Test and Analysis of Transient Process on the Cold-Starting of Diesel Engine

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Abstract—In order to acquire and carry out the transient parameter of the diesel engine cold-starting, the portable data acquisition system has been developed. Based upon the transient data acquisition systems, several instantaneous parameters about transient process of the diesel engine cold-starting, such as, temperature, starting voltage, starting electric current and starting rotate speed are measured. The instantaneous process of the diesel engine cold-starting is tested and analyzed. The test results show that the time of start process is 4.8 second, the maximum temperature variation of the cooling fluid is 0.5 ℃, the maximum starting electric current is 678A, the minimum starting voltage is 9.3V, the maximal starting torque is 200 N.m. The regulation and the variation of instantaneous parameters can meet the need of the cold-starting of the diesel engine greatly.

Keywords- Transient data acquisition; Diesel engine; Start voltage; Start electric current; Start rotational speed

I. INTRODUCTION

Along with the increasing strict of the emission control regulations on automobile, it is stringent and important to control the emission of the cold-starting diesel engine, transient performance is profoundly researched on the diesel engine for vehicles [1]. It is very important that the diesel engine transient data acquisition systems have high-precision and high-frequency. At present, there are many methods at acquiring transient data of the engine [2], [3], [4]. Which is applied on the immovable engine laboratorial platform. In the cold-starting process, to the start motor transient parameters, their transient fluctuant rates and values are changed very rapidly, and their signals are required very highly in-phase. So the ordinary data acquisition apparatus can’t achieve the needs on the on-line acquisition.

In order to understand the work characteristic of the diesel engine and its accessorail equipments on the cool-starting, so it is necessary to develop a data acquisition system for researching the cold-starting performance of diesel engine. Based upon the transient data acquisition systems of the diesel engine, the dynamic process of the diesel engine is tested and researched on the cool-starting, several dynamic parameters of the diesel engine about temperature, starting voltage, starting electric current and starting rotate speed are measured. The test results show: (1) during the cooling start of the diesel engine, the variation of the start rotational speed is about 25%, the whole start process time is 7.8 second, the maximum temperature variation of the cooling fluid is 0.5 ℃. The maximum decreasing value of storage battery instantaneous starting voltage is 1.8V and the temperature variation range of the storage battery is minimum, about 0.4 ℃. All of these are accorded with the facts. (2) The maximum starting electric current is 678A, the minimum starting voltage is 9.3V, and the maximal starting torque is 200 N.m, which completely satisfy the performance requirements of the cold-starting diesel engine. (3) It is reliable that the transient data acquisition systems and its signal deal circuit can carry out real-time collection, display, storage and analysis. It can be easily controlled by interface and demarcate program. It can meet the needs of the dynamic data acquisition for the cool-starting diesel engine greatly.

II. TRANSIENT DATA ACQUISITION SYSTEM

Figure 1 is the transient data acquisition systems of cool-starting diesel engine.

From Figure 1, It is used the data acquisition card, contained with voltage sensor, electric current sensor, rotate speed sensor and F/V. At first It can carry out real-time collection of starting battery voltage, starting electromotor current, the electrolyte temperature and the diesel engine rotate speed by multi-channel, then it can magnify and filter the signals, and change

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analog signals into digital signals by A/D, finally it can also storage, transact and display the signals in the same time by compiling the convenient interface and demarcate program by DASYLab in the computer. Every temperature is inspected by SKE-32AD, which makes transient data acquisition systems work smoothly.

A. The hardware

(1) The temperature sensors are selected by the platinum-resistance temperature sensor. The electronic current and the voltage sensor are designed base on the Hall sensor. A/D is 2FV-5000A. The temperatures on the cooling fluid, the air, the lubricating oil and the electrolyte are inspected and protected by SKE-32AD.

(2) The data acquisition card prepositive channels carried through the deal of the input signal, such as, the offset deal, the anti-jamming and the mutual infection of AC/DC, etc. So the high-powered filter with channels is utilized in the system. Every channel is designed the high-powered amplifier controlled by the procedure in order to magnify the signals. The single chip and the memorizer are installed in all the modules, the parameters of each channels are controlled by the software in order to confirm the amplificatory frequency. The on-line parameters are set and the transient signals are dealt by RS-232.

(3) The data acquisition card is the central part in the whole system. Its performance affects the whole data acquisition system. As every channel is tested, the testing frequency is high and the testing data are real-time. So DAQP-308PCMCIA is utilized in data acquisition system. The eight performance parameters on the voltage, the electronic current, and the rotate speed, etc, are on-line tested by DAQP-308PCMCIA in the diesel engine cool-starting process, the maximal testing speed is 1MS/s. The signals are carried to the computer by the 12-digit D/A output channels. The input voltage is controlled from ±1.25V to ±10V. The data FIFO with the 4K is designed in order to reduce effectively the load of CPU. The testing parameters are matched optimization with CM350 using DASYLab [5].

B. The software

DASYLab is the multifunctional and combinatorial software with the test and analysis of the data, the control of the process. It has 118 functional modules so that it can effectively utilize the whole advantaged functions and figure interfaces supplied by Microsoft Windows, and it has truly recurrence function on the tests [6]. It can also storage, transact and display the signals in the same time by compiling the convenient interface and demarcate program by DASYLab in the computer.

III. THE SIGNALS DEAL CIRCUIT

A. The start voltage and electronic current

The electronic current sensor and the voltage sensor are designed on the Hall sensor. They are utilized to test the start voltage and the start electronic current of the motor, and transformed into the normal signals by A/D. And carried to the computer after the filtering. Figure 2 and Figure 3 are accordingly the structural charts of the start electric current sensor and the start voltage sensor. From Figure 2, 1 port, 2 port, 3 port and 4 port are accordingly connected by +15V, -15V, the output voltage of the motor (V_{out}) and the ground. OFS is zero adjective knob. GIN is the value adjective knob. From Figure 3, 1 port and 2 port are accordingly connected by the negative and the positive of the input signals. M, + and - are accordingly connected by the output signal, +15V and -15V.

![Figure 2. Schematic of start electric current sensor](image)

![Figure 3. Schematic of start voltage sensor](image)

Figure 4 is the testing circuit on the start voltage and the start electric current. Based on the electromagnetic theory[7], the measure resistance (R_m) is selected from 100Ω to 800Ω. As R_m is 200Ω and the electronic current of the sub-winding (I_2) is 25mA, the output voltage is 5V. To the voltage sensor, the optimal precision of the sensor is decided by the resistance of the primary winding(R_1), which is matched with the rated voltage(U_1) and the electronic current of the primary winding(I_1), namely, R_1 = U_1/I_1. The signals measured by the sensor must be dealt with to satisfy the functions, such as, calculating the parameters and analyzing the wave on the voltage, the electronic current and the frequency. The sensors have very high respond speed to satisfy the few phase displacement, in order that the whole dynamic process of the voltage and the electronic current could be effectually tested in the cool-starting process of the diesel engine.
The sensors on testing the dynamic temperatures have the follow types, such as, the resistance, the transistor and the thermocouple. The platinum-resistance temperature sensor in the data acquisition system is selected to measure the temperatures on the cold-starting process of the diesel engine, such as, the input gas, the lubricating oil, the cooling fluid and the electrolyte, etc.

B. The start rotate speed

Usually, the types of the rotate speed sensor have the magneto electric, the photoelectric and the Hall, etc. The magneto electric sensor is utilized to measure the rotate speed of the diesel engine in the data acquisition system. Figure 5 is the deal circuit of the start rotational speed sensor.

Figure 5. Deal circuit of the rotational speed sensor

From Figure 5, it is composed of two circuit modules: (1) the magnifying and plastic circuit. (2) The F/V circuit. The primary part of the magnifying and plastic circuit module is CA3240, two diodes (D1 and D2) and the capacitances (CZ1) are used to filter and magnify the signals of the rotate speed. Secondly, the signals are switched into the voltage by the F/V circuit, which is made up of LM331. Finally, the signals are output by ICZ1B. The multiple anti-disturbing functions are designed in the deal circuit of the start rotate speed to carry out the high-precision test.

IV. EXPERIMENT

A. The temperature test

The cold-starting test of the diesel engine is carried through at -17℃. The temperatures on the input gas, the lubricating oil, the cooling fluid and the electrolyte are measured and controlled by the data acquisition system. Figure 6 is the performance compare of the four temperatures. From Figure 6, along with the cold-starting process of the diesel engine, the temperatures are little ascended. The fluctuant range of the cooling fluid temperature is maximal, namely, 0.5℃. The fluctuant range of the electrolyte temperature is minimal, namely, 0.4℃, which is accorded with the facts.

B. The performance tests

Figure 7 is the performance curves of the start voltage and the start electric current in the cold-starting process of the diesel engine. From Figure 7, the fluctuant rate of the starting voltage is 25%, the maximum and the minimum of the electronic current are accordingly 678A and 0.5A, which satisfies the demands of the starting performance on the motor. The variation trends and the fluctuant rules of the dynamic parameters on the starting electronic current and the starting voltage are tested, memorized and analyzed in the whole cold-starting process of the diesel engine, in order to appraise and analyze the characteristic of the low temperature on storage battery.
C. The starting rotate speed test

The rotate speed is tested and memorized in the cool-starting process of the diesel engine. Figure 8 is the performance curve on the cold-starting rotational speed of the diesel engine. From Figure 8, the diesel engine is warmed for 4.8 seconds before the start, then the diesel engine is turned by the motor, the average rotate speed is 195 r/min, and the fluctuant rate of the rotate speed is lesser. After 6.3 seconds, the rotate speed of the diesel engine is quickly increased, the maximal rotate speed is 1390 r/min. After 1.5 seconds again, the rotate speed of the diesel engine is steady at 725 r/min. The whole start time is 7.8 seconds. The performance data on the fluctuant rate and the fire can be utilized to appraise and analyze the cool-starting process of the diesel engine. The test results show the performances of the data acquisition system are very good, which is completely measured and deal with the data on the cool-starting process of the diesel engine.

V. CONCLUSIONS

(1) It is reliable that the transient data acquisition systems and its signal deal circuit can carry out real-time collection, display, storage and analysis. It can be easily controlled by interface and demarcate program using DASYLab. It can meet the needs of the dynamic data acquisition for the cold-starting diesel engine greatly.

(2) The test results show: during the cold start of the diesel engine, the maximum temperature variation of the cooling fluid is 0.5℃ and the temperature variation range of the storage battery is minimum, about 0.4℃. The variations of the start rotational speed and the start voltage are accordingly about 25% and 30%. The maximum starting electric current is 678 A, the minimum starting voltage is 9.3 V, the maximal starting torque is 200 N.m. Which completely satisfy the performance requirements of the cold-starting diesel engine.

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REFERENCES