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The Design of Software for Three-Phase Induction Motor Test System

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Abstract. The design and development of control system software is important to three-phase induction motor test equipment, which needs to be completely familiar with the test process and the control procedure of test equipment. In this paper, the software is developed according to the national standard (GB/T1032-2005) about three-phase induction motor test method by VB language. The control system and data analysis software and the implement about motor test system are described individually, which has the advantages of high automation and high accuracy.

1. Introduction

The three-phase induction motor is an important mechanical and electrical production, which is widely used as the prime mover in machinery, steel and other industry. In the traditional motor test system, the Oscilloscope or other wave recorder are used to measure the stator current, voltage and the power input current, voltage, then the recorded waveforms are offline processed to calculate the relevant parameters of each test item. These test system has some disadvantages, such as low test accuracy, low automation, manual recording of test results, and difficult to carry out statistical analysis, which is unable to meet the requirement of the modern testing.

With the rapidly development on industry and information technologies in recent years, the control of all equipment has been performed through the use of computers. Most equipment uses intelligent instruments and PLC to connect with computers to monitor each load and electricity consuming devices. The waveforms of motor parameters are collected by the intelligent instrument through the sensors, and then transferred to the computer. The analysis of motor running status is realized on the computer by the control system software, at the same time the instructions are sent to the PLC to control the motor running. In this way, the close-loop control of the motor test system is established. In addition, there are also other ways to automate the motor test, such as virtual instrument technology, adaptive fuzzy PID controller. Therefore, the test system would be more simple, flexible and convenient with the powerful computer software replacing the traditional instrument.

In the paper, we design and implement the three-phase induction motor test system with high accuracy and highly automation, which has great practical significance for improving the production quality and reducing the labour intensity.

2. The composition of three-phase induction motor test system

There are two variable frequency power supplies and a control board in the test system, one provides power to the test motor, and the other provides power to the load motor. The system control block diagram is shown in figure 1.

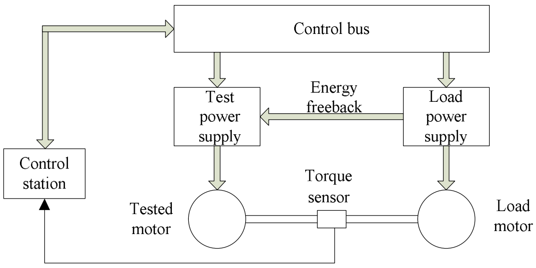

Figure 1. The system control block diagram.

The motor test system consists of a control station, an electric cabinet and a motor test platform, the control station concludes industrial computer, intelligent instrument; and the electric cabinet concludes the variable frequency power supply, PLC, the capacity, the transformer and relay; the motor test concludes T-slot platform, the tested motor, the load motor and the torque sensor. The test power supply and the load power supply are controlled by PLC, meanwhile, PLC's instructions are sent by the industrial computer. The tested motor, the load motor and the torque sensor are rigidly connected. When the test system works, the speed, torque, voltage and current of tested motor are collected by the intelligent instrument, then these test data is sent to the industrial computer, and saved as data file. When the load motor is in the status of power generation, the generated energy could be fed back to the test power supply. The motor is controlled by adjusting of voltage and frequency, which is based on the data of sensors, the motor is in closed-loop control.

3. The design of the test software

The software of test system is written by Visual Basic 6.0, which concludes two parts, one is the control system software; the other is the test data processing software.

3.1. The design of control system software

3.1.1. The design of the operator interface. As shown in figure 2, the operator interface concludes the experiment number, the nameplate of tested motor, environmental parameter, display instrument, test items, the system status area, and test record.

Figure 2. The operator interface of control system

3.1.2. The design of the test items. According to the national standards GB/T 1032-2005《Test procedures of three-phase induction motors》, there are eight test items such as no load test, locked rotor test, load test, mechanical characteristic test, over torque test, over speed test and heating test. The control flow of each test item is determined according to the test procedure, at the same time the data of tested motor is also sampled and saved, which is processed as the input data of the processing test data software.

3.1.3. The flow of test item. The flow of each test item is shown in figure 3, and test items are corresponding to the eight choice buttons in figure 2. The main parameters and the target control parameters values of tested motor are inputted to the table on the operator interface. Among these test items, the test procedure of heating test is the same as that of load test except the collection of data.

3.1.4. The control step of equipment.

3.1.4.1 The starting and stopping of tested and load motor. In order to prevent the starting current from too large, the tested and load motor are started (unloaded) with the frequency and voltage raised (decreased) step by step. The terminal voltage and frequency are applied to the motor according the VF control, thus the load motor can be smoothly connected to the tested motor without impacting.

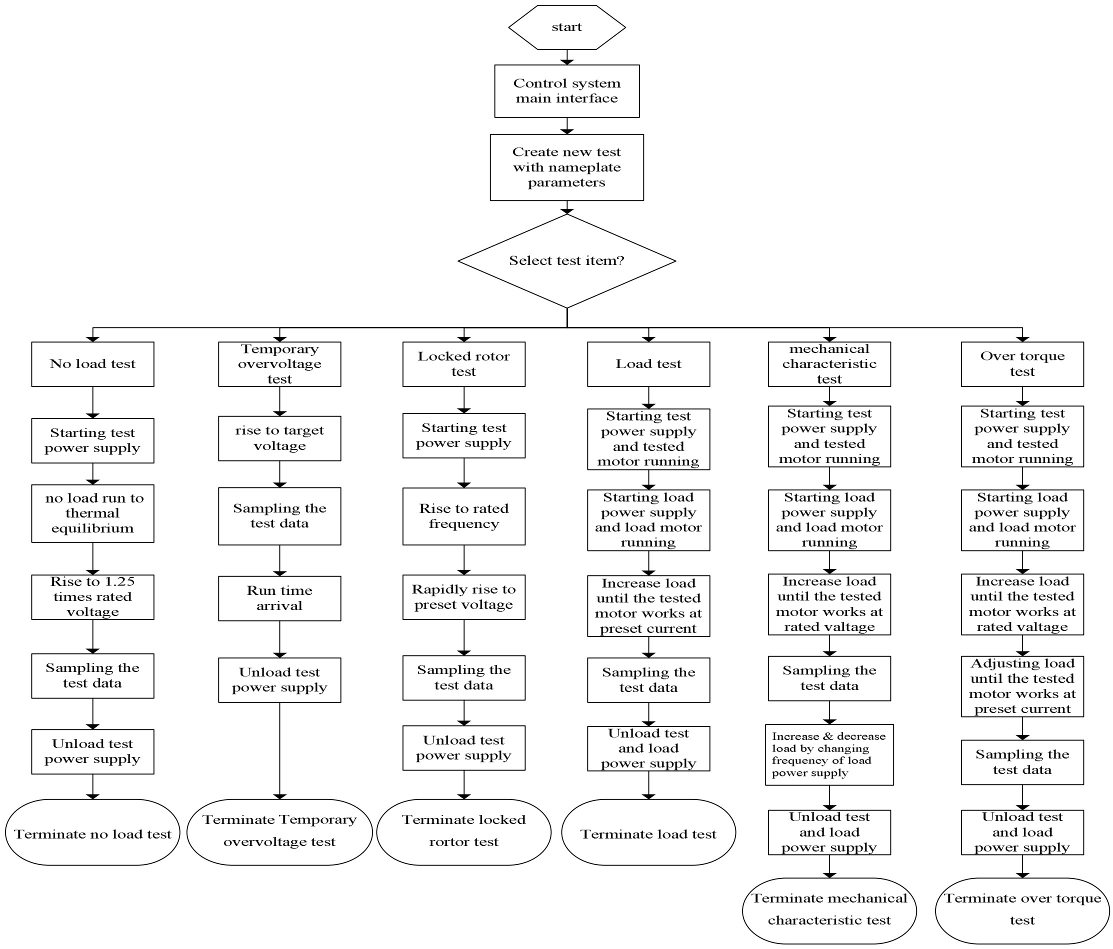

Figure 3. The procedure of test items.

3.1.4.2 The control of mechanical characteristic test. Firstly, the test voltage is preset, the tested and load motor are started according the relevant step. Secondly, the test data is sampling and recorded, and the frequency of load motor is decreased with 2Hz each cycle, it is descended from 50Hz to 0.5Hz in 20s. Thirdly, the ascending frequency process begins with the target frequency is 50Hz, at the end of ascending frequency process the tested motor and load motor are all at no-load working condition.

3.2. The design of test data processing software

3.2.1. The design of the operator interface. The operator interface is designed according to test items, which concludes test number, nameplate parameter, data analysis options and instructions, the calculation interfaces of every test items. In each test item there are the raw data area, the processing data area, the environment and auxiliary data area, the analyzing data area, which is shown in figure 4, the default is no-load interface.

3.2.2. The classification and flow chart of processing test data software.
3.2.2.1. The calculation of no-load test data. When the tested motor runs in thermal stable status, the no-load test data is sampled. The no-load test data processing flow chart is shown as figure 5.

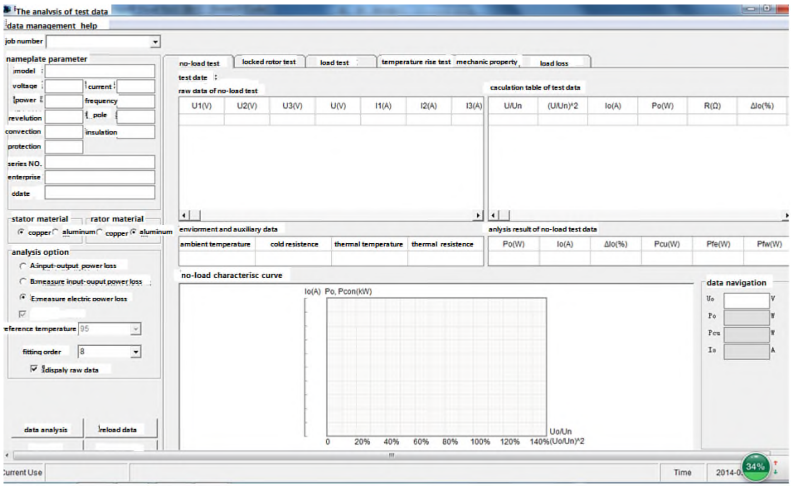

Figure 4. The operate interface of processing test data software.

The raw data of no-load test concludes three-phase terminal voltage, stator line current and input power, the terminal voltage is normalized as U/U_N and $(U/U_N)^2$ (U_N is the rated voltage 380V) so that the tested data curve could be drawn conventionally. The figure 6 is the curves of no-load test data, which is the least square fitting curves of the existing data points, these curves include $P_0 = f(U_0/U_N)$, $I_0 = f(U_0/U_N)$, $P_{con} = f(U_0/U_N)^2$, $P_{fe} = f(U_0/U_N)$. The first two curves are drawn from the raw test data, the third curve is P_{con} versus $(U_0/U_N)^2$, and the wind friction loss is obtained when this curve intersects the vertical axis, thus the fourth curve is equal to the third curve minus the wind friction loss.

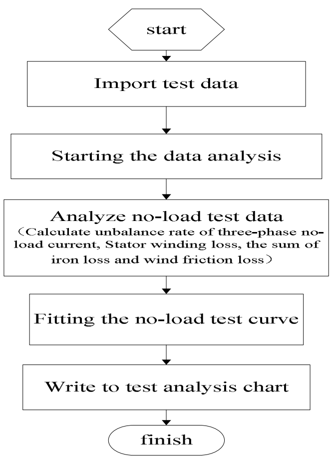

Figure 5. The flow chart of no-load test data.

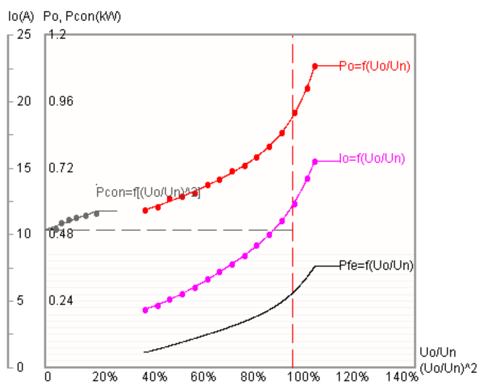

Figure 6. The curve of no-load test.

3.2.2.2. The calculation of locked-rotor test data. The locked current and locked torque are measured in the locked-rotor test data. The raw data concludes the locked voltage U_K, locked current I_K, locked torque T_K and locked input power P_K. The locked-rotor test data processing flow chart is shown in figure 7, when $U_K \geq 0.9U_N$, the curves of $I_k = f(U_k/U_N)$, $T_k = f(U_k/U_N)$ and $P_k = f(U_k/U_N)$ are fitted by the least square method based on some locked-rotor test data; when $U_K < 0.9U_N$, the parameters are calculated by linear regression method, that is, linear $Lg(I_K) = F(Lg(U_K))$ is fitted at first, then the locked current at rated voltage is obtained from the extended curve of this line, just as the dashed line in figure 8, the locked torque is calculated according $T_{kn} = T_K(I_{kn}/I_k)^2$, and the locked power is calculated according $P_{kn} = P_K(I_{kn}/I_k)^2$, where I_{kn} & T_{kn} is the locked current and locked torque at rated voltage, I_k & T_K are the locked current and locked torque at the maximum locked voltage.

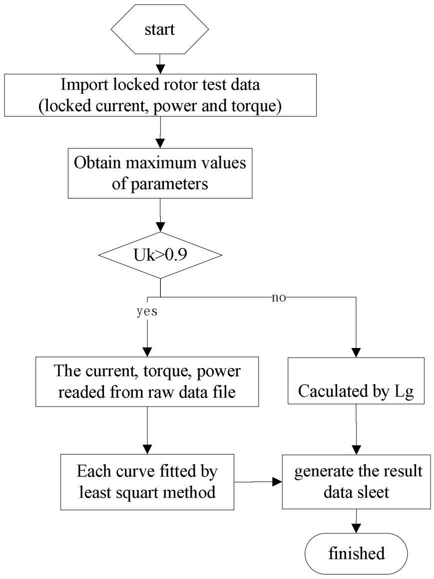

Figure 7. The flow chart of locked-rotor test data.

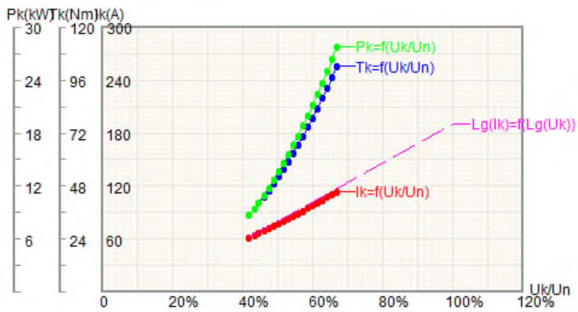

Figure 8. The curve of locked-rotor test.

4. Conclusion

The test system software discussed in the paper has advantages of having fine interface, manipulating conveniently and having reliable operation. The operator interface of control system is designed as entering some test parameters and clicking the starting buttons, then the test system could complete the requirements of main test items; similarly, by using the processing test data software the raw test data is transformed to the needed data, then the export of related parameter calculated results is obtained with drawing the curve diagram, which is dramatically reduced the test labor, and the accuracy of test data meets the requirement of the test.

On the other hand, the test system also has some shortcomings, such as the parameters of tested motor are not be coved those of the test system, the modification of the control software is a complex thing, therefore, the perfections and stability system software are greatly depended on the user's feedback to faults .

Up to now, more than ten types of motor tests have been carried out on the test system. The system software has also been slightly modified in accordance with different motors, and satisfactory results have been obtained. With the improvement of computer, we will consider the use of MATLAB to optimize the processing software for experimental data analysis.

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