Research On Control Technology of Double Winding High Power Switched Reluctance Motor

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ABSTRACT

The research on the control technology of switched reluctance motor is a hot research at home and abroad, the motor power is relatively small we control technology is a relatively mature; but control for switched reluctance motor with high power, we should not only improve from the structure of the motor, but also to take into account the electromagnetic compatibility in the control box the problem. So we designed a double winding motor, and in the design of motor drive circuit, we use the optical drive.

INTRODUCTION

Switched reluctance motor (SRM) is widely used in household appliances, electric vehicles, aerospace and other fields because of its wide speed range, high system reliability and high starting torque. The research of switched reluctance motor control system in China started relatively late, and the technology of controlling high power switched reluctance motor is not very mature. High power switched reluctance motor has large winding current. When the speed is relatively high, its current change frequency is relatively high, and there is a large electromagnetic interference. The problem of electromagnetic compatibility should be considered in the design of drive control system. In this paper, low power switching control technique based on switched reluctance motor was improved...
through the optimization of control strategies to achieve improved control of high-power motor, and the motor has high torque, stable efficiency, meet the requirement of industrial applications, and the requirement of energy saving.

ANALYSIS OF STARTING OPERATION OF SWITCHED RELUCTANCE MOTOR

Switched reluctance motor always operates in the state of position feedback, and its starting is very simple[1]: three phase or three phase switched reluctance motor can start any rotor position in forward and reverse direction without auxiliary equipment. The good starting performance, such as large starting torque, small starting current and small starting current, is one of the advantages of switched reluctance motor.

For three-phase switched reluctance motor (SRM), there are two starting modes: one phase winding starting and Hybrid energized starting mode.

One Phase Winding Starting Mode

Figure 1 is the torque-angle characteristic of three phase winding.

\[ \theta_s \] is the intersection point of C and A. In order to obtain larger starting torque, when the rotor position is in the region from \( -15^\circ + \theta_s \) to \( \theta_s \), C is for electrical. When the \( \theta_s \) arrives, the switch is switched on to the A, and then, after each step, the switch is switched to the next one, so that the SR motor starts running.
Hybrid Energized Starting Mode

As shown in Figure 2, in this starting mode, the SR motor is sequentially energized according to the order of C-CA-A-AB-B-BC-C. Six shots for a round, each turn of electricity, the rotor rotation 45 degrees. Under this starting mode, the synthetic torque of the two phase intersections is greatly improved, and the load capacity is improved accordingly[2]. At the same time, the difference between the maximum starting torque and the minimum starting torque in this starting mode is reduced, and the starting process is relatively stable. Under a certain load torque, the current required for this starting method is smaller. It can be seen that the starting performance of this mode is much stronger than that of single-phase starting.

ANALYSIS OF VOLTAGE CHOPPER CONTROL MODE

Voltage chopping control realizes the control of switched reluctance motor by adjusting the winding voltage. The turn-on angle $\theta_{on}$ and the turn off angle $\theta_{off}$ are fixed under voltage chopping control. During switching phase, the switching device is controlled by adjusting the duty cycle of PWM, thus controlling the winding average voltage and winding current. When the PWM output is high, the switching device is connected, the winding is connected with positive pressure, and the current rises; when the PWM output is low, the switching device is turned off, the winding is connected with the negative pressure, and the current is decreased.

The current waveform of voltage chopping control is shown in figure 3.
In the same way, the voltage chopping control mode is divided into single chopper mode and double chopper mode according to the different switching modes of the power switch. When the voltage chopping is performed by double chopper mode, two power switching devices act at the same time, which increases the switching loss of the system, and the current drops rapidly, resulting in a larger torque ripple[3]. When the single chopper is used, only one of the two power switches in the main circuit is in the chopper state, and the other one is always on. Due to the long-term switching of a switching device, the loss is serious, affecting the consistency of switching devices. Figure 4 is an improved way that turns cut tube, two switching devices with one arm in a cycle of the opening turns each half cycle, another switching device for PWM chopper. In this way, the switching times of switching devices in a cycle are averaged to two switching devices, which reduces the loss of switching devices and increases the service life.

Figure 3. The current waveform under CVC mode.

Figure 4. PWM waveform of voltage chopping method.
SIMULATION OF VOLTAGE CHOPPING CONTROL

As shown in Figure 5, a voltage chopping control model built in Matlab/Simulink is presented. The model mainly includes power converter model, motor body model, voltage PWM generation module, position signal generation module and so on. The motor speed control system adopts the current speed double closed loop regulation mode.

![Figure 5. The model of voltage chopping control method.](image)

In the simulation model, the given target parameter is 2500 rpm, the load torque is $10 \text{ N} \cdot \text{m}$, the turn-on turn off angle is not ahead of time, that is, open at 0 degrees and turn off at 22.5 degrees.

The simulation waveform of voltage chopping control are shown in figure 6. It can be seen that the torque peak is about $85 \text{ N} \cdot \text{m}$ at the start time and has a great torque ripple; when the motor is low speed, the peak current is large, the maximum can reach 38A; the maximum speed is up to about 1350 rpm. These waveform are in line with the characteristics of voltage chopper control. It can be seen that the speed regulation system controlled by voltage chopper is not satisfactory. When the motor is in low speed, there is a large current peak and the torque ripple is obvious, so it is necessary to add current chopping control.

![Waveforms](image)

a. The torque waveform  
b. The current waveform
SIMULATION OF VOLTAGE CHOPPING COMBINED WITH CURRENT CHOPPING CONTROL

Figure 7 is a control model of speed regulation system combining voltage chopping control mode and current chopping control mode. On the basis of the voltage chopper control model, the current chopper module is added.

Figure 7. The combination of voltage chopping and current chopping control module.

The current chopper module is set to 18A, and the other given parameters remain unchanged. The simulation results are shown in figure 8.

It can be seen from the diagram that the torque waveform controlled by voltage chopping combined with current chopping is more stable than that by single voltage chopper, and the torque ripple is smaller than that by single voltage chopper. Due to the existence of current chopping, the original current spike is flattened near 18A, showing flat topped waveform, which effectively suppresses the problem that the current peak is too large at low speed, but the speed is still not improved. The characteristics of current chopping control mode are verified: it is suitable for low speed operation of motor, and the torque is relatively stable.
CONCLUSIONS

The design of this study, combined with the control method of switched reluctance motor single winding small power, on the basis of the control strategy was optimized by simulation analysis can separate voltage chopping control although there is a certain effect, but there still exist some problems in current chopping control; adding after we can see that the torque ripple relatively small, the peak current is relatively small.

REFERENCES