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补偿磁路对永磁涡流限速器的制动性能影响研究

摘要

对于高温气冷堆控制棒落棒限速系统，提出了一种新型永磁涡流限速器，其输出的阻尼转矩具有在宽温度范围内对运行温度不敏感的优点。通过采用铁镍合金材料的永磁体包壳，建立了一条补偿磁分路，以抑制永磁体剩磁和导体盘电导率的负温度敏感性对阻尼转矩的不利影响。基于三维有限元仿真方法，验证了补偿磁分路对转矩的运行温度敏感性的抑制作用，并研究了结构参数的影响。此外，在不同的转速和运行温度范围内，对于应用补偿包壳的永磁涡流限速器开展了系列实验。实验结果验证了仿真模型的准确性，实测的转矩温度敏感性小于 0.023%/◦C。本研究对于同类装置提高宽运行温度范围内的转矩稳定性具有重要意义。

关键词

涡流制动器，有限元分析，磁路，敏感性分析，温度补偿

Abstract

A novel permanent magnet eddy current retarder (PMECR), with a characteristic of temperature-insensitive damping torque over a wide range of operating temperatures, is proposed for speed limit systems. A compensating magnetic shunt is accomplished by utilizing the magnet cladding composed of iron–nickel (Fe–Ni) alloy, and it is used to equalize the adverse effects of temperature sensitivity of the magnet remanence and the conductor disk conductivity on damping torque. Based on the 3-D finite element method, the suppression effect of compensating magnetic shunt design on the sensitivity of torque to operating temperature has been verified, and the influence of main structural parameters is studied. Moreover, experiments with different compensation structures are conducted, varying the rotational speed and changing the operating temperature within the range of 20 ◦C–150 ◦C. The experimental results validate the accuracy of the simulation model, and the achieved quantitative indicator of torque temperature sensitivity is less than 0.023%/◦C. Additionally, compensating capabilities are determined for the potential range of cladding thickness in engineering. With the compensating magnetic shunt, similar devices can maintain torque stability with the dynamic wide change of the operating temperature.

Keywords

Eddy current brake, finite element analysis, magnetic shunt, sensitivity analysis, temperature compensation

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