§22. Design Optimization of Bi2212 HTS Tubular Bulk with Conical Shape for Current Lead

Tamura, H., Mito, T.,
Yamada, Y., Tachikawa, K. (Tokai Univ.),
Heller, R. (FZK)

The performance of high-Tc superconductors (HTS) has been improving and many practical applications have been introduced. The major advantage of using a HTS system is a low heat load to the lower temperature region since it has a low thermal conductivity compare with a metallic conductor. They are expected as a current lead between a low-Tc superconductor and a conventional current lead which is used between room temperature and intermediate temperature. Yamada et al. has developed Bi2212 bulk material by using diffusion reaction. To obtain high transport current, increasing of the cross-sectional area can be efficient since the diffusion layer is synthesized on the surface of the substrate. A tubular bulk seemed to be appropriate to maximize the surface area. We have made some tubular bulk to investigate an electrical performance of the HTS bulk and the maximum transport current of 8 kA was achieved at 4.2K.

A current lead usually has a temperature distribution along its warm end to the cold end. From the result of the transfer current against temperature rise, the maximum transfer current was 2 kA under the condition of warm end temperature was 50 K[1]. Under this condition, the cross section of the cold end can be smaller since the temperature of cold end is almost 4.2K[2]. Based on the consideration, we made a new type of tubular bulk which had a conical shape. The conical bulk had 47 mm/39 mm in diameter at the warm end and that of 27 mm/19 mm at the cold end. The bulk was connected to end caps made of copper with solder. Fig. 1 shows the current profile and the temperature change at the warm end, HTS part, and cold end. No temperature rise due to the current flow was observed for any region of the specimen. The voltage generation in the HTS region was less than 25 μV. These data show that the current transport behavior is quite stable in the HTS region even when the current exceeded to 4 kA.

To show the effect of the conical HTS and for a practical use of the Bi2212 bulk, we considered a conceptual design of a current lead. The nominal current was set to 2 kA. The calculation model of the current lead consists of 3 parts; conventional heat exchanger part, HTS part, and low Tc superconductor part. The heat exchanger part was assumed that consisting of 114 bundle copper wires being 1.5 mm in diameter. The warm end of the HTS part was assumed to be cooled by 60 K helium gas with 0.9 g/s of mass flow rate. The cold end was connected to NbTi/Cu low Tc superconductor which was in the liquid helium. Thermal conductivity of the HTS part was obtained from the measurement of the Bi2212 plate. CURLEAD analysis code was used for the calculation. Fig. 2 shows the results of the calculations. We fixed the outer/inner diameter at the warm end to 47 mm/39 mm. The outer/inner diameters at the cold end of the cylindrical and conical model were set to 47 mm/39 mm and 27 mm/19 mm, respectively. Then the length of the HTS part was changed to obtain an effect for the heat leakage to the cold end. As the result, the heat leakage of the conical shaped HTS was almost 2/3 of that of the cylindrical one. The heat leakage would be less than 1 W if the length of the HTS part was longer than 150 mm.

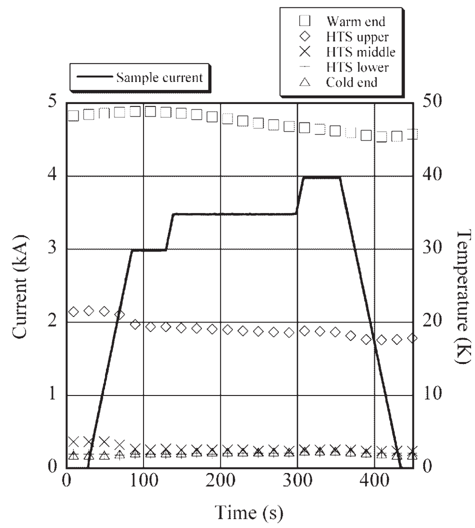

Fig. 1. Current profile and temperature of each part.

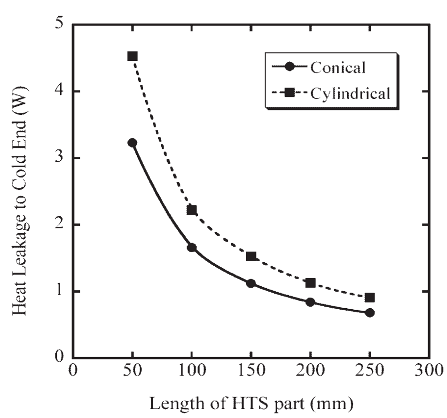

Fig. 2. Heat leakage to the cold end of the current lead as a function of length of the HTS part.

References

1) Yamada, Y. et al.: IEEE Trans. Appl. Superconduct. 13 (2004) 638.
2) Tamura, H. et al.: IEEE Trans. Appl. Superconduct. 13 (2004) 686.