Research and Development of Intelligent Motor Test System

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***Abstract*—This paper presented an intelligent motor test system in order to adapt the development trend of larger data scale and more complicated acquisition environment, and solve the low efficiency problem of motor testing device. It described the scheme of computer automatic data acquisition and processing system, application program structure and distributed network group control strategy of the intelligent motor testing system. The network group control system performes automatic switching and automatic controlling under various units running conditions in motor type testing. The paper also described in detail the equivalent circuit algorithm for motor working characteristics calculation and the non-linear LSM data fitting method for experiment curve. The system took full advantage of hybrid programming technology in interface developing, and of Period Tracking Technology which could solve the problems of measurement errors and low efficiency. It had been successfully applied in several motor manufactories.**

***Index Terms*—nonlinear least square method, curve fitting, motor testing, intelligent**

I. INTRODUCTION

Recently, with the rapid development of computer applications, Computer-based Automatic Testing System (ATS) for electrical motor has been greatly popularized [1]. Since Computer-based ATS has remarkable advantages such as test function, measurement accuracy and other performance indexes, it gradually replaces the traditional artificial method and makes motor testing technology enter a new stage.

In present, computer-based ATS can be divided into two kinds, PLC-based system and PC-based system. For PLC-based system, process control of the test is realized by the hardware platform, while the computer system only involves data processing and curve plotting. For example, the automatic testing system of motor developed by Westinghouse Electric Corporation [2] is a typical PLC-based ATS. In [7], the PLC is adopted to act as both a local and a remote controller for the motors. For PC-based system, the personal computer controls not only the data processing but also the data acquisition and the entire testing process, and the PLC solely executes the commands from PC. Some research institutes such as Shanghai Institute of Motor Technology, China, have achieved lots of results in the testing system of induction motor and PM motor. In [3], a distributed intelligent motor type test system based on ActiveX and COM Technique is introduced. In [4], by adopting the PC as the measure and control center, a computer-aided type test system is presented. And in [5], a novel USB based detecting system for the high-power propulsion motor is proposed. Also, in practice, the 300-type process control computer, which manufactured by Siemens for Munich University motor lab, has firstly designed and it greatly simplified the measurement of parameters in motor test. The integrated motor performance test machines MDP101 and MDP102, which are designed by Japan International Test Corporation, can automatically test the desired projects and implement the data processing. Meanwhile, the expert system with automatically diagnosing ability for motor test is appeared in [6].

Although the PC-based ATS has been widely applied in motor test, this paper proposes a novel PC-based distributed group network system for motor test, which uses the touch screen based interfaces, the PLC based control and the configuration analog meters based display. With the integration of the power testing unit and machine control unit, this paper describes in detail a scheme for designing the distributed network control system. By using hybrid programming technology, the problems (large quantity of testing project, heavy workload and big testing error) can be well solved. The computer-aided intelligence system is developed by fitting motor measurement curves based on nonlinear least square method and successfully applied in a middle type motor testing system design for XTE Motor Manufactory. The system can be operated both in pattern design and delivery testing for various motor categories including asynchronous, synchronous, DC and special motors. Moreover, the proposed scheme can be reconstructed according to user requirements and be used to intellectualize the motor testing process.

This work is supported by 2009 Science and Technology Achievement Cultivation Project of Hunan province (09CY018)

doi:10.4304/jcp.7.9.2192-2199

II. Composition of The Motor Testing System

The propose motor network testing system is shown in Fig.1, which mainly composed of data acquisition and processing subsystem, unit drive control subsystems [7]. By integrating the testing power part and the controller part, the unit drive control subsystem performs as a distributed network control system. It provides stable DC excitation power to units in motor testing process, and switches between different running states according to test requirement. In automatic data acquisition and processing subsystem, the acquired electrical and non-electrical quantities are sent to the PC through field bus, and subsequently preprocessed. After that, the obtained data is processed through hybrid MATLAB/VB programming technology and non-linear fitting method. The processed results are stored in computer database and output by printer [8].

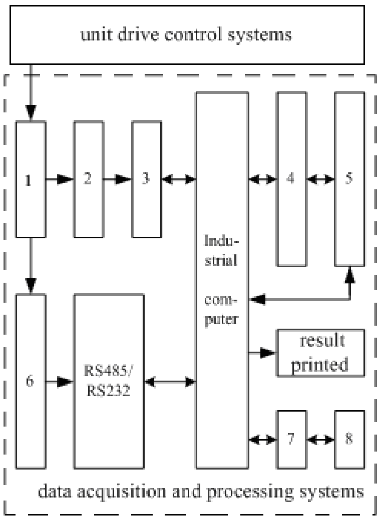

Fig.1. Block diagram of the test system
1— sensor and transmission circuit
2— signal conditioning
3— data acquisition card
4— ACESS database
5— MATLAB and VB hybrid programming
6— Intelligent instrument array
7— Data server
8— Enterprise management network

III Design of Automatic Data Acquisition and Processing System

In order to improve the measurement accuracy of Voltage Harmonic Distortion (VHD) rate, the signals are firstly be processed by signal conditioning circuit and then sent to DAQ card. After that, the testing data will be processed by PC and the results will be either displayed or printed. The whole test-beds with embedded PCs form a TCP/IP LAN. The data server is linked to enterprise management network. In the system, the motor's electrical signals are measured by intelligent instruments, such as two-way intelligent digital display controller (WP-MD807-200-1212), industrial level digital tachometer (CA27) and so on. The test circuit is remarkably simplified for the application of intelligent instruments with RS485 interfaces, which can realize remote controlling [9,10].

The analysis requires detecting the type, scope and assembly requirements of signals. The measured signals of the system include three-phase voltage, three-phase current and rotary speed of intermediate frequency generator, three-phase voltage, current and DC excitation voltage and current of vice exciter. The effective values of AC voltage vary between 0 and 300 V for intermediate frequency generator and 0 ~ 30 V for vice exciter, respectively. Also, DC voltage range is 0 ~ 30 V; AC current effective value ranges are 0 ~ 100 A and 0 ~ 2 A, DC current range is 0 ~ 2 A. The amphibious AC and DC sensors used in this system are as follows:

- SX1T500V050V7 voltage sensor: input voltage is 0~500V, output current is 0~50mA, and used for the measurement of voltage signals.
- SE1T100C50V6 current sensor: input current is 0~100A, output current is 0~50mA, and used for the measurement of generator three-phase current.
- SG1T5C25V6 current sensor: input current is 0~5A, output current is 0~25mA, and used for the measurement of three-phase line current and DC excitation current of vice exciter.

A. Period Tracking Technology

In automatic motor test system, when the motor to be tested is a generator, the frequency of its output voltage is always not constant [11]. If the sampling period Ts and the sampling times N in a period are constant, the N sampling will exceed or not cover a signal period, which brings large error. In our system, the sampling frequency is set to be fixed and the actual sampling times N will be changed real-timely and followed the variation of the value of voltage period T. Thus, the measurement error caused by period fluctuations in the signal can be eliminated [12]. According to the frequency characteristcs of tested motors, the highest harmonic number to be analyzed is set to be 30 and the signal highest frequency is 12 KHz. In order to improve the real-time performance, sampling should be operated and completed within two fundamental periods of the sampled signal.

According to the non-period sampling theory of period signal, the required sampling frequency of 10-channel parallel sampling is 254 kHz. This requirement can be met by adopting the data acquisition card - PCI9118 DAQ card [13].

B. Adoption of Intelligent Instruments and Meters

Both the pattern tests and delivery tests of motors include measuring current, voltage and network frequency, revolution speed and temperature. Intelligent instruments and meters with interface RS485 have advantages of remote controllability, isolation of internal CPU system and external inputs, robust ability of anti-interference, and thus simplifying the circuit. For example, the selection of dual-channel intelligent digital display controller WP-MD807-200-1212 avoids using several kinds of meters. To satisfy the requirements of the test, the intelligent instruments and meters chosen in our system are listed as: technical grade digital tachometer CA27, multi-channel temperature itinerant detector, programmable 5KV digital insulation measuring apparatus HT7050, vibration-measuring analyzer VA-11, noise spectrum analyzer AWA6270, digital micrometer PC9A-1, technical grade digital tachometer with interface RS-232 CA27, intelligent frequency display controller WP-LEQN1C6E1, etc [14].

IV. Design of the Unit Drive Control System

In the design of units control system, we adopt total distributed control method to centralize the manage and distribute the control for the units [15]. The 5 sets of excitation power supplies in the test station are separately controlled in closed-loop form by corresponding control unit, and each control cabinet is provided with local control and works in remote control modes. Meanwhile, the DC speed regulation system (6RA70) is constituted in a complete double closed-loop form. During the system operation, the upper computer is in charge for the unified manage of the 5 sets of excitation powers and the pair of speed regulation systems. Through the PLC simulation module, the upper PC outputs control command to the lower computer in remote and the lower computer controls each power subsystem in local system [16]. The operation parameters of the subsystem should be sent back through the detection interface and are displayed on the touch screen. The whole motion control system is composed of PLC, touch screen, the excitation magnetic control cabinet and the speed regulation subsystem in a distributed network control structure.

A. Design of Test Power System

The unit drive control system is composed of 5 motors, 5 suites of excitation power sources with MCU, and a full-digital DC speed regulating equipment (SIMENS 6RA70). The interfaces of the test project are shown in Fig.2. In Fig.2, the notation "117D" denotes Siemens full digital DC speed regulator 6RA70, B is motor to be tested, P is accompany motor , TD is AC synchronous motors, TF is AC synchronous generator, ZF denotes DC motor, LT is the exciter current feedback, LV is the voltage feedback .

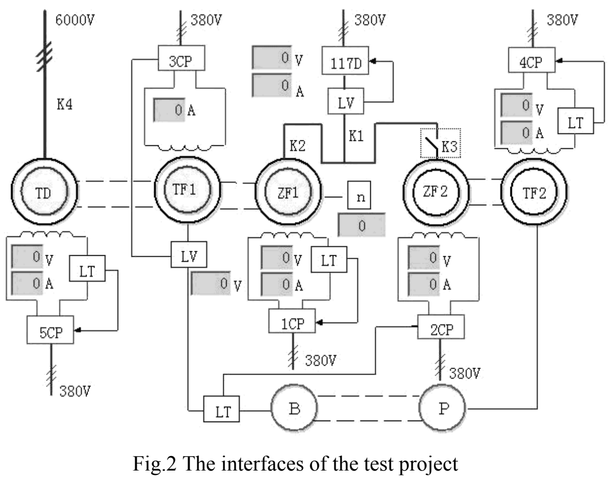

Fig.2 The interfaces of the test project

The project is tested under different operating frequency such as 50Hz, superposing-frequency. The running state is different in different tests, as well the feedback signals. Also, for manual control mode, it sometimes requires some inconvenient operations such as repeated adjustments and heavy workload. After taking into account the complexity of unit control and the need of running state switching in testing process, closed-loop control is adopted for the motor's excitation. The tests use two DC SCR cabinets, two synchronous motor separate excitation cubicles, and a synchronous motor separate excitation SCR cabinet to control the excitation of the motors. The upper-level monitor management system is composed of touch screen and PLC, which can automatically switches between different running states and control modes.

B. Composition of Unit Drive Control System

The Siemens full digital DC speed regulator 6RA70 is very powerful and is commonly used in single machine dual-closed-loop control system. For the system design, the control structure and the parameters of the test object is essentially the same, thus the control parameters' adjustment and performance tuning are very convenient. In our system, there are two different working modes for speed regulating system: (1) stable voltage mode,which supplies armature voltage for two motors – double motor drive; (2) speed regulating mode, which controls the stability of ZF1's speed – the single-motor drive. It will be a waste of hardware when using two power sources to meet the application requirements. Through demonstration and analysis, during double-unit drive control, we use Siemens full digital DC speed regulator (6RA70) for DC motor ZF1 and ZF2, which can adjust control parameters accordingly so as to ensure the system meet the control performance requirements.

In the 50Hz feedback pilot project, the power units work as follows. Step 1. Motor TD is electrified and grid-connected, and works in electro motion state. The synchronous motor TF1 is turned through shaft. At the beginning, it cannot reach the synchronous speed (f=50Hz), so TF1 couldn't connect to excitation current. TF1 is connected to DC motor ZF1 through shaft. ZF1 is not initially exited but starts by remanence in generating state. Then its excitation current is adjusted to make the system's speed to reach synchronous rated speed. Also, TF1 is connected to excitation current and works in generating state. Step 2. Electricity generated by TF1 is sent to motor B for testing and motor B works in electro-motion state. The companion motor P, which is connected to B through shaft and works as a generator, is used as a workload of motor B. Step 3. The electricity generated by P is sent to synchronous motor TF2 to force TF2 in electro-motion state. Also, DC motor ZF2 is connected to TF2 through shaft and is in generating state. After that, by disconnecting K1 and closing K2, K3, motor ZF2 and ZF1 is connected in a closed-loop. Step 4. ZF2 receives the input current of the motor to be tested as its closed-loop feedback current. TD, ZF1 and ZF2 use their own excitation current for closed-loop feedback current control. And TF1 uses its own armature voltage for closed-loop feedback voltage control.

C. Composition of Network Control System

In order to achieve the control requirements, facilitate the operation of main control loop, and communicate with upper-level management PC, we integrate the testing power source with the unit control system to form a network control system. The upper-level machine is composed of touch screen (TP270) and PLC (S7-200), while the lower-level machine system includes a double-closed-loop full digital DC regulator system (Siemens 6RA70) and five real time excitation power control system. The management PC is connected to upper-level machine and receives management commands, transfers operation parameters of power system. It communicates with lower-level machine to monitor the management process and transfer control parameters through field bus. The multi-level distributed network power control system provides a good test environment for motor testing and well fulfils the test and control requirements.

V. CURVE FITTING FOR EXPERIMENT DATA

In motor type test and delivery test, we need to measure the motor speed n, power factor $\cos\phi_1$, efficiency η, rated current I_1, and the relationship curve between the electromagnetic torque T and the output power P_2. In our design, the chosen intelligent instrument is configured with a RS485 interface, which is convenient for remote control. The internal CPU system is separated from external signal, thus it has a strong anti-interference ability. The test circuit is greatly simplified while meeting the automatic test requirements. After the temperature rise test, working characteristic test proceeds while loads vary between $0.25P_N$ and $1.25P_N$. The widely used methods include torque meter direct measurement, indirect measurement and circle diagram method by solving induction motor Γ equivalent circuit. The measured three-phase asynchronous motor YKKL355-4 has a high capacity with 220kW rated power, 6000V rated voltage and 26.4A rated current, which is suitable for equivalent circuit method.

A. The Equivalent Circuit of Three-phase Asynchronous Motor

The equivalent circuit of one phase of the 3-phase asynchronous motor is shown in Fig.3. R_1 is the resistance of the stator winding phase. X_1 is the stator's leakage reactance. G_{Fe} is the equivalent conductivity of stator iron loss. B_m is the master excitation susceptance. S is the slip ratio. R_2 is rotor phase resistance converted to rotor side. X_2 is rotor leakage reactance converted to rotor side. The equivalent circuit method is a way to calculate working characteristic through equivalent circuit according to motor empty load and stall test.

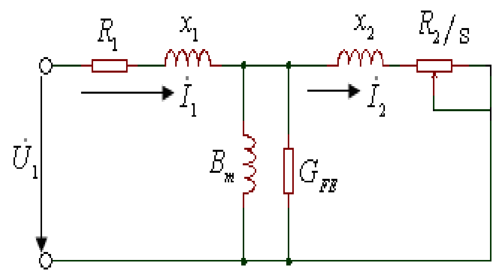

Fig. 3 The equivalent circuit of 3-phase induction motor

B. Equivalent Circuit Measurement Method

Step 1. Empty load test: set $U_0 = (1.1 \sim 1.3)U_n$, then measure the empty load current I_0, empty load voltage U_0, empty load input power P_0, and the stator resistance R_{10} at the end of the test. There are 7~9 sets of data in the test.

If $U_O/U_N = 0$, the empty load loss is equal to the iron loss as

$$P_{OC} = P_{fe} \tag{1}$$

If $U_O/U_N = 1$, the mechanical loss is equal to rated empty load loss minus iron loss as

$$P_{fw} = P_{OC} - P_{fe}. \tag{2}$$

Step 2. Low-frequency short-circuit test: measure the three-phase voltage U_{1k}, three-phase current I_{1k}, input power P_{1k} and the resistance R_{1k} of the stator winding. There are 7 sets of data in the test. The equivalent circuit's parameters of the three-phase asynchronous motor are calculated through iterative method. Let the motor reactance is X_1, X_2, X_m, master excitation susceptance B_m, iron loss equivalent conductivity G_{FE}, rotor resistance R_2, the slip ratio of rated point S_n. The total impedance can be calculated as following:

$$Z = R + jX \tag{3}$$

Step 3 Calculating working characteristic: Suppose the slip ratio of rated point in the previous step is S_n, and let S equal to 0.25 S_n, 0.5 S_n, 0.75 S_n, 1.0 S_n, 1.25 S_n respectively, the equations to calculate working characteristic are as follows

Input current:

$$I_1 = U_n / Z \tag{4}$$

Input power:

$$P_1 = 3I_1^2 R \tag{5}$$

Rotor copper loss:

$$P_{cu1} = 3I_1^2 R_{1ref} \quad (6)$$

where R_{1ref} is an equivalent conversion under standard temperature of the stator winding resistance.

Thus, the iron loss is calculated as

$$P_{fe} = 3I_1^2 \frac{G_{fe}}{Y^2} \quad (7)$$

rotor copper loss:

$$P_{cu2} = 3I_2^2 R_2 \quad (8)$$

where $I_2 = \frac{I_1}{Z_2 Y}$

If $S = S_n$, the stray losses is calculated as

$$P_s = 0.005P_1 \quad (9)$$

or else

$$P_s = P_{1n} \times \left(\frac{I_1}{I_{1n}} \right)^2 \quad (10)$$

the total loss is calculated as

$$\Sigma P = P_{cu1} + P_{cu2} + P_{fe} + P_{fw} + P_s \quad (11)$$

Therefore, the efficiency is calculated as

$$\eta = \left(1 - \frac{\Sigma P}{P_1} \right) \quad (12)$$

and power factor is

$$\cos\phi = \frac{R}{Z} \quad (13)$$

C. Non-linear LSM Data Fitting

We want to find a function $y = y(x;a)$ to approximate the working characteristic curve in Table 1. The two most commonly used methods are interpolation and fitting. Here, we adopt different fitting methods according to the characteristics in the proposed intelligent motor testing system. When fitting motor's empty load characteristic, since straight line fitting and high-order polynomial fitting cannot meet the requirements, we use quadratic and cubic polynomial two-segment fitting method to get the optimal characteristic curve. For $\cos\phi = f(P_2)$, we use non-linear LSM data fitting and Lieweibuge - McQuirter method to obtain good performance.

Suppose there is a functional relationship $\cos\phi = y(P_2;a)$ between $\cos\phi$, variable P_2, and parameter $a = (a_1, \cdots, a_m)^T$, and let $(P_{2i}, \cos\phi_i)$ $(i = 1, \cdots, n)$ denote n observations of $(P_2, \cos\phi)$. The objective is to minimize

$$x^2(a) = \sum_{i=1}^{n} [\frac{\cos\varphi_i - y(P_{2i};a)}{\sigma_i}]^2 \quad (14)$$

where σ_i is the standard deviation of measurement error of the i-th point $(P_{2i}, \cos\phi_i)$;

The Lieweibuge - McQuirter method is equivalent to solving the following non-linear equation

$$\nabla \chi^2(a) = 0 \quad (15)$$

Initializing a to $a^{(0)}$, and using the improved Newton iteration method, we have

$$a^{(q+1)} = a^{(q)} + \Delta a^{(q)} \quad (16)$$

$$\nabla^2 \chi^2(a^{(q)}) \Delta a^{(q)} = -\nabla \chi^2(a^{(q)}) (q = 0,1,2,\cdots)$$

For fixed Q, let

$$[a] = \frac{1}{2} \nabla^2 \chi^2 a^{(q)}, \beta = -\frac{1}{2} \nabla \chi^2(a^{(q)}) \quad (17)$$

$$\Delta a = \Delta a^{(q)} \quad (18)$$

In above equation, we define

$$[a] \Delta a = \beta \quad (19)$$

$$\Delta a = \mu\beta \quad (20)$$

Combine (19) and (20), according to the Lieweibuge - McQuirter method, we have

$$([a] + \lambda D) \Delta a = \beta \quad (21)$$

where $D = diag(a_{11}, a_{22}, \cdots, a_{mm})$

The gradient vector of the minimization function χ is

$$\frac{\partial \chi^2}{\partial a_j} = -2\sum_{i=1}^{n} \frac{\cos\phi_i - y(P_{2i};a)]}{\sigma_i^2} \frac{\partial y(P_{2i};a)}{\partial a_j}, j = 1, \cdots, m$$

Linearlize Hessian matrix:

$$\frac{\partial^2 \chi^2}{\partial a_l \partial a_j} = 2\sum_{i=1}^{n} \frac{1}{\sigma_i^2} [\frac{\partial y(P_{2i};a)}{\partial a_l} \frac{\partial y(P_{2i};a)}{\partial a_j} - [\cos\phi_i - y(P_{2i};a)][\frac{\partial^2 y(P_{2i};a)}{\partial a_l \partial a_j}]$$

So, we have

$$a_{lj} \approx \sum_{i=1}^{n} \frac{1}{\sigma_i^2} [\frac{\partial y(P_{2i};a)}{\partial a_l} \frac{\partial y(P_{2i};a)}{\partial a_j}], l = 1, \cdots, m$$

VI. VB SOFTWARE DESINGING

VB (Visual Basic) is a high efficiency visualization software development platform. By taking advantage of VB in user interface development, we avoid using the complicated C++. The VB subprogram "MRQA" is one iteration step of Lieweibuge - McQuirter method, and "MRQB" is used to estimate linear fitting matrix (Hessian Matrix, Hessian and minimization function's gradient vector) of Lieweibuge - McQuirter method. We refer to VB Algorithm Collection to develop the program, and the efficiency is greatly improved [17].

A. Application Program Structure of Intelligent Motor Testing System

The application program structure of intelligent motor testing system is shown in Fig.4.

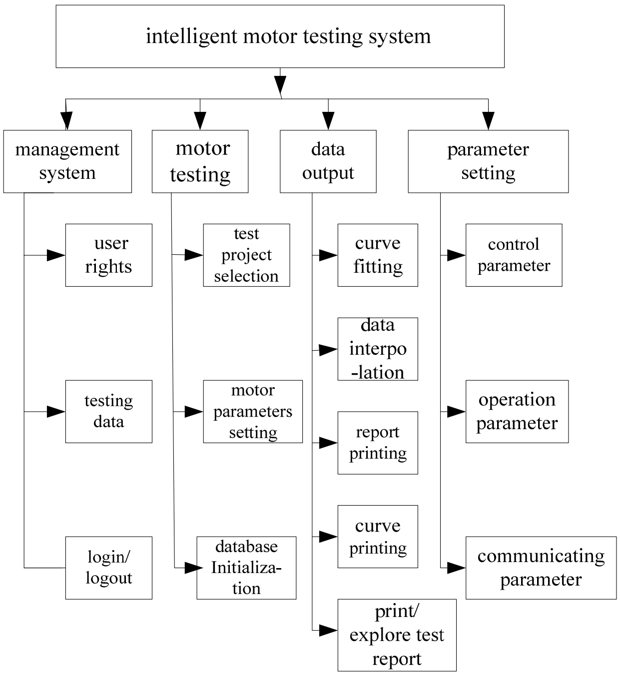

Fig. 4. Application program structure of intelligent motor testing system

For this testing system, master control software is responsible for command and coordination of the entire system and communicates with operator directly through the man-machine interface. The software can execute tasks of receiving data, data processing, fitting and plotting test curves, generating and printing test reports, test data access and management, etc [18]. In intelligent motor testing system, process control, data collection and display, and dynamic parameters setting are implemented in several classes including dialog box classes for empty load test, dialog box classes for loaded test, dialog box classes for locked-rotor test, dialog box classes for temperature rise test etc. All of these are designed and implemented with functions of data access and process.

Due to the merits of VB programming, the designed user interface of master control software offer the channel of man-machine conversation, and has a friendly operating platform which is easy to understand. Once the interface of each test is designed, the system is easily setup for real-time monitor test. All the test data are saved and stored in database for further analysing the running performance and quality of motors.

B. Curve Fitting Sub-program Flow Char

The main procedure of intelligent motor testing system's load experiment includes: pilot project selecting, testing preparation, load regulating, data acquisition and processing, thermal resistance sampling, motor working characteristic calculating, curve fitting, result printing, and curve draw. The flow chart of non-linear LSM curve fitting for working characteristic curve $\cos\phi = f(P_2)$ is shown in Fig.5.

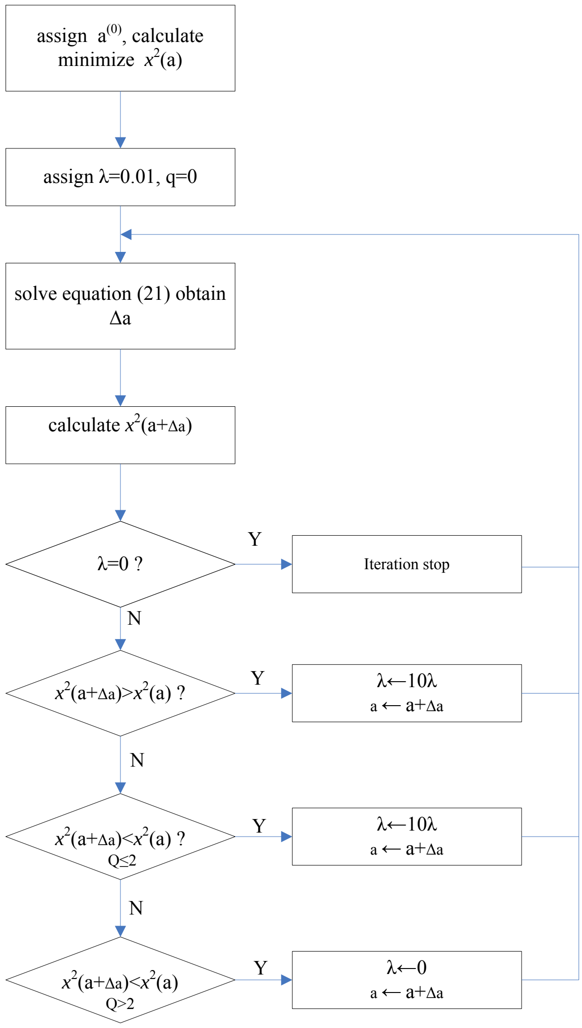

Fig. 5. Curve fitting sub-program flow char

C. Hybird Programming Technology

MATLAB is a mathematical software with high performance of numerical analysis, signal processing and graphical display, and it has high efficiency in complex algorithm implementation, but low efficiency in developing man-machine communication interface [19] [20]. Visual Basic (VB) is an efficient visualization software platform, which enables programmers to quickly and easily develop friendly user interfaces. We use VB /MATLAB hybrid programming techniques to develop test system software, where VB is used to develop the interface and Matlab as the background operation procedure [21].

Executable files (.exe) technology is a relatively simple call method [22]. MATLAB software itself provides a start to run M files "startup.m", so we write the problem solving algorithm program in the" startup.m" at first. Then we use the VB Shell calls MATLAB, MATLAB starts immediately and executes the "startup.m", reads the data file preprocessed by VB. When MATLAB accomplished data processing, it closes itself and returns to VB, VB implements the data virtual display.

VII. TESTING RESULT

The tested motor (YKKL335-4) is a three-phase asynchronous motor with rated voltage 6000V. We use equivalent circuit method to measure the working characteristic. The testing and calculation data are shown in Table 1.

TABLE I.
CALCULATION OF WORKING CHARACTERISTIC

U (V)	6000	6000	6000	6000	6000
I (A)	11.570	16.165	21.487	26.968	32.389
P (kW)	69.006	129.081	186.792	241.389	292.290
Sref (%)	.247	.494	.741	.9883	1.235
Pcu1 (kW)	1.008	1.968	3.478	5.479	7.904
Pfe (kW)	6.728	6.626	6.500	6.353	6.190
Pfw (kW)	6.09	6.09	6.09	6.09	6.09
Pm (kW)	61.268	120.487	176.813	229.555	278.196
Pcu2 (kW)	.151	.595	1.310	2.268	3.436
Ps (kW)	.345	.645	.934	1.206	1.461
∑P (kW)	14.323	15.926	18.313	21.399	25.082
P2 (kW)	54.682	113.156	168.478	220	267.208
H (%)	79.24	87.66	90.20	91.14	91.42
Cosφ	.573	.768	.836	.861	.868

The characteristic curve of the three-phase asynchronous motor (YKKL335-4) is fitted by non-linear least square method. The characteristic curve of rated voltage and frequency is shown in Fig. 6.

A motor empty load test measurement data at n = 4000 r/min are shown in Table 2, and the fitted characteristic curve of empty load test is shown in Fig. 7.

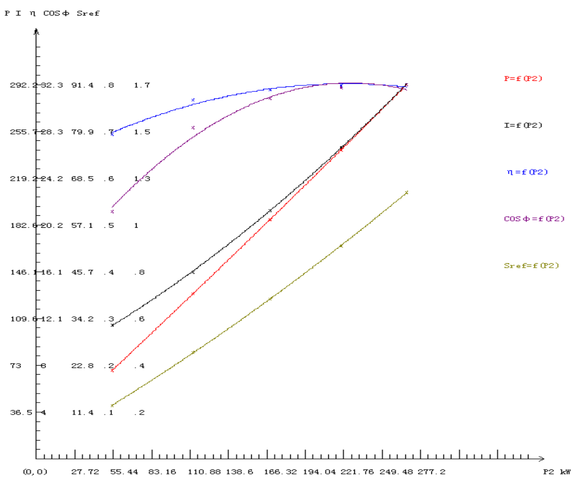

Fig. 6. The characteristic curve of rated voltage and frequency

TABLE II.
EMPTY LOAD TEST

Uuv V	Uu4v4 V	Uf2 V	If2 A
35	5	0	0
120.5	19	6.3	.34
180	29	11	.58
200	32	12.6	.67
220	35.2	14.8	.78
240	38	17.3	.91
260	41.5	21.5	1.12
280	44.5	27.8	1.43

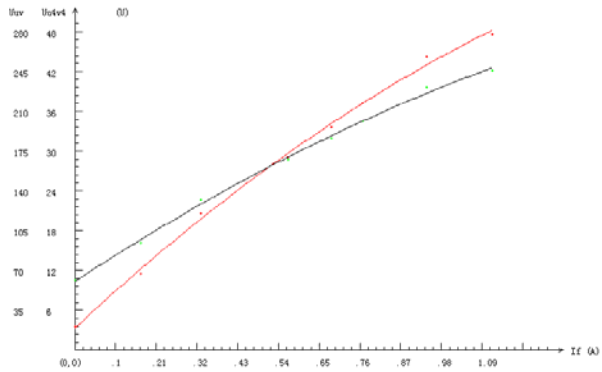

Fig. 7. The characteristic curve of Empty load test

Fig. 8 gives the characteristic curve of short-circuit test.

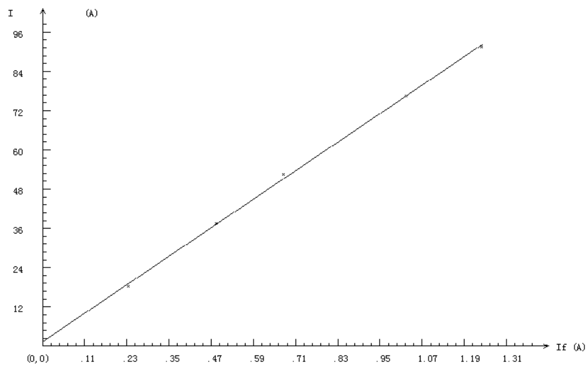

Fig. 8. The characteristic curve of short-circuit test

In the design and development of intermediate frequency motor testing system, test data acquisition and processing and resulted virtual display are implemented by using VB/MATLAB hybrid programming technology. The sinusoidal aberration rate of voltage wave and wave crest ratio of dynamic measurement are given in Fig. 9.

UUV	UVW	UWU	peak value	wave coefficient	distortion
197.2	197.7	198	289.3	1.45	2.09
197.3	197.7	198	289.1	1.44	2.29
197.3	197.7	198	289.3	1.44	1.68
197.3	197.7	198	289.3	1.44	1.76
197.3	197.7	198	289.3	1.45	1.85
197.3	197.7	198	290.27	1.45	1.85
197.3	197.7	198	289.3	1.44	1.62
197.3	197.7	198	290.86	1.45	1.77
197.3	197.7	198	289.1	1.45	2.11
197.3	197.7	198	290.47	1.44	1.62
197.3	197.7	198	289.3	1.44	1.62
197.3	197.7	198	289.3	1.44	1.63
197.3	197.7	198	289.3	1.44	1.63
199.5	200.8	202	283.43	1.4	2.52
199.3	200.6	201.8	284.22	1.41	2.71
199.4	200.6	201.8	286.17	1.42	2.51
200.5	201.7	202.9	283.43	1.4	2.75

Fig. 9. Section result of test data acquisition and processing

From Fig.9, the running results show that , as to the sinusoidal aberration rate of voltage wave and wave crest ratio of dynamic measurement, the precision of measuring results reaches 0.01% , while traditional method VHD only has 0.1%.

By taking advantage of VB in user interface developing, the drawing interface of characteristic curve is very friendly. And the fitting result reflects real data very well, which meets the requirement of intelligent motor testing system.

VIII. Conclusion

The computer-aided intelligence system designed in this paper has been used in XTE motor manufactory and been generalized in all type motor testing stations for lots of motor factory. The proposed testing system has been proved to test accurately and efficiently by field experiment. This system can well resolved the problems such as huge workload of data processing, synchronous reading and multi-data real time display at testing process in intermediate frequency generator testing. Compared with manual measurement, the system meets the test requirement of motor testing system well, for it has less than 0.4% testing error, stable performance and favorable display interface. It presents a new approach for automated performance testing of motors.

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