

The Design of Synchronous Motor Excitation System Based on the Eurotherm590

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Abstract — This paper introduces a synchronous motor excitation system controlled by a digital DC device Eurotherm590, and gives detailed explanation on the components of the system, working principle and debugging methods. This excitation system not only maintains original launch and operation features of the synchronous motor, but also reduces volume of the system. Further more, it has the function of self diagnosis and fault protection, and has the advantages of a wide range of parameter adjusting, friendly human-machine interface, convenient parameter setting. The operation results indicate that this excitation system possesses the character of simple operation and reliable working performance, and the expected goal is achieved.

Keywords - Eurotherm590; Synchronous motor; excitation system

I. INTRODUCTION

Synchronous motor consists of stator windings and rotor windings, of which the stator windings build the rotating magnetic field by three-phase alternating current and the rotating windings excite by direct current, both of them form the rotating magnetic pole with bi-polar excitation alternating motor^[1]. Its working principle is that the magnetic force of the rotating magnetic field produced by the stator windings drags the magnetic pole which is made up of the rotating windings and lets it revolve synchronously. Adjust the exciting current of the synchronous motor properly according to the load, then you can alter its reactive current component and improve its imaginary power. Therefore, large load equipment commonly use synchronous motor to provide power. For example, large-scale ball mills, compressors, blast-furnace blowers and so on.

According to the operation characteristics of synchronous motor, synchronous motor adopt the asynchronous start. Firstly, input the three-phase alternating current to stator windings of the synchronous motor. When the motor speed is close to the synchronous speed and rotor slip reached 4% ~ 5%, input the DC current to the excitation winding to produce synchronous torque to put motor in the synchronous running state. At present, most excitation systems for synchronous motors widely used are composed of the analog control circuits of thyristors. Due to

the use of discrete components, the failure rate is higher; debugging and maintenance workload is heavier after a period of running.

Upon the existing problems in the original excitation system of synchronous motor, we carried out a new design, Eurotherm590 fully digital DC control device to control the original excitation control system. The new excitation system has the six following advantages:

- A. The new excitation control system adopts the digital thyristor control mode, and maintains the original starting and running characteristics of the synchronous motor.
- B. Based on the integrated control devices, the volume of excitation control equipment is substantially reduced.
- C. The new excitation system has the function of running state self-diagnosis and fault protection, making the equipment running more safer and reliable.
- D. The wide adjusting range of control parameters can meet the requirements of different specifications of synchronous motor excitation control.
- E. The parameters of the adjustment are displayed on the menu, the operation is simple, the human-machine interface is friendly, the parameters are easy to be set, and one just need simple training to use the system for work. System adjustment is more convenient.
- F. Spare communication interfaces for centralized control.

II. BASIC FUNCTION OF EURO THERM590 DIGITAL DC DEVICE

The Eurotherm590 digital thyristor DC control device is the controller which is based on the microprocessor. Because of the full digital design, the power supply voltage and frequency range is wide, the anti-interference performance is good, and the power frequency of the system can be changed from 45Hz to 65Hz. The voltage range of the control system is from 110V to 240V. And the system is not affected by the rotation direction of power phase sequence when connecting wires. At the same time, the system has the function of excitation, operation and fault monitoring for synchronous motor. The control function of the controller is accomplished by parameter setting. And it has the functions of self-adaption, parameter optimization, fault self-diagnosis. The communication interface can establish communication with the upper computer or the remote control station to implement the remote control of the system. This device provides protections for the operation of synchronous motor such as overvoltage, under-voltage, over current, power phase shortage, and over temperature of the motor. So it is especially suitable for field control and debugging^[2].

III. THE CONSTRUCTION AND WORKING PRINCIPLE OF THE NEW EXCITATION CONTROL SYSTEM

The composition of the new excitation system for Eurotherm590 control is shown in Fig.1.

According to the excitation control principle of a synchronous motor, the new design of control system should meet the working requirements of synchronous motor, and keep the inherent operating characteristics of a synchronous motor. In the full-voltage starting process of motors, when the rotor speed reaches the sub synchronous speed (slip rate from 4% to 5%) should be clockwise polarity input excitation, synchronous motor is put into synchronous operation.

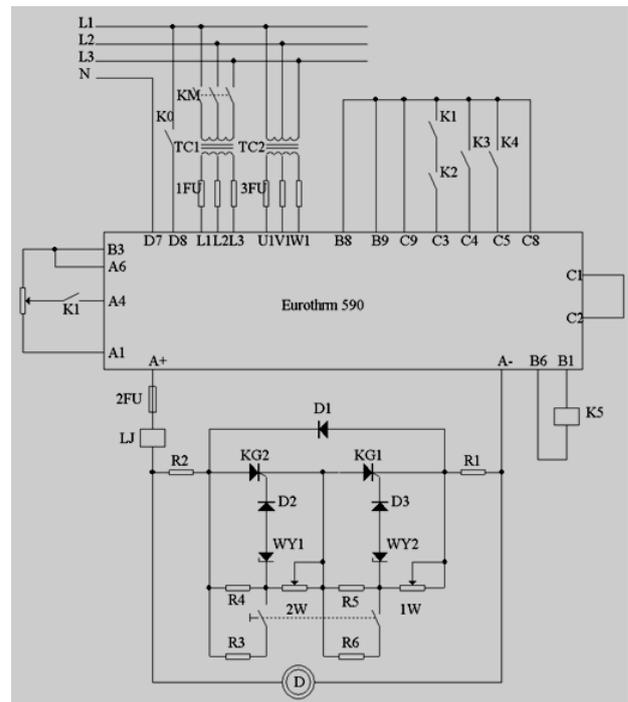


Figure 1. The diagram of Eurotherm590 excitation control system.

In the step-down starting process of synchronous motors, when the rotor speed reaches about 90% of the synchronous speed, full voltage will be automatic input to accelerate synchronous motors to sub synchronous speed, then excitation will be suitable polarity input, synchronous motor in synchronous operation. And the new excitation control system should have negative voltage negative feedback and current negative feedback, when the grid voltage or load fluctuations, it can automatically maintain a constant excitation. The control system should automatically extinguish the excitation in starting and stopping, adjust the excitation voltage and current of the system flexibly to adjust the power factor.

The host controller of the new excitation system is the Eurotherm590 DC device, which completes the excitation control of the synchronous motor by circuits of external excitation input, de-excitation control, etc.

When the synchronous motor stator winding is connected to the three-phase AC power supply to create a rotating magnetic field, the rotating magnetic field in the rotor winding produce AC induction electromotive force,

the positive half wave by R1, D1, R2 constitute a loop current and negative half wave through R2, KG2, KG1 and R1 into a current loop. Therefore, the positive and negative half wave of the rotor winding current which flows through the starting process of the synchronous motor is symmetrically, thus ensuring the normal starting torque of the synchronous motor.

When the synchronous motor speed rise to sub synchronous speed, (slip is 0.05), amplitude and frequency of rotor winding induced electromotive force are reduced, and then the excitation control link sends the excitation control signals, K1 and K2 are closed, the C3 control terminal of excitation device obtains the electric energy, the excitation control device sends out the signal, and output the exciting current according to the current value that is given by the A3 terminal, and KG1 and KG2 shutdown and synchronous motor will be put into synchronous operation. Eurotherm590 DC excitation system has current feedback link and can automatically maintain the output of the excitation current constant. When the motor stops running K1 is released, the excitation device is transferred into the inverter state immediately, and the rotor of the motor is ensured to smooth out the magnetic field. When grid voltage drops to a specified value, starting the K3 and the C4 electrical terminal of excitation devices is energized to strengthen excitation.

The process of de-excitation is that, at the starting of the synchronous motor, KG1, KG2 are on, which enables the positive and negative semiwave of the current which flows from the motor rotor to be symmetric, in order to get a good starting characteristic, after the starting, turn off KG1 and KG2. At the initial stage of the starting, before the excitation control command is sent, the direct-current excitation system has no exciting current output, so the rotor winding inducts relatively large alternating voltage, and forms a loop among R1,1W,R5,2W,R4,R2. When the partial voltage reaches or goes beyond the nominal value of the voltage stabilizing diode WY1, WY2, WY1 and WY2

are break down, which provide KG1, KG2 with gate trigger voltage, and break over KG1, KG2, once the motor enters the synchronous operation, the induced voltage of the motor rotor drops, and the partial voltage on the 1W and 2W becomes small at this time, and too weak to break over the WY1 and WY2. Then let KG1 and KG2 to judge automatically, and the Eurotherm590 device provide the rotor winding of the synchronous motor with exciting current.

IV. CONTROL PARAMETER SETTINGS

Eurotherm590 excitation control device consists of voltage and current feedback loop, and adopts PI adjustment controller to stabilize the excitation output voltage current. The current-control signal can obtain constant value from the voltage controller or at the spot directly, and forms the error signal with the current control signal which is transferred to the PI adjustment controller to produce control signals. The parameters of PI adjustment controller can be set flexibility according to the controlled member. The current control loop has the ability of adjusting automatically. When debugging the current loop, use an oscilloscope to monitor the output waveform, so as to judge the working status of the controller.

There is a calibration board in the controller, which can set the limit value of the output current according to the working current of the load motor, and adjust the potentiometer which deals with the parameter of actual current value, so the output current of the controller is changed. We need to set independent corresponding current value as required when using it. This step is quite important, when setting this parameter, never let the controller work beyond the rated output current in case it is destroyed. There is a group of dial switches which can set the maximum output voltage of the controller as needed.

The menu of the controller parameter settings is illustrated in Fig.2 ^[3].

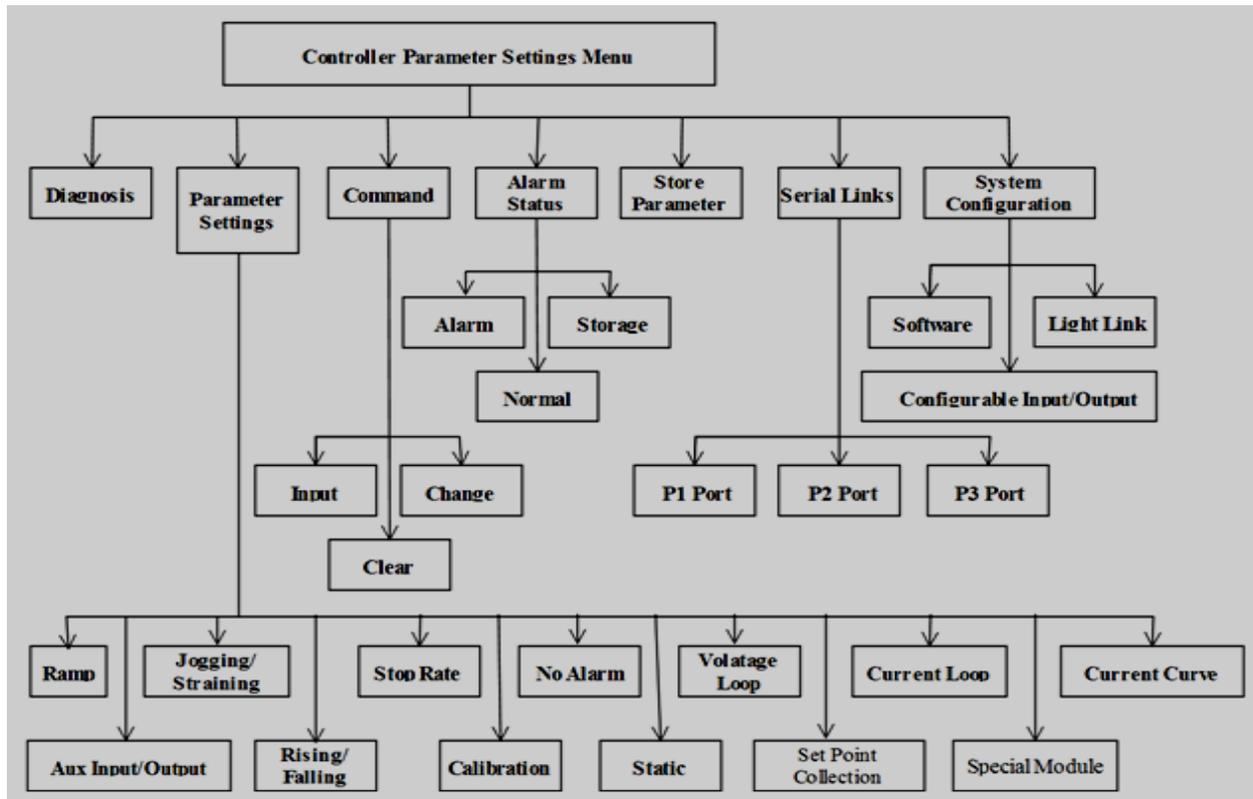


Figure 2. The menu of the controller parameter settings.

The current Loop can be set as the following parameters according to the actual situation:

Current limiting value, main current limitation, proportional gain, integration gain, automatic tuning, additional set value, bipolar clamp, forward current clamp, negative current clamp, the given current value isolation.

The voltage loop can be set as the following parameters according to actual situation: proportional gain, integration time constant, integration forbidden, feedback selection, ramp current gain, zero current level.

V. OPERATION OF CONTROLLER

A. There are four functional buttons on the panel

1), “M” is the menu selection button, which is the access to the menu and function, and will not change the parameters stored.

2), “E” represents escape, which allows users to select the menu forward, this will not change the parameters

stored.

3), “↑” is the upward button, which allows users to move to the forward menu, so as to find usable options.

4), “↓” is the downward button, which allows users to move to the next menu, so as to find usable options.

B. Controller needs the following inspection work before powered on

- 1), The voltage of the auxiliary power should be correct;
- 2), The voltage of the main power should be correct;
- 3), The rated output voltage and current should match with the load;
- 4), All external wiring: power wiring, control wiring, motor wiring should be correct.

C. Switch on the auxiliary power D7, D8

- 1), LCD displays text;
- 2), Measure with a digital voltmeter: C9 is positive 24 Volts; B3 is positive 10 Volts; B4 is negative 10 Volts.

- 3), Press button “M” to enter “MENU LEVEL”;
- 4), Operate “Upward” or “Downward” button to enter “SETUP PARAMETERS”;
- 5), Press “M” again to enter the menu of parameter settings, press “Upward” or “Downward” button to find different sub menus;
- 6), Enter relevant sub menus, and users can set corresponding parameter.

D. Parameter storage: Whenever, the parameters must be saved after the modification, so as not to lose

- 1), Press "M" to enter "SAVE PARAMETERS";
- 2), Press the "M" and display the "Up to Action";
- 3), Press the "rising" and display the "Saving" on the display screen to indicate that the system is storing data;
- 4), When the display of the "Finished", the data is stored.

E. Data Protection

To protect the security of the parameters, the controller is protected by the password. The operation of password are divided into three categories: enter password, clear password, change password. For example, the password stored in the controller is nonzero, the man-machine interface to access is restricted, and setting parameters can only be display but not be changed.

Enter the "input password" submenu, input password value, you can open the limit. The default value of the password is zero.

F. Instructions and monitoring

There are 6 LEDs as working indicator of the system in the controller panel; all the LEDs are bright under normal working conditions while the extinguished diode indicates the corresponding failure.

VI. CONCLUSIONS

The project has characteristics such as convenient, high efficiency, safe, stable, easy to learn , easy to use and so on. We use the method to update the new excitation system of synchronous motors such as 150 oxygen generators. After the installation and debugging, I delivered it to the user, and got good response that the effect was perfect. All the technical performances of the reorganizing excitation system have met with the designing requirement and related products have been put into production.

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