MT 26
International Conference on Magnet Technology
Vancouver, Canada | 2019

Contribution ID: **1086** Type: **Poster Presentation**

Wed-Mo-Po3.05-03 [30]: Design and Analysis of High-Speed Permanent Magnet Synchronous Generator Considering Rotor Structure

Wednesday, 25 September 2019 09:30 (1h 45m)

Owing to their many advantages, such as high efficiency, high power density, simple mechanical construction, no excitation loss, and good reliability, high-speed permanent magnet synchronous generators (PMSGs) are gaining considerable attention from academia as well as industry worldwide. Because of the high-magnitude centrifugal forces that are exerted on the permanent magnets (PMs) in high-speed PMSGs, a robust rigid rotor construction is paramount. In particular, to protect the PMs in the rotor, the surface of rotor is coated with a retaining sleeve constructed from either an alloy or carbon fiber. Furthermore, a high-strength material is used for the shaft coupling component of the PMSG because of the stiffness of the shaft. Nevertheless, because this high-strength material might possess magnetic properties itself, it can influence the electromagnetic characteristics in the end effect. Moreover, the winding reactance includes significant leakage reactance because of the robust rigid rotor structure. Therefore, it is important to accurately calculate the total leakage reactance for the electromagnetic evaluation of high-speed PMSGs. In this study, an accurate analysis to determine the electromagnetic parameters of high-speed PMSGs is proposed; in addition, the influence of the rotor structure on the electromagnetic performance of these generators is analyzed. Because finite element (FE) analyses capable of solving transient models that include rotational and external circuits are now widely available, using these advanced computational methods, it is possible to determine the electromagnetic performance of the generators considering realistic features such as saturation, magnet segmentation, and end effects. In particular, in contrast to the existing 2D FE analysis approach, the electromagnetic parameters that are influenced by the rotor structure have also been identified and included in our proposed approach to accurately predict the electromagnetic performance of high-speed PMSGs. Finally, the efficacy of the proposed method is evaluated using 3D FE analysis and experimental verification.

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Session Classification: Wed-Mo-Po3.05 - Generators I