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Research on Efficiency Control of Direct Drive Switched Reluctance Generator

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Abstract:

Aiming at the problems of single rotor rotation and low efficiency of the existing switched reluctance generator and the problems of high noise and high vibration of the generator, a new deflectable double stator Switched Reluctance Wind generator is proposed. The generator adopts inner and outer double stator structure, and the hydraulic console is connected on both sides of the rotor, which can realize multi degree of freedom deflection, adapt to different wind directions and apply to all kinds of wind power generation occasions; The temperature rise, stress and vibration displacement are obtained through the simulation calculation of magnetic thermal solid coupling field. A nonlinear simplified mathematical model is established to analyze the loss. The main loss of the motor, namely copper loss, is minimized by minimizing the effective value of phase current. The combination of on angle and off angle with minimum phase current effective value, minimum copper consumption and optimal efficiency is obtained to improve the generator operation efficiency and power density. The effectiveness of the proposed optimization method is verified by comparing the operation performance of switched reluctance generator before and after optimization.

Keywords*: alternator; Switched reluctance; Vibration displacement.*

I. INTRODUCTION

Switched Reluctance Wind turbine has the advantages of simple and compact structure, convenient maintenance, low starting wind speed, stable output power and so on. The generator with double stator structure has fast response, high-precision positioning and strong overload capacity. Its working efficiency can be greatly improved when the generator body structure and external wind speed are certain. Literature introduces the structural types [1-3], research status and development trend of double stator motor at home and abroad; A new type of double stator low-speed rare earth permanent magnet synchronous generator is proposed in reference [4-6], and it is concluded that the generator with double stator structure is better than that with single stator structure in output characteristics; Reference [7] proposes a three degree of freedom motor driven by permanent magnet composite, which improves the torque characteristics of the motor and has the advantages of high efficiency and flexibility compared with the previous deflectable multi degree of freedom motor [8-11]. Before the 1970s, the research on the temperature rise of motor mainly focused on the simplified formula of motor, which has poor

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calculation accuracy and can only calculate the average temperature rise of motor, which can not meet the design needs. Reference [12] establishes a three-dimensional equivalent thermal network model based on the traditional motor temperature rise thermal circuit model, which provides a basis for the temperature rise calculation of switched reluctance motor. However, in order to improve the calculation accuracy, the number of network nodes and thermal resistance must be increased, which greatly increases the workload. In recent years, some scholars use the finite element method to carry out thermal analysis, transfer the research object from the overall to the local element, and solve the heat conduction equation [13], so that each local element in the whole calculation area can obtain reliable calculation data, so as to guide the design of motor more accurately and reasonably.

At present, scholars at home and abroad have also put forward many methods to suppress voltage ripple. Reference [14] suppresses the output voltage ripple by optimizing the capacitor filter at the output of the power converter and combining with the voltage feedback regulator. However, the high-capacity capacitor required by this method is expensive and increases the complexity of the circuit, which will bring certain engineering difficulties to the later popularization and application. Literature [15] uses adaptive genetic angle control algorithm to adjust the output voltage. The programming implementation of this method is complex, and the search speed of this algorithm is relatively slow. It takes a long training time to obtain more accurate control quantity. Reference [16] uses fuzzy control to obtain the angle compensation, and then changes the excitation time of the motor. Because the design of fuzzy controller mainly depends on experience and does not have integral link, the steady-state accuracy is not high. Reference [17] adopts fuzzy sliding mode control to compensate the current loop by adjusting the conduction angle to control the output voltage. The sliding mode gain is selected by one-dimensional fuzzy controller, the control accuracy needs to be improved, and the diversity of SRG control parameters is not fully utilized. Reference [18] proposed a pulse sequence control method based on capacitive current, which comprehensively considers the capacitive current and output voltage to form a pulse sequence to control the on-off of the switch. This control method reduces the ripple of output voltage to a certain extent, but does not consider the rapidity of SRG voltage building. Reference [19] uses the current distribution function to reasonably distribute the current of each phase in the commutation section, so as to reduce the pulsation of the output voltage, but the anti disturbance ability of the system is not strong.

II. STRUCTURE AND MODELING PARAMETERS OF SWITCHED RELUCTANCE GENERATOR

2.1 Modeling parameters of generator

According to the structure of the generator body, it can be approximately regarded as composed of two internal and external generators, that is, an internal rotor switched reluctance generator composed of an external stator and an internal rotor, and an external rotor switched reluctance generator composed of an internal stator and an external rotor. Two sets of motor systems are integrated in the space to connect the inner stator windings (D, E, F) and outer stator windings (A, B, C). The inner and outer motors are

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independent of each other and can be controlled to work in different states.

The conduction angle of the control circuit is adjusted by the structural parameters, and the counterclockwise direction is specified as the positive direction of motor rotation. When the rotor position is within the range of (17.5 ° - 27.5 °), the d-phase winding of the inner stator is connected; When the rotor position is within the range of (25 ° - 35 °), the B-phase winding of the outer stator is connected. In this paper, the rotor position angle is selected as 38 °. At this time, the rotor is in the middle position relative to the outer stator, that is, when the tooth poles of the rotor and the tooth poles of the outer stator partially coincide, the d-phase winding of the inner stator and the B-phase winding of the outer stator are in the state of simultaneous power generation. Wherein, the generating current of phase B winding is 25 A.

2.2 Theoretical analysis of magnetic field heat source

Switched reluctance motor allows two-way flow of energy. It can be used as both motor and generator. It has the special advantages of low manufacturing cost, high power density, strong fault tolerance, stepless speed regulation, four quadrant operation and working in harsh environment [20], It has been applied in many occasions of speed regulation and transmission. Switched reluctance generator has high energy density and good power quality when generating power at high speed. It is suitable for hybrid power, aerospace, wind power and other fields. At present, the efficiency of switched reluctance generator is excellent.

In this paper, the six phase 12 / 10 switched reluctance generator is taken as the research object, the optimal efficiency and minimum loss are taken as the control objectives, and the excitation parameters with the minimum effective value of phase current are optimized in the range above the base speed. The control strategy is verified by simulation experiments to achieve the control objectives.

III. CONCLUSION

Based on the electromagnetic field temperature field stress field module, the temperature rise of the generator is analyzed. The stress and corresponding vibration displacement of the stator system caused by loss as the heat source and thermal expansion are analyzed. The results show that their values are small and have no impact on the normal operation of the generator; Compared with other parts of the stator structure, the stress on the stator yoke and stator teeth in the stator structure is larger.

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