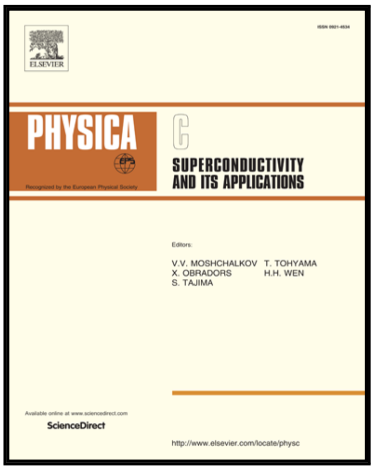

Pulsed Field Magnetization Strategies and the Field Poles Composition in a Bulk-type Superconducting Motor

Zhen Huang, H.S. Ruiz, T.A. Coombs

PII: S0921-4534(17)30030-8
DOI: 10.1016/j.physc.2017.01.004
Reference: PHYSC 1253125

To appear in: *Physica C: Superconductivity and its applications*

Received date: 30 September 2016
Revised date: 15 December 2016
Accepted date: 22 January 2017

HIGHLIGHTS

- High temperature superconducting (HTS) bulks offer the potential of trapping and maintaining much higher magnetic loading level compared with the conventional permanent magnets used in rotary machines, although the effective magnetization of multiple HTS bulks with different relative orientations over the surface of cylindrical rotors creates new challenges. In this paper, we present the design and numerical validation of the Pulse Field Magnetization (PFM) strategy considered for the magnetization of the four-pole synchronous fully superconducting motor developed at the University of Cambridge. Different compositions of the magnetic poles have been obtained depending on the relative orientation of the magnetizing coil and the surfaces of the columns of bulks that conform a magnetic pole. For the first PFM strategy, the experimental measurements have shown that only six out of fifteen columns of five HTS bulks each, have been magnetized along the radial direction. Thus, in order to explain these observations, two bidimensional models accounting for the electromagnetic response of the top and lateral cross sections of three columns of HTS bulks subjected to multiple pulsed magnetic fields, and after the thermal relaxation of the entire system, have been created. Both models are built in COMSOL Multiphysics, based upon the so-called H-Formulation for the solution of the Maxwell equations over the superconducting domains, and the Fourier's heat transfer equation for accounting the typical pool boiling characteristics of the liquid nitrogen over their surfaces. Our numerical results have shown an excellent agreement with the experimental observations, revealing the occurrence of a nearly orthogonal distribution of current profiles in the outer columns of a three column pole, this regarding the main direction of the magnetization in the central column which is directly subjected to the PFM. Then, in order to maximize the magnetized area of the four-pole superconducting rotor taking advantage of the whole number of HTS bulks, an extended PFM strategy has been proposed by considering the magnetization of at least three successive columns of HTS bulks per pole. In the extended PFM strategy although the area of each one of the poles can be seen increased by a factor of 200%-400%, the maximum peaks of trapped magnetic field over the cylindrical distribution of HTS bulks can be reduced in up to a 50% of their original radial magnetization. Thus, although the effective area of the poles can be enlarged by using a significantly larger number of magnetized HTS bulks, the amount of trapped magnetic field is lower and the synchronization of the rotation of the shaft with the frequency of the supply current can be significantly challenging when there is an uneven distribution of HTS bulks over the active surface of the rotor, or when there are even slight differences between the sizes of the HTS bulks and their physical properties.