Shielding Cylinder Effect in High-Speed Electric Machines

B. Hannon[1], P. Sergeant[1]

[1]Ghent University, Ghent, Belgium

Abstract

In the field of electric machines, a trend towards both higher efficiency and higher power density is observed. This has led to a growing importance of Permanent Magnet Synchronous Machines (PMSMs). However, the magnets used in these machines risk demagnetization at high temperatures. Especially in machines operated at very high speeds, where cooling of the rotor is difficult and the importance of induced currents in the magnets grows, demagnetization is a major concern.

A commonly proposed solution is the shielding cylinder, a conductive sleeve wrapped around the magnets [1], [2]. At the one hand eddy currents are induced in this shielding cylinder, resulting in additional loss. But at the other hand unwanted harmonics in the rotor field are suppressed by the shielding cylinder's magnetic field, reducing the rotor's eddy-current losses. Intuitively, it is expected that at low rotational speeds the additional losses in the shielding cylinder will dominate the overall gain in the rotor. Indeed, at low frequencies the penetration depth will be very high and the shielding effect will be negligible. The full paper will present a quantitative analysis of the relation between rotational speed and loss reduction.

The analysis was performed in COMSOL Multiphysics® using the Rotating Machinery interface to model a 5 kW slotted high-speed PMSM with shielding cylinder. This model was then used to compute the losses in the shielding cylinder and the magnets at various speeds (5000 - 100000 rpm) and shielding cylinder conductivities (0 - 5.107 S/m). While constructing the model a net current equaling 0 was enforced in the magnets via a single turn coil domain. The currents imposed in the windings were chosen to be sinusoidal and their phase was chosen such that the power factor approximates 1. Lastly, integration variables were used to compute the average electromotive force (EMF) in every slot. These values were then combined to calculate the EMF per phase.

Reference

[1] Fengzheng Zhou et al. “Study of Retaining Sleeve and Conductive Shield and Their Influence on Rotor Loss in High-Speed PM BLDC Motors”, IEEE Trans. on Magn., vol. 42, no. 10, pp. 3398-3400, Oct. 2006
[2] Shuangxia Niu et al. “Eddy Current Reduction in High-Speed Machines and Eddy Current Loss Analysis With Multislice Time-Stepping Finite-Element Method”, IEEE Trans. on Magn., vol. 48, no. 2, pp. 1007-1010, Febr. 2012