Study on Feedback Speed Control System of Hetero-Rotor Structures under Cloud Computing

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Abstract: The traditional speed control system has the problem of low operating efficiency. To solve this problem, a feedback speed control system with hetero-rotor structure in cloud computing environment is proposed. Based on the design of the hardware, the resonant principle is used to control the rotor loop current in a closed loop. Based on the design of the software, the concept of speed regulation integral and the control precision of the speed control system are introduced. Through the combination of software and hardware, the design of the feedback speed control system in the hetero-rotor structure under the cloud computing environment is completed. Experiments show that the proposed system is more efficient and more in line with the requirements of real working conditions.

1. Introduction

In recent years, more and more research has been done on speed control systems, and it has received great attention from the transportation department and the power sector. In particular, today's power industry is gradually relying on a combination of large-scale power generation and small-scale distributed power generation, which its core is a distributed power supply; among many power supply units, small and low-pollution gas turbines are the most commercially competitive equipment. However, the feedback control system of the hetero-rotor structure studied in the paper has important theoretical significance and practical application value. Therefore, this paper collects relevant data and conducts in-depth research to numerically simulate the hetero-rotor structure. Through the research of the subject, the research data of the better hetero-rotor structure is obtained, which lays a good foundation for the next experimental research [1-3].

The traditional rotor circuit and the additional potential of the rotor potential at the same frequency are to achieve the speed regulation of the motor by changing the potential amplitude and phase, but when the motor runs at low speed, the slip power in the rotor will be consumed on the rotor winding, which result in the motor operating efficiency is too low, since most of the slip power is absorbed by the additional potential that is transferred. In order to make the motor enter a new stable working state and improve its operating efficiency, a feedback speed control system with hetero-rotor structure in cloud computing environment is proposed [4-6].

2. Design of feedback speed control system in hetero-rotor structure

2.1 Hardware design

In the feedback speed control system of the hetero-rotor structure, the voltage of the IGBT is basically not changed when the IGBT is turned off; and the magnitude of the IGBT current changes with the change of the speed, especially in the high-speed section, the IGBT is turned off at a high current, which causes a large loss. At the same time, in the process of shutting down, it will also cause high voltage, which will cause the switch tube to break [7]. For this reason, the resonance principle in the design of the circuit is used to complete the energy transfer until the final feedback, so as to achieve lossless. The method does not need to increase the switching tube, and only needs to use the buffering element to form a waveform of the voltage and current during the switching process, and the angle can be shifted by a certain angle, so that reduce the loss of the switching tube.

The following is the working principle diagram of the feedback speed control system in the hetero-rotor structure, as shown in Figure 1.

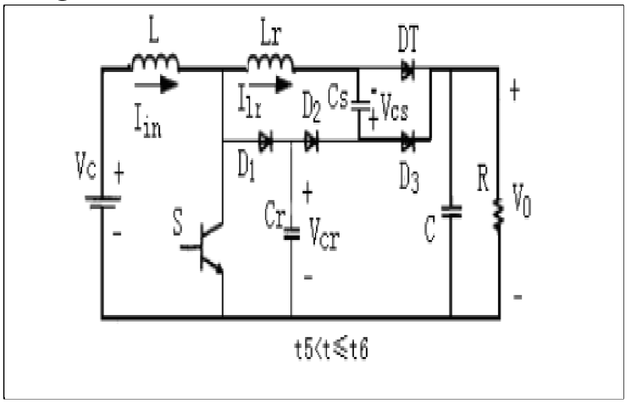

Figure 1. Working principle diagram of feedback speed control system in hetero-rotor structure

It can be seen from Fig. 1 that the schematic realizes the zero-current turn-on of the switching device s; at the same time, because of the presence of the auxiliary diodes $D1$, $D2$, $D3$, it can effectively ensure that the switching device s does not exceed the output voltage V_O when it is turned off. The inductor Lr in the figure provides a zero-voltage turn-off condition for the switching device s, and the capacitor C_s is a snubber capacitor. The circuit schematic divides it into seven operating modes, assuming that all components in the circuit are ideal components, then when the inductor L is large enough, the input current is constant I_{in}. If the output capacitor C is large enough, the output voltage is constant V_O [8]. In addition, the electrical performance parameters should also be considered, otherwise the final using effect will be affected. The electrical performance parameters are shown in table 1.

Table 1. Electrical performance parameter

parameter	symbol	Minimum value	Typical value	Maximum value	unit
Auxiliary supply voltage	*VP*	20	15	27	*V*
Input pulse voltage	*VPWN*	0	11	10	*V*
working frequency	*IPWM*	0	12	12	*MV*
Duty ratio	*FOP*	0	13	5.5	*KHZ*
Minimum working pulse width	δ	9	14	12	%
Protection interaction threshold	*TONMIN*	5	-	9	μS
Soft turn-off time	*VN*	1	-	-	*V*

In the feedback speed control system of the hetero-rotor structure designed in the paper, it is necessary to detect the current of the electronic rotor loop in order to control the closed loop of the electrode, which is also the most important in the whole system, and is related to the control precision of the speed control system. Therefore, the accuracy and speed requirements of the current detecting circuit are also improved. If ordinary current transformers are used, it is difficult to meet the requirements. For this reason, the LEM current sensor module can be used to detect signals from DC to AC of several hundred *KHZ*. The range of current measurement is 0-5A and the working voltage is 15V. After that, it will be sent to the PAO pin of the MCU, and the current feedback signal [9] will be generated by A/D conversion. The circuit diagram is shown in Figure 2.

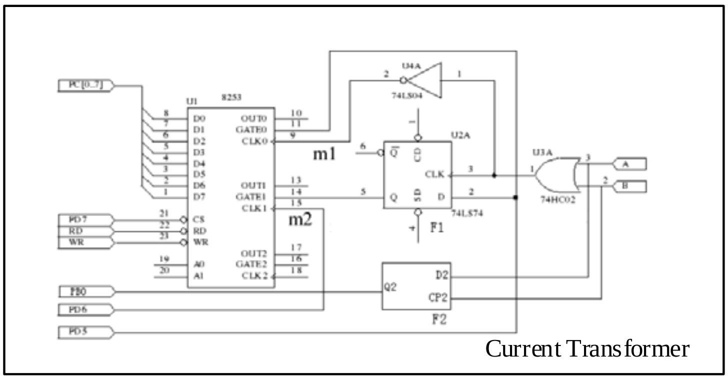

Figure 2. Current detection circuit

It should be noted that in order to ensure the regulation of the current loop, the current transformer cannot be saturated during the startup process, otherwise it will affect the control effect [10].

2.2 Software Design

In the design of the software, for the problem of the operating efficiency of the system, the hetero-rotor structure and the three Hall elements are symmetrically arranged at an interval of 120° from each other in space. On this basis, the analysis process is simplified in a hypothetical way, first, the motor core saturation is ignored, second, the armature reaction is not counted, and third, the cogging effect is ignored [11].

According to the above ideal assumptions, the feedback speed control equation in the different rotor structure is established in combination with the operating conditions. The equilibrium equation expression for the electrode is:

$$U = Iy + L\frac{di}{dt} \tag{1}$$

In the equation (1), U represents the winding phase voltage, i represents the winding phase current, d represents the winding self-inductance, L represents the winding mutual inductance, and y represents the differential operator. When the circuit is commutating, because the diode has the effect of freewheeling, there will be a current flow in the three-phase winding, but since the duration is short, the effective value of the electric quantity is relatively small, so in the process of steady state analysis, it should be ignored, which in order to simplify the calculation..

In order to adjust the characteristics of the motor, it is necessary to set the relationship between the speed of the motor and the U_d in a constant state and steady state operation.

The stability of the motor operation and the overshoot of the speed control system are important indicators for evaluating the quality of the feedback speed control system in a hetero-rotor structure. For this reason, it is necessary to obtain a given value that has not been reached in the early stage of adjustment according to formula (2), so that a large accumulated value is generated in the integral link, and it will increase with the accumulation of the integral link. When the output of the regulator reaches a certain range, or exceeds the upper and lower lines of the input signal of the actuator, the actuator will enter the saturation zone, and the amount of control required will not occur. It should be noted that the controller also takes a long time to exit the saturation zone, so during this period, the actuator will stay at the limit position and temporarily lose control. which indicates that the system has failed and needs to be processed in time. If the integral environment saturation occurs, it is necessary to introduce a shift integral to improve it. The basic idea of speed regulation integral is introduced, the cumulative speed of the original integral link is changed to adapt to the adjustment time, and the magnitude of the deviation is matched; if the final deviation value is large, it is necessary to slow down the accumulated acceleration of the integral link; If the deviation value is small, it is necessary to speed up the accumulative acceleration of the integral link, which not only can suppress the overshoot of the integral link, but also shorten the time of the speed regulation and effectively improve the precision of the control.

3. Experiment analysis

This experiment is to verify the application value of the feedback speed control system in the hetero-rotor structure under cloud computing environment. The traditional speed control system was set as the control group by numerical comparison. It is assumed that the feedback speed control system of the hetero-rotor structure in the cloud computing environment is the experimental group, and the effectiveness of the proposed system is verified by numerical comparison.

3.1 Experimental environment

In the process of experiments, the operating efficiency of the feedback speed control system in the hetero-rotor structure under the cloud computing environment was tested, and the Xicheng system development tool launched by Texas Instruments was used to test it. The rated voltage of the motor is $n_N = 3000r/\min$ during normal operation and the rated torque is $T = 0.4N \bullet M$.

3.2 Experimental results

The comparison results between the traditional speed control system and the operating efficiency of the feedback speed control system in the different rotor structure in the cloud computing environment are shown in Figure 3.

The operating efficiency between traditional speed control system and feedback speed control system is compared in different rotor structure under cloud computing environment, as shown in Figure 3.

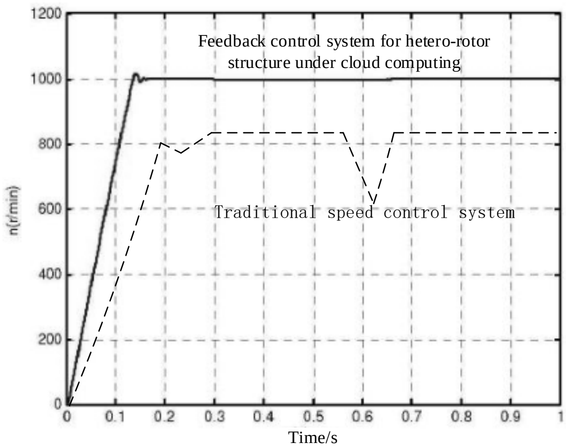

Fig.3 Experimental comparison result

It can be seen from the experimental comparison results of Fig. 3 that the commutation sequence of the three-phase windings of the electrodes adjusted by the conventional speed control system is abnormal, and the hysteresis of the driving signals and the disorder of the control signals occur, which causes the motor to be hindered during the operation and the system to run inefficiently. When the different rotor signals are collected by the feedback control system of the hetero-rotor structure under the cloud computing environment, the test results are consistent with the expected targets. The performance is very stable during high-precision sampling, and the performance is very stable under real working conditions without the phenomenon of signal disturbance.

4. Conclusion

A preliminary study on the traditional speed control system in the paper is conducted to design it according to the defects of the system. Aiming at the defects of the traditional speed control system, a feedback speed control system with hetero-rotor structure under cloud computing is proposed. The debugging work is carried out on the built-up hardware circuit. In addition, the control method of the hetero-rotor structure in the commutation process is also deeply analyzed. Based on this, the application speed and control strategy are proposed. Finally, the effectiveness of the feedback speed control system in the different rotor structure under cloud computing is proved by practice and experiments.

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