0~5V voltage signal and compared with the position of the electronic accelerator pedal to obtain a deviation. When the deviation is less than the steady state error, the throttle actuator control is completed. When the deviation is greater than the steady-state error, the PID controller immediately generates a control action, adjusts according to the set tuning parameters, and controls the PWM output to control the rotation of the throttle drive motor to reduce the deviation and stabilize the system. Data acquisition and storage by LabVIEW during operation [5].

4.2. Steering function simulation

The steering system has an extremely important influence on vehicle handling stability. An electric vehicle (4WID-4WIS) with four-wheel independent drive and four-wheel independent steering has become one of the hotspots of future vehicle research. It is very necessary to have a steering simulation function for the electric wheel comprehensive performance test bench, but the test bench developed at home and abroad rarely has this function. This test bench not only has the function of setting the steering angle arbitrarily during steering, but also can set the dynamic lateral loading function of the different side forces of the electric wheel when steering.

4.3. Brake Simulation Function

One of the advantages of the electric wheel is that it can use the characteristics of the motor for regenerative braking. The car brake system is related to the safety of the vehicle. The test bench developed should have the function of braking simulation. The brake simulation should include mechanical brake simulation, electric brake simulation, and electric brake and mechanical brake coupling simulation functions. At the same time, it can carry out simulation test of electric brake and mechanical brake coupled anti-lock brake.

4.4. Hub motor performance test function

The hub motor is a key component of the electric vehicle, and its performance directly determines the performance of the electric vehicle. Therefore, the performance test of the mechanical characteristics and efficiency characteristics of the hub motor is crucial. Not only that, but the test bench can also test the basic parameters of the maximum power and rated power, maximum torque, rated torque, maximum speed, rated speed, maximum current, rated current, moment of inertia, time constant, torque constant and so on. This test bench has the function of testing the performance characteristics and basic parameters of the hub motor.
4.5. Control of electromagnetic clutch

The electromagnetic clutch is separated and closed by a digitally controlled switch. LabVIEW uses the capture card DO to output a digital signal control switch, as shown in Figure 3. The PCI-1716 data acquisition card provides two port ports. By configuring the DIO Write Bit function information, you can control the digital signal output of the clutch.

4.6. Simulation of the running resistance of the gantry

When the bench test is carried out, the speed of the drive shaft is collected by the speed torque sensor, and the corresponding wheel speed can be calculated after conversion. The other running resistance is obtained by the formula (1):

\[ \sum F = F_f + F_w + F_i = Gf \cos \alpha + \frac{C_D A u^2}{21.15} + G \sin \alpha \]  

(1)

Where \( G \) represents vehicle gravity (N); \( f \) represents rolling resistance coefficient; \( \alpha \) represents road gradient angle (°); \( C_d \) represents air resistance coefficient; \( A \) represents windward area (m²); \( u \) represents vehicle speed (km/h).

During the bench test, the measurement and control system monitors the speed of the drive shaft and converts it into the wheel speed in real time, calculates the theoretical driving torque that should be applied, and sends it to the electric dynamometer control unit via USBCAN to realize the real-time loading of the driving resistance. Dynamically simulate the purpose of the car's driving load. By calling the Matlab script node and using MATLAB’s powerful calculation function, the driving resistance torque is calculated, and LabVIEW sends it to the dynamometer to simulate the gantry driving load [6].

5. Practical application

Taking the intelligent discharge instrument as the control object, the power battery pack discharge test was carried out to evaluate and verify the application effect of the data acquisition and control system based on CAN bus. In order to simulate the discharge condition of the power battery pack when the vehicle is used, the discharge current is set based on the actual operation data of the pure electric bus.
5.1. Vehicle running test

The vehicle test was carried out on the data of the pure electric bus speed, the drive motor speed and the total current of the power battery pack of the model BWC6100BEV and length 12m. The pure electric bus actually runs 1600s when the air conditioner is turned on, and the actual vehicle data is collected at a frequency of 2Hz. The curve is shown in Figure 4 [7].

![Fig. 4 New energy vehicle speed and battery current curve](image)

5.2. Throttle actuator test

Data acquisition monitoring and storage with LabVIEW measurement and control system. After connecting the device, adjust the throttle actuator position and switch to the initial position to start the test. Turn on the D2P power switch, download the driver to the D2P ECU, and calibrate it with Moto Tune to observe the voltage follow-up. The PID parameters determined by the test calibration were KP=2.8, KI=1.5, and KD=0.01. From the test results and the oscilloscope monitoring comparison, the sensor voltage, torque, and speed signal acquisition are normal, all within the range of sensor torque and speed accuracy. The dynamometer constant power mode is loaded normally. When the adjustment time is 20s, the dynamometer loading mode is stepped. Therefore, the adjustment time should be reduced as much as possible during the bench test to meet the real-time control of the driving load.

6. Conclusion

Based on the virtual instrument LabVIEW development platform, the multi-channel real-time dynamic data acquisition and analysis system realizes data acquisition, waveform display, data storage, signal processing and historical data playback. And through experiments, it is proved that the data acquisition system can accurately obtain the data information, and plays the functions of dynamic monitoring, analysis, fault alarm and so on. In the LabVIEW environment, based on D2P, the gantry simulation of the electronic control and driving load of the engine, motor, electromagnetic clutch and electric dynamometer is realized. Finally, the interface and application program of the measurement and control system are developed, which can be quickly and intuitively displayed through the interface. The bench test verified the reliability of the control system.

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