Direct Self-Control Strategy for Axial Flux Ironless Permanent Magnet Synchronous Motors Based on Duty Ratio Control

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ABSTRACT

Axial flux ironless permanent magnetic synchronous motor (AFIPMSM) is a new permanent magnetic motor. It has many advantages, such as high torque-to-weight ratio, good efficiency, no cogging torque, and the sinusoidal back EMF. It gradually becomes the good choice in drive system. However, the small armature winding inductance causes the current is not continued with the PWM control based on VSI, it is a fatal shortcoming of the motor on the control. To solve this problem, a novel automatic control method based on a modified dc-dc converter is used to regulate the current. And the torque control rule is proposed to ensure the tracking of the torque-producing current of the AFIPMSM to the commanded value according to the motor rotor position under all operating conditions. Simulation and experimental results confirm the validity of the proposed control method.

Keywords: Automatic Control Strategy of Torque, Axial Flux Ironless Permanent Magnetic Synchronous Motor (AFIPMSM), DC-DC Converter, Disc Coreless, Permanent Magnet Synchronous Motor (PMSM)

1. INTRODUCTION

Axial flux ironless permanent magnetic synchronous motor (AFIPMSM) is a new type of high performance servo motor developing in recent years. The AFIPMSM with outer rotor introduced in this paper is shown in Figure 1 (a), which has two disc rotors and a winding with ironless stator. The two disc shaped rotors carry the axially magnetized NdFeB magnets which are mounted axially on the inner surfaces of the two rotor discs. Halbach array were used in the
rotor, and the flux density in circumferential direction is approximate sinusoidal distribution, which makes the back-EMF is sine. The waveforms of no-load back EMF is shown in Figure 1 (b).

Because of the ironless structure, there is no tooth or slot in the stator of the motor. The stator structure can not only eliminate cogging torque and reluctance torque, but also the quality of the motor has been reduced. And the motor’s efficiency is increased, because there have no iron losses in it. The parameters are linear for the magnet medium of AFIPMSM is almost air. The armature reaction is so small that the effect to no-load magnetic field may be neglected. Compared with the conventional motors with iron core, AFIPMSM have the advantages of high power density, small size, high overload capability, efficiency, no cogging torque and so on. Since it has the characteristics of the flat structure, particularly suitable for the workplace where have special requirements of the volume of motor (Wang Xiaoyuan, Chen Jing, Wang Pingxin, 2010; Xiaoyuan Wang, & Jingjuan Du, 2006). Based on the AFIPMSM has the advantages of the above, most studies for Axial flux ironless permanent magnetic synchronous machines focus on the electromagnetic aspects of analysis, optimization, design and the characterization of axial flux generator (A. Mahmoudi, S. Kahourzade, N. A. Rahim, and H. W. Ping, 2012; T. F. Chan, and L. L. Lai, 2007; S. Javadi and M. Mirsalim, 2008; W. Fei, P. C. K. Luk, and T. S. El-Hasan, 2011; S. M. Hosseini, M. Agha-Mirsalim, and M. Mirzaei, 2008; R. J. Wang, M. J. Kamper, K. V. Westhuizen, and J. F. Gieras, 2005; F. Sahin, A. M. Tuckey, and A. J. A. Vandeput, 2001; R. J. Hill-Cottingham, P. C. Coles, J. F. Eastham, F. Profumo, A. Tenconi, and G. Gianolio, 2002).

However, as the coreless structure, the value of winding inductance is very small, which makes the winding current cannot be continued with the PWM control based on VSI, resulting

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Figure 1. Basic structure and the wave of Back EMF
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