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ORIGINAL ARTICLE

Increasing flux density by HTS shielding pellet in superconducting synchronous machine based on flux concentration

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Abstract In this paper, we propose a solution which enhances the performance of the inductor in high-power superconducting synchronous machines based on the flux concentration while keeping the same topology and using a high temperature superconducting shielding pellet located between the two coils of the inductor. This pellet permits to recover the magnetic field which vanishes in the medium region due to the opposite direction of the coils. A method for 3D magnetostatic field analysis using the control volume method with unstructured grid is proposed. With this topology, we have obtained a maximum efficiency of about 8 % in the flux density.

Keywords Control volume method · Flux concentration · HTS shielding pellet · Superconducting synchronous machines

1 Introduction

High-temperature superconductors (HTS) have created the opportunities for a great leap forward in the technology of large electrical machines. HTS motors and generators will operate as conventional machines and became smaller, lighter, more efficient, and less expensive to manufacture (Kalsi 2002). Most of classical superconducting motors have been designed for marine propulsion and wind power system, with a classical geometry using superconducting inductor with the same cryogenic solutions (Tixador et al. 1999). Complex topologies have been suggested for superconducting low-power motors based on axial high flux density and complex design as for general aviation aircraft (Masson et al. 2007a).

The high-power HTS synchronous machines based on the flux concentration show satisfactory results on the load test to provide best performances with NbTi wires (Ailam et al. 2007; Masson et al. 2003). In the same way, a modification of HTS shield length should decrease the magnetic flux concentration.

To increase the power in these types of machines, several ways are proposed. The first evident solution suggests new superconducting wires with higher current density possibility, the second one consists in a biggest inductor radius dimension, and the third alternative is to explore a long inductor length (Moulin et al. 2010; Masson et al. 2007b; Masson and Luongo 2005).

In this work, we propose a solution which increases the flux density by using a HTS shielding pellet between the two coils of the inductor. The introduction of this pellet enhances the performance of the inductor while keeping the same geometry as in the original topology. This pellet permits to recover the magnetic field which vanishes in the medium region due to the opposite direction of coils. A three dimensional (3D) magnetostatic field analysis using the control volume method (CVM) with unstructured grid is proposed.

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