APP1-2

One-dimensional quench analyses combined with quench experiments of conduction-cooled RE-123 coated conductors

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We have been accumulating data of quench experiments using short-pieces of conduction-cooled coated conductors. We aim to clarify the conditions for successful quench detection and protection of conduction-cooled magnets. The short turnaround time of such an experiment allows us to accumulate data at various operating conditions, but it cannot completely simulate circumstances in real magnets. The transverse thermal conduction cannot be simulated, because one side of our sample is attached to a GFRP sample holder, and another side is exposed to vacuum. A limited length of a short sample may affect quench propagation, because both ends are attached to current terminals, which are copper blocks with large heat capacity. We combined one-dimensional quench analyses with quench experiments to study the influence of such restrictions of short-sample experiments.

Our quench analysis model was formulated with the one-dimension heat conduction equation, in which the following factors were considered: the local and transient thermal disturbance inducing quench; the heat conduction along the conductor; Joule heat generation based on the current-sharing model; the transverse cooling (heat conduction to adjacent turns etc.) by using a simplified model. To consider the transverse cooling, we attached a GFRP piece with a certain thickness, which increased entire heat capacity and conducted heat through its thickness, to the sample coated conductor. The temperature of the outer side of this GFRP piece was assumed to be the operating (initial) temperature. The thickness of this GFRP piece was used as a parameter to fit the calculated longitudinal voltage distribution to the measured one. To consider the limited length of the short sample, the length of coated conductor in the model is limited, and the temperature at two ends is constant, same as operating (initial) temperature.

Keywords: Coated conductor, Conduction-cooled, Protection, Quench

APP1-3

A Study on Temperature Distribution Measurement for a No-Insulation HTS Coil with Encapsulated Optical Fiber Based on Raman-Scattering Technology

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In high temperature superconducting (HTS) applications, especially for HTS magnets, quench detection before burning out is very difficult, and it is considered as a key issue. As a potential candidate method, the technology based on optical fibers is proposed in recent years, and some progress is shown in HTS quench detection. However, the combination methods between optical fibers and HTS tapes in present study are inapplicable to HTS applications using long length tapes. In this paper, we proposed a novel HTS tape with two encapsulated optical fibers along the two sides to make good contact between the optical fibers and HTS tapes. To verify the feasibility of temperature distribution measurement for this novel HTS tape, a no-insulation coil is fabricated, and also a DTS system based on interrogating Raman-scattering is prepared. The structure of this novel HTS tape is introduced in this paper. Besides, critical currents of the novel HTS tape before and after winding are tested. Moreover, temperature distribution of the no-insulation HTS coil in air and in liquid nitrogen is measured. More specification of the no-insulation coil and the experiment results are presented and discussed in this study.

Keywords: optical fiber, DTS system, temperature distribution, HTS tapes

APP1-4

Substrate Temperature Dependence of AC Loss in BHO-doped SmBCO films

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REBCO have been studied to be applied to rotating machines for airplanes, generators, and so on[1]. For these applications, it is necessary to improve their transport properties and reduce their AC losses. There are various ways to reduce their AC losses such as a laser scribing[2], a transposed parallel conductor[3], and so on. We focused on a magnetic field dependence of critical current density J_c in low field. That was because the less J_c in the field below an operating field was, the less AC loss was. In this study, we fabricated REBCO films which were introduced impurities into and controlled them. In results, their AC losses decreased.

Pure and BHO-doped SmBCO films were fabricated on IBAD-MgO buffered metallic substrates by using the PLD method. The BHO content was 2.3vol.%. The substrate temperatures T_s were changed from 840°C to 880°C. Magnetic field dependence of J_c in the films was measured at 77 K and at fields of 0-9 T. Magnetic field amplitude dependence of AC losses in the films was estimated from the magnetic field dependence of J_c.

Figs.1(a) and (b) showed magnetic field dependence of J_c and magnetic field amplitude dependence of AC losses at 77 K and $B//c$ in pure and BHO-doped SmBCO films fabricated in various T_s. As a result, the AC loss in the BHO-doped film of T_s = 880°C was lower than one in the pure film in low fields, although the in-field J_c in the BHO-doped film was higher than one in the pure film. That was because that the J_c in self-field in the BHO-doped film was lower than one in the pure film. In addition, J_c in the BHO-doped film of T_s = 840°C was almost the same as one in the pure film but the AC loss in the BHO-doped film was lower than one in the pure film at fields of 0-9 T. In particular, the AC loss at 1 T was about half. We will discuss transport properties and AC losses in BHO-doped SmBCO films fabricated in lower T_s with various BHO contents.

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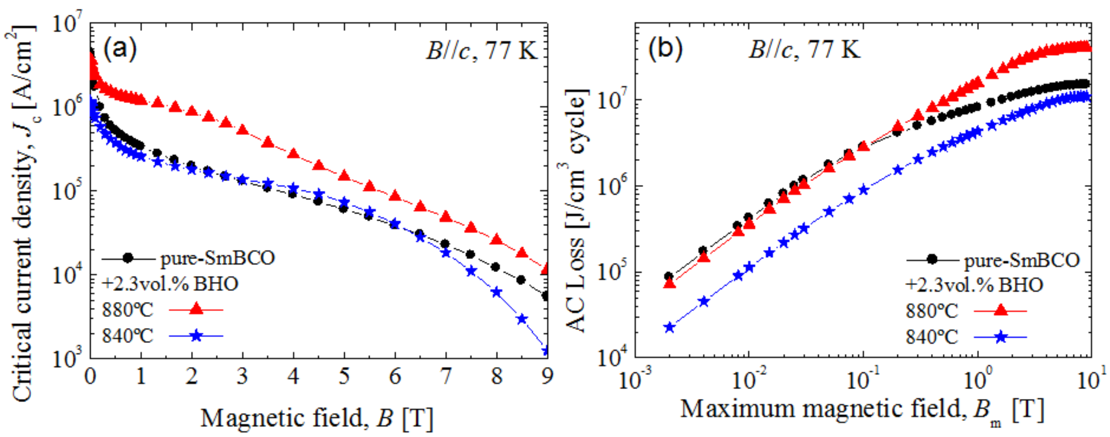

Keywords: High Temperature Superconductivity, AC Loss, Artificial pinning centers, BaMO3

APP1-5

AC loss calculations of superferric magnets using HTS coils wound with stacked coated conductors and wound with CORCÒ wires

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In order to reduce the electricity consumption of rapid cycling synchrotrons (RCSs), we consider to apply superferric magnets using HTS coils to them. Because magnets for RCSs are required to generate time-dependent magnetic fields, the reduction of ac losses is one of the important issues when using HTS coils for superferric magnets for RCSs. When we consider to wound HTS coils for superferric magnets with single conductors, there are several problems such as mechanical strength of single conductors and large inductance of HTS coils. Using assembled HTS conductors is one of the solutions of these problems, and we focused on stacked coated conductors and Conductor on Round Core (CORCÒ) wires [1].
In the analyses of superferric magnets for RCSs using HTS coils wound with stacked coated conductors, we use the method same as we developed before [2] with assumption that all coated conductors carry same current. In the case of HTS coils wound with CORCÒ wires, we approximate the one part of HTS coils as an infinitely-long CORCÒ wire exposed to the external magnetic field assumed to be uniform along the CORCÒ wire. In order to get this external magnetic field, we calculate the magnetic field in the one part of HTS coils which generated by magnetized iron yokes and current in the other parts of HTS coils. Then, we carry out the three-dimensional electromagnetic field analysis to calculate ac losses of an infinitely-long CORCÒ wires exposed to external magnetic fields and carrying current.
We design the superferric magnets using HTS coils wound with stacked coated conductors and wound with CORCÒ wires which generate magnetic field of about 1.4T in the beam region, and calculate ac losses of those magnets. The magnets are operated at frequency of 100 Hz, and temperature of 65-70 K. The ac loss distributions in the HTS coils of those magnets are compared and discussed based on magnetic field and current density distributions in the HTS coils. Influence of the CORCÒ wire's three-dimensional geometry on the ac loss is discussed.

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Keywords: Rapid cycling synchrotron, Accelerator magnet, Assembled HTS conductor, AC loss

APP1-6

Theoretical Evaluation of AC Losses and Screening-Current-Induced Fields in HTS Insert for High Field Magnet

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AC losses and screening-current-induced fields (SCFs) in a high temperature superconducting (HTS) insert for high field magnet are evaluated theoretically. The HTS insert is composed of stacked pancake coils, which are wound using two-ply conductors, where the superconducting-layer sides of two rare-earth-based coated conductors are attached to each other without electrical insulation. The theoretical formulas of AC loss and SCF in the two-ply conductor are derived for the simultaneous applications of a transport current and an external magnetic field parallel to its broad face. The obtained formulas consist of three terms, the contributions from the external field, transport current and gap between the superconducting layers. In order to evaluate the influence of the radial component of applied magnetic field on the magnetization in pancake coil, the electromagnetic-field distribution of stacked two-ply conductors exposed to only the external field is calculated numerically by means of a two-dimensional finite element method. The AC losses in the two-ply conductors a little far from the ends of stacked conductors can almost be reproduced with the theoretical formula as a result of the magnetic interaction between the conductors. By taking into account the magnetic-field profile in the HTS insert and the magnetic-field dependency of critical current density in the coated conductor, the AC losses and SCFs are estimated using the theoretical formulas for monotonical increase in a central field up to 25.5 T in 60 minutes in combination with low temperature superconducting outsert coils. In the case where the gap between the superconducting layers is 40 μm, the parallel-field loss becomes 17 W in maximum at about 10 minutes, which could be cooled by using prepared cryocoolers, after that, it monotonically decreases due to the decrease in the critical current density. The SCFs produced by the axial magnetic moments in two-ply conductor windings of the HTS inserts are positive, and it might be expected that the center fields in the high field magnets become a little larger than the design value.

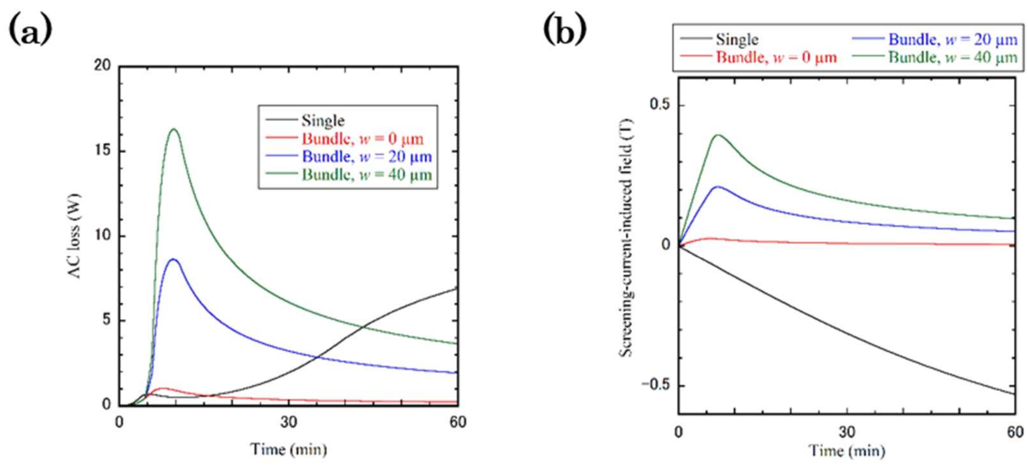

Fig. (a) AC losses in HTS inserts, (b) SCFs in HTS inserts

Keywords: High field magnet, HTS coil, AC loss, Screening-current-induced field

APP1-7

Finite Element Analysis of Electromagnetic Responses in Pancake Coils for High Field Magnet Wound Using Two-ply Conductors

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AC losses in stacked conductors exposed to external magnetic fields are numerically evaluated by means of a two-dimensional finite element method formulated using a self-magnetic field due to currents induced in an analysis region [1]. Fig. (a) shows the schematic illustration of two-dimensional numerical analysis model. The conductor is composed of two-ply tapes, in which the flat face close to a superconducting layer in one coated conductor is attached to that for the other coated conductor without electrical insulation to improve the thermal stability. The copper layer is sandwiched by two superconducting layers in the conductor. The external magnetic fields are increased monotonically from zero so as to simulate the electromagnetic responses in several typical parts inside a pancake coil for high field magnet. In order to understand only the geometrical effects on the AC losses, it is assumed that the transport property of superconductor can be expressed by the Bean model, in which the critical current density is independent of the local magnetic field. The influences of the numbers of bundle conductors, the gaps between superconducting layers and the angles of applied magnetic fields on the AC losses are investigated numerically. Fig. (b) shows the numerical results of AC losses in eleven conductors stacked at even intervals.

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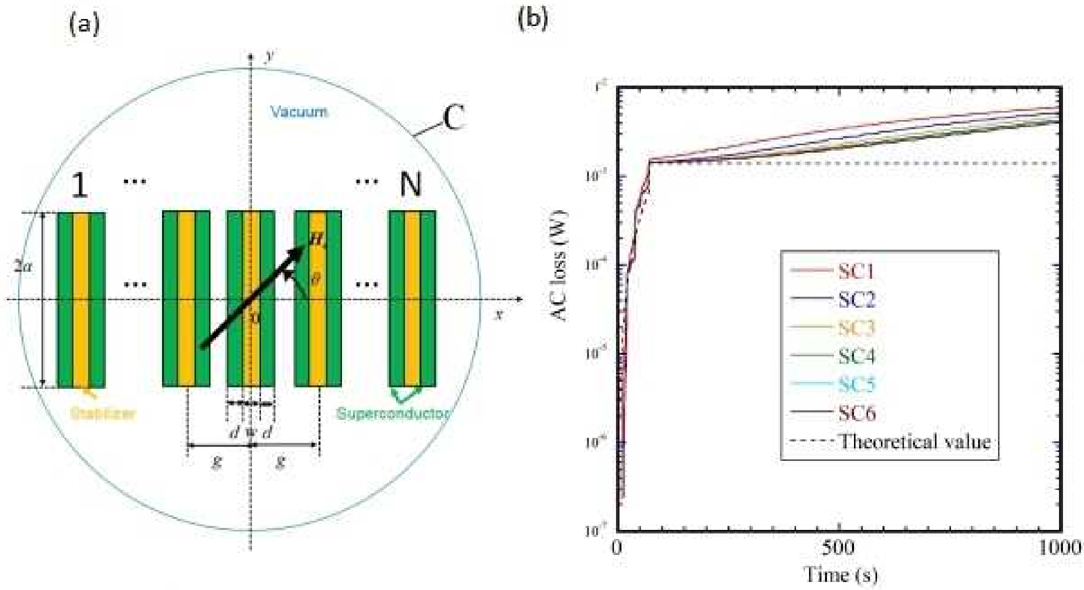

Fig. (a) Two-dimensional numerical analysis model, (b) numerical results of AC losses in stacked

Keywords: AC loss, Finite element method, Magnetic interaction, Pancake coil