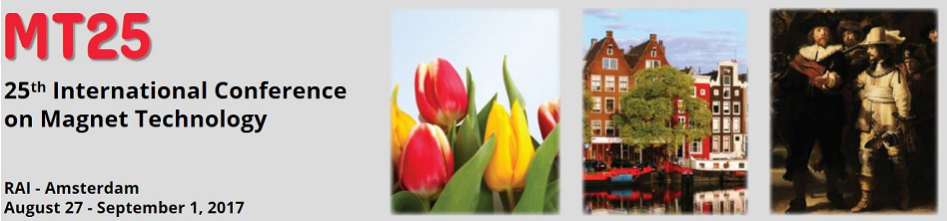

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Simulation studies of mechanical stresses and trapped field in annular REBaCuO superconducting bulk magnet for NMR spectrometer during field-cooled magnetization

Tuesday, 29 August 2017 13:15 (1h 45m)

Nuclear magnetic resonance (NMR) spectrometer with high resolution using superconducting coils is a powerful apparatus to analyze complex molecular structure or to develop new drugs. Recently, a compact and cryogen-free NMR spectrometer with a medium resolution of 200 MHz (4.7 T) has been developed using annular REBaCuO superconducting bulks, in which the NMR spectra of ethanol with a full width at half of the maximum (FWHM) of 0.1 ppm (21 Hz) were achieved [1]. The magnetic resonance imaging (MRI) was also investigated using the same apparatus. In the apparatus, the annular REBaCuO bulks are magnetized by field-cooled magnetization (FCM), in which large hoop and radial stresses are experienced and the bulks are sometimes fractured for higher applied field. The metal ring support must be considered to avoid the bulk break. In this paper, we performed the numerical simulation of the mechanical stresses (hoop stress and radial stress), together with the electromagnetic properties (trapped field and induced persistent current density) in the actual annular REBaCuO bulks reinforced by aluminum alloy ring during FCM from 4.7 T and 9.4 T at 50 K using the finite element method (FEM). The hoop stress became the maximum at the innermost edge of the uppermost ring bulk at intermediate step in FCM and increased with increasing applied field. The thermally compressive stress was also applied to the annular bulks during cooling to operating temperature because of the difference of thermal contraction coefficient between bulk and aluminum alloy ring. The actual total hoop stress due to both cooling and FCM was analyzed and the possibility of the mechanical fracture was discussed. A new method to reduce the total hoop stress is proposed.
[1] T. Nakamura, D. Tamada, Y. Yanagi, Y. Itoh, T. Nemoto, H. Utumi and K. Kose, J. Mag. Reson. 259 (2015) 68.

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