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A Two-dimensional Equivalent Mode of a Homopolar Synchronous Machine

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Homopolar synchronous machine (HSM) has a solid rotor with no permanent magnet, winding and any other components. Therefore, the HSM has the merits of high speed operation, high energy storage density, brushless excitation, reliable structure, etc. However, when the HSM is analyzed and optimized by finite element analysis (FEA), the 3-D magnetic flux distribution in the HSM leads to the great demands on the computation resource and time. In order to solve the aforementioned problem and simplify the analysis, a 2-D equivalent mode is proposed in this work. Firstly, the method of air-gap flux density spatial overlay analysis is proposed and illustrated. Afterward, based on the above analysis, the structure and equivalent principle of 3-D to 2-D mode are investigated, such as the rotor structure, the value of exciting current, and so on. Finally, the air-gap flux density and back electromotive force of 2-D mode and corresponding 3-D mode are calculated by FEA. An experimental platform of HSM is also constructed to validate the proposed 2-D mode. The simulation and experimental results show that the proposed 2-D model can be equivalent to the 3-D HSM, which would be helpful for the design and optimization of this kind of machine.

Submitters Country

China

Author: Mr YANG, Jiangtao (Huazhong University of Science and Technology)

Co-authors: Mr YE, Caiyong (Huazhong University of Science and Technology); Mr XIN, Liang (Huazhong University of Science and Technology); Mr XU, Wei (Huazhong University of Science and Technology)

Presenter: Mr XIN, Liang (Huazhong University of Science and Technology)

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