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Permanent magnet synchronous motor direct torque control system

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Abstract: This paper mainly summarizes the development and application of permanent magnet synchronous motor and its speed control system, and establishes the mathematical model of permanent magnet synchronous motor in different coordinate systems, and the torque of the direct torque control speed control system of permanent magnet synchronous motor. The pulsation was divided, designed and improved. The generation of the suppression torque ripple is achieved by introducing vector control. At the same time, the traditional direct torque control system and the improved vector control based direct torque control system are simulated and compared. It is concluded that the improved system can effectively suppress the generation of torque ripple, which proves that the design of this paper is correct and reasonable. Finally, the improved control system is based on DSP-based hardware electric cheese design, further Improve this paper.
Keywords: PMSM, DSP, System.

1. INTRODUCTION

With the continuous development of power electronics technology, motors are also making continuous progress in design optimization, control strategies, and control methods. As new types of permanent magnet materials continue to emerge, the performance of permanent magnet synchronous motors is gradually increasing. Permanent magnet synchronous motors have become the research hotspots of domestic and foreign experts because of their high energy specific density, high reliability and small moment of inertia, which can greatly improve the performance of ships and automobiles. And in today's increasingly mature control technology, the performance indicators of permanent magnet synchronous motors have not lost to DC motors. Compared with developed countries such as the United States, Germany and Japan, China is still at a disadvantage in terms of manufacturing and control technology of electric motors, and there are many technical gaps. However, it is well known that China has a large reserves of rare earth materials, as long as it can break the monopoly of foreign technology, it will be able to obtain great advantages in the research and application of permanent magnet synchronous motors.

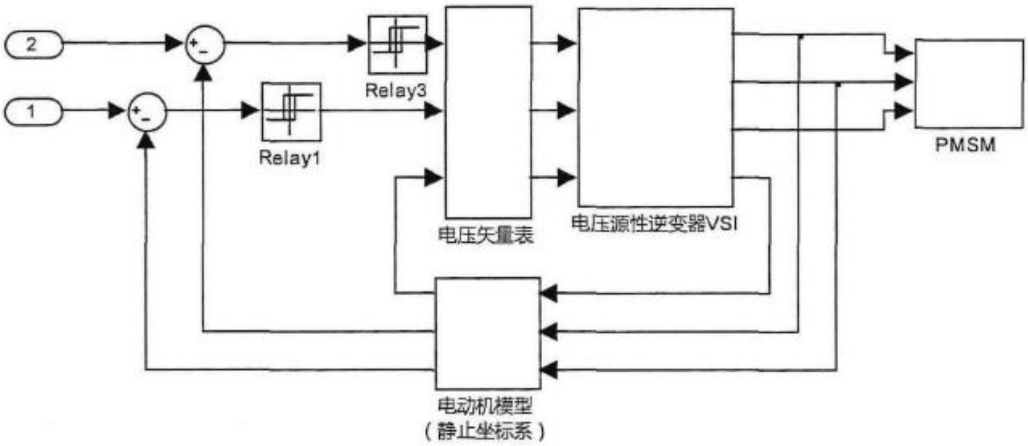

Fig 1.1 Principle diagram of permanent magnet synchronous motor direct torque control system

The application process of direct torque control technology (DTC) and vector control is quite similar. Firstly, it is applied to asynchronous motors. Later, it is gradually extended to the control of field weakening control and synchronous motor [1]. The direct torque control speed control system of permanent magnet synchronous motor is shown in Figure 1.1. From the perspective of system structure, it is similar to the direct torque control of asynchronous motor. The direct torque control technology of the permanent magnet synchronous motor controls the stator magnetic field and torque of the motor through the voltage space vector generated by the inverter.

2. Structure and Dynamic Mathematical Model of Permanent Magnet Synchronous Motor

2.1 Construction of permanent magnet synchronous motor

The schematic diagram of the permanent magnet synchronous motor is shown in Figure 2.1, which mainly includes the base, the stator core, the stator winding, the rotor core, the permanent magnet, the rotor shaft, the bearing and the motor end cover, etc., in addition to the rotor support member and the vent hole. Or cooling water channels, external junction boxes, etc[2].

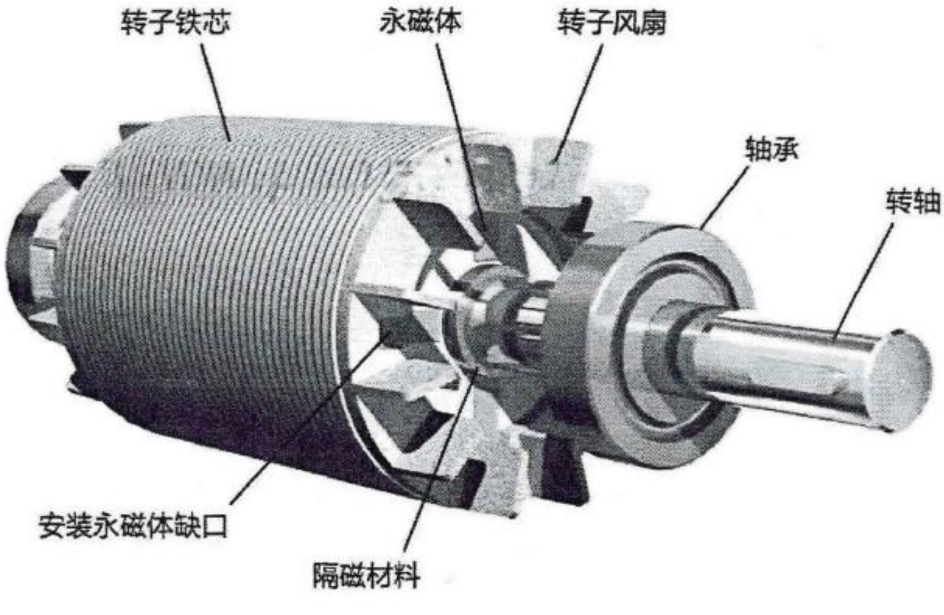

Fig 2.1 Schematic diagram of permanent magnet synchronous motor

The SPM rotor structure in Fig.2.2 is characterized in that the permanent magnet is attached to the outer side of the circular iron of the rotor; since the relative magnetic permeability of the permanent magnet material is close to 1, the effective air gap length is the air gap and the radial direction. The sum of the thicknesses of the permanent magnets; the magnetic circuit of the cross-axis is basically symmetrical, and the salient pole rate of the motor is p=Lq/Ld=l, so SPM is a typical hidden pole motor with no salient pole effect and reluctance path torque. This type of motor is easily demagnetized because the permanent magnet is directly exposed to the air gap magnetic field, and the weak magnetic energy is limited. However, because of its simple manufacturing process, low cost and wide application, it is especially suitable for brushless DC motor [3].

The permanent magnet of the built-in permanent magnet synchronous motor (IPM) is buried inside the rotor iron, and its outer surface and air gap are There is ferromagnetic material between them, the permanent magnet is protected by the pole piece; the q-axis inductance is larger than the d-axis inductance, which is beneficial to the weak magnetic speed increase, and the permanent magnet is in the rotor shovel and the inside, and the structure is firm, which can improve the safety of the high-speed rotation of the motor[4].

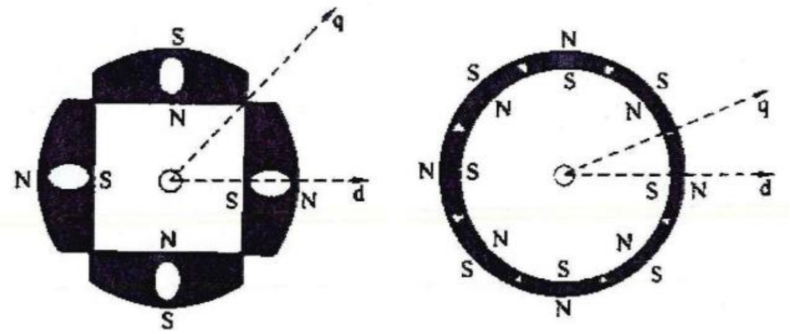

Fig.2.2 Typical SPM permanent magnet motor

2.2 The basic working principle of permanent magnet synchronous motor

The work of the PMSM is achieved by the interaction of the current between the stator and the magnetic field in the rotor. Therefore, the effect of the force between the stator winding and the permanent magnet rotor and the salient pole rotor is mainly analyzed here.

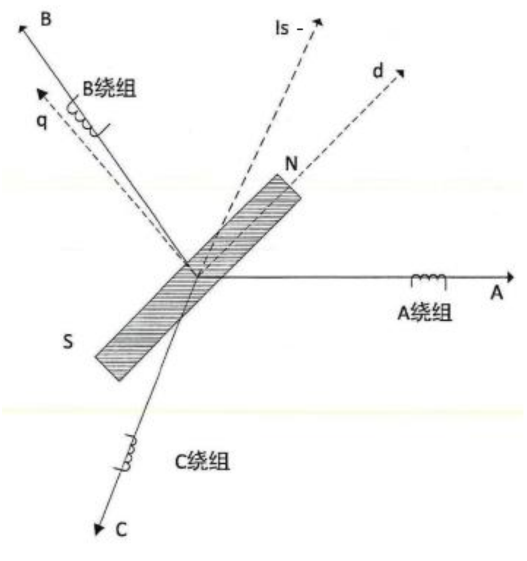

Fig. 2.3 Schematic diagram of stator magnetic field and rotor magnet

It can be seen from Fig. 2.3 that in the case where the rotor of the PMSM is stationary, the permanent magnet generates a DC magnetic field in the direction of the d-axis as shown in the figure, because the rotor is stationary at this time, and the magnetic field is still in space. A magnetic field is also generated after the current is supplied to the stator winding, and at this time, different magnetic field positions can be obtained by simply controlling the magnitude of the current flowing in. A force is generated between the two magnetic fields. And because the stator is fixed, the rotor is not fixed. Under the above force, the rotor will start to rotate.

The presence of the salient poles of the PMSM rotor complicates the magnetic field of the motor. For convenience of explanation, in Fig.2.3, it is assumed that the magnetic field of the salient pole rotor is distributed on two axes - the d-axis and the q-axis, and the stator winding is also replaced. A d-axis winding (D in the figure, with two terminals, the current direction is positive in the figure). When the d-axis current id and the q-axis current iq of the stator winding are excited in the magnetic paths of the d-axis and the q-axis, respectively, the magnetic flux Φq of the d-axis is generated. The force between the stator winding and the salient rotor is mutual, and the force of the rotor can be calculated by analyzing the force of the stator winding.

3. EQUIVALENT CIRCUIT DIAGRAM OF PERMANENT MAGNET SYNCHRONOUS MOTOR

Figure 3.1 and Figure 3.2 show the dynamic circuit of the PMSM on the d-axis and the q-axis, respectively. The voltage equation and the excitation equation are embodied in the circuit[5].

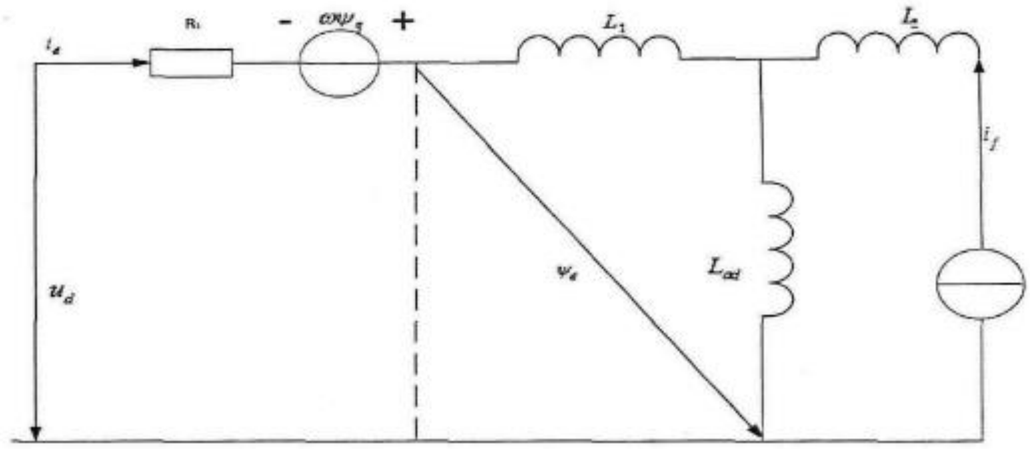

Fig 3.1 D-axis dynamic equivalent circuit of PMSM

In the d-axis equivalent circuit of Fig 3.1, the stator side has a rotational electromotive force, the rotor side has an exciting current, and the permanent magnet and the stator d-axis armature reaction magnetic field together constitute an air gap magnetic field.

The q-axis rotational electromotive force is on the stator side, and the q-axis air gap magnetic field has no permanent magnet participation, and is only composed of the q-axis stator armature's own reaction magnetic field. The equivalent circuit is shown in Fig 3.2.

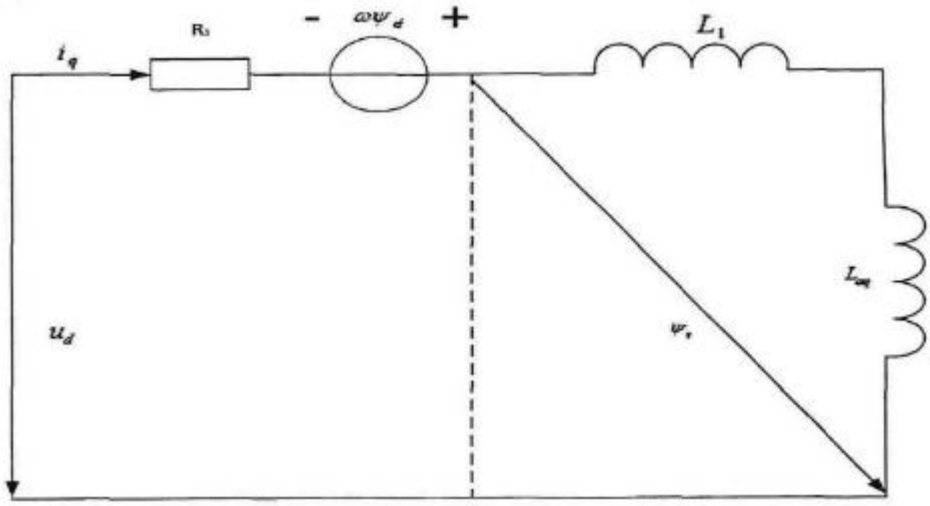

Fig 3.2 Q-axis dynamic equivalent circuit of PMSM

When the PMSM is in steady state operation, the current, flux linkage and voltage of the dq axis are constant values, and both ends of the dotted line in Fig 3.1 and Fig 3.1 are equipotential.

4. CONCLUSION

In the development of today's society, permanent magnet synchronous motors are playing an irreplaceable role with their unique advantages, so they are receiving more and more attention from all walks of life. The research and development of the permanent magnet synchronous motor speed control system has also changed. It is getting hotter and hotter. Since the direct torque control system proposed by German and Japanese scholars, the research and development of direct torque control system has attracted more and more attention, but the problems of torque ripple and low speed performance still exist. Experts from various countries have also done a lot of research and experiments to solve these problems. This paper puts forward some improvement measures based on the previous research and the analysis of the structure and operation principle of permanent magnet synchronous motor and the reasons for these problems.

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