Research on the Drop Hammer Impact Test System

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Abstract. The drop hammer impact test system adopts the multi-purpose and modular design to solve the four problems of the airbag door of automobile test instrument panel: the test conditions are generally inconsistent with the actual conditions; The secondary impact problem exists in the collision test. The experiment does not have the experimental data, cannot provide the technical question for the enterprise; There are some problems in the equipment construction mode, such as universality, repeatability and low utilization rate. The improvement of mechanical structure and control system makes the device simple in structure, powerful in function, able to obtain accurate experimental data, and able to realize the instrument panel airbag door detection of different vehicle models.

Keywords: The drop hammer impact test system, multi-purpose, modular design, mechanical structure, control system.

1. Introduction
The existing drop hammer impact test equipment has a variety of problems, such as the difference between the test conditions and the actual situation, the existence of secondary collisions, the real-time data acquisition of the test problems, and the equipment has low universality, poor repeatability and low utilization rate. [1, 3] The corresponding solutions to these problems are put forward.

2. Modular Design
On the basis of summarizing and sorting out the foreign advanced testing standards on the automobile dashboard airbag door opening force testing methods, this paper puts forward a set of testing methods that fit the requirements of the standards, and preliminarily plans the testing platform, functional modules and software control flow.

2.1. Modular design of the mechanical part
As an irregular object, a scientific and rigorous mechanical structure design is essential in the process of force analysis. This design on the basis of reference foreign advanced detection standards, several key parameters of the dashboard for a complete mechanical system design, it includes a machine frame, block, clamping and releasing device, block device and to prevent secondary impact device, guarantees for the subsequent testing process automation, modularization design for subsequent mechanical structure design optimization.
2.2. Modular design of electric control part
The whole electric control part is mainly composed of PLC main control module, motor drive module, sensor module and switching volume I/O module. The motor drive module is responsible for the normal operation of the motor. The sensor module is responsible for measuring the velocity, acceleration data and the impact force at the moment of collision during the test. Switching volume, I/O module is responsible for the detection of input signals such as start, emergency stop button and limit sensor, as well as the control of output signals such as indicator light. This modular structure can be combined or expanded according to the functional requirements of the control system, which is very convenient for maintenance and modification. The relationship is shown in Fig.1.

![Figure 1. Schematic diagram of module composition](image)

2.3. The modularization design of upper PC terminal software
The upper PC software includes motion control module, data acquisition and processing module, data display module and data storage module. Among them, the motion control module is used to send control instructions to THE PLC to control the movement of each mechanism; The data acquisition and processing module is used to read the data of each sensor from PLC and PCI8510 and process the collected data; Data display module and data storage module are used for real-time data display and full range dynamic data report generation. Obviously, the modular design greatly enhances the reusability and extensibility of the software, and provides conditions for the maintenance of subsequent programs and the upgrading of system functions.

3. Implement Repeatability Tests
As shown in figure 2, in the concrete operation, servo motor drive screw nut, and through the wire rope will impact block along the rail to set the initial position, and drive the unlock cylinder, the cylinder rod contraction realizes the unlock the manipulator and release the block, block free pendulum, the impact of fixed a test car dashboard, to complete a test. After a collision, the block is pulled to a stop under the action of the anti-secondary impact device. Prepare for the next repeat test by rearranging the wire rope. After the test, the data acquisition and processing system collects the data, analyzes and processes the data, and completes the data storage, so as to realize the seamless repeated cycle test.
4. Overall Scheme of Mechanical Structure Design

Through the above analysis of the existing problems of the equipment in service and the implementation scheme and technical route adopted, this subject puts forward a new design concept for the drop hammer impact testing machine. The new type of drop hammer impact testing machine mainly includes the testing machine frame, drop hammer height adjustment device, lifting device, anti-secondary impact device and aiming mechanism. Its overall schematic diagram is shown in Figure 2.

The advantages of the above scheme are as follows:

The structure of the drop hammer is designed to solve the problem that the filter does not match the force sensor for a long time. A new type of pulley and guideway equipment is used to reduce the error caused by falling friction. Adjustable height can adapt to different vehicle test requirements; Through the accurate simulation design, the situation of airbag hitting automobile dashboard can be perfectly realized. The test equipment has perfect maneuverability, repeatability and versatility, which can effectively reduce the test cost.

5. Overall Scheme of Control System Design

In this subject, the logic control is the main one. Therefore, in the control system of this subject, the programmable logic controller is adopted as the main controller, and the control program of the whole set of equipment is written with it, so as to realize the detection of automobile dashboard. The whole system uses PLC as the main control platform. Because the force signal and acceleration signal have a large frequency in the strength test, and the signal is an analog signal, the high-speed and high-precision data acquisition module PCI8510 is used to collect acceleration signal and force signal, and A/D conversion is used to process relevant data. The upper computer adopts PC, establishes data processing program and displays it on the monitor in real time, and provides the storage and printing of database data.

The drop hammer pull-up device driven by servo motor and driven by ball screw is adopted to realize accurate control of the height of the drop hammer by controlling the positive and negative rotation of the servo motor. Meanwhile, a calibration device is installed below the device to accurately locate the impact position of the drop hammer when it falls. Through real-time capture of each limit sensor signal to ensure the safe operation of the equipment; The whole set of equipment adopts the data acquisition and processing of four force sensors and four acceleration sensors to obtain more accurate experimental data. Meanwhile, the real-time data of the speed sensor and Angle encoder collected can realize the
dynamic monitoring of the whole test process, so as to ensure the standardization of the test and the accuracy of the experimental results.

According to the control requirements of the testing machine, the software part of the system is divided into three levels: upper computer monitoring management software, lower computer control software and communication layer software. The software structure diagram is shown in Figure 3.

The upper computer adopts LabVIEW as the software development platform for data processing, display, saving and playback. The lower computer adopts programmable logic controller. It uses a class of programmable memory, used for its internal storage program, to perform logical operations, sequential control, timing, counting and arithmetic operations and other user-oriented instructions, and through digital or analog input/output control various types of machinery or production process. First, the program is initialized and each communication protocol is set up. After the data acquisition card is inserted into the PCI slot, the driver can be installed on the upper computer to establish communication with the board card. Communication between PLC and upper computer is through RS232 serial communication line connection, that is, the use of RS232 serial communication protocol. Secondly, establish various test methods and save them to the database so that they can be directly called out from the database during the test. Finally, the test method is called, and the existing test method is called from the database according to the specific conditions of the test. Software control is realized by executing operation module, data acquisition module and data processing module.

![Software structure block diagram](image)

**Figure 3. Software structure block diagram**

6. Conclusion
The new drop hammer impact testing machine adopts modular design to facilitate the subsequent maintenance and repair of the equipment. The innovative design of the falling hammer structure greatly reduces the friction existing in the original equipment and makes the experimental data basically accord with the results obtained from the actual collision. The new software structure and interface construction make the equipment operation process simpler and more convenient. The use of a large number of sensors makes the real-time transmission and acquisition of experimental data easy. The instrument panel and its technical requirements of different models are fully considered in the design of the whole structure, so that the equipment can meet the requirements of universality. To sum up, it is a perfect substitute for airbags to test the airbag door of car dashboard. The equipment is shown in Figure 4 below.
Figure 4. Actual picture of equipment operation

Acknowledgments
This work was financially supported by Yanfeng Biou Automotive Interior System Co. LTD fund.

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