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MATERIALS AND STRUCTURES SYMPOSIUM (C2)
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NUMERICAL INVESTIGATION ON CONDUCTION-COOLED SUPERCONDUCTING MAGNETS IN SPACE

Abstract

Superconducting magnets can revolutionize space missions and can be applied to the following technology in space: Magnetic sail, Electric propulsion and Radiation magnetic shields. The propulsion systems benefit from superconducting magnets by reducing weight and increasing the thrust power/mass ratio. We have been studying High Temperature Superconducting (HTS) magnets aiming at such space applications. For these applications, we need to establish a light-weight superconducting magnet system with a large magnetic moment based on radiation and/or conduction cooling. In this study, for optimal design of an HTS magnet system in space, we investigated the basic characteristics of Bi-2223/Ag (Bi) and YBCO (Y) superconducting coils, which are the candidates for space missions. First, we obtained the electric field versus current density characteristics from experiments using short length samples (30 mm length HTS tape). These characteristics are formulated on the basis of the percolation depinning model, which can describe the above mentioned characteristics as a function of temperature and magnetic field vector. Next, we made an analysis method to predict the current transport properties of the HTS coils by summing up the local voltages given by the percolation depinning model. Taking the magnetic sail drive coil (diameter: 3.5 m, turn number: 201, layer number: 20, operational temperature: 20 K) for instance, the simulation results showed that the critical current of the Y coil are only one third of that of the Bi coil. This came from the fact that the manufacturing technology of Y tapes does not mature. Furthermore, in order to examine the thermal characteristics of the HTS coils, we obtained the heat diffusivities of Bi and Y tapes from experiments and analysis. And then, by calculating a two-dimensional heat balance equation, we simulated thermal stabilities of the magnetic sail drive coil during current applications. As a result, we showed that the Y coil cause thermal runaway only at more than 94 A due to the extremely low thermal diffusivity. On the other hand, the Bi coil can be stably excited at 187 A. In conclusion, at present, Bi magnets are the most promising candidates for the space missions, from the point of view of the current transport properties and the thermal behaviours.