

## §26. Design Study of HTS Current Lead Using Bi-2212 Prepared by Diffusion Process

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High Tc superconductors (HTS) have been expected as a current feeder between a low-Tc superconductor and a current transport material at higher temperature. Since they have low thermal conductivity, significant advantage is that the heat load to a cryogenic system is much lower than a conventional normal resistive current feeder. Bi-Sr-Ca-Cu-O system is a candidate material for a current lead since it has higher critical current density at low temperature than other HTS materials.

Yamada et al. have developed Bi-2212 system prepared by using a diffusion reaction<sup>1)</sup>. Transport current performance tests for the Bi-2212 HTS bulk at 4 K have been carried out at NIFS under collaboration program with Tokai University. The substrate of the Bi-2212 HTS could be made in any shape because it is made by using a cold isothermal pressing method. In this point, the Bi-2212 bulk has a potential for flexible design. On the other hand, HTS naturally has such disadvantage concerning with mechanical strength. It is needed to reinforce the bulk superconductor or to fix the bulk to an appropriate support structure as a size becomes large, especially for a practical use. Rigidity reinforcement and absorption of thermal contraction during cooling down have to be considered simultaneously for a design of a current lead using HTS. We investigated a reinforcement using glass fiber with epoxy resin, and confirmed a validity of this method<sup>2)</sup>. Several other materials were surveyed and AlO<sub>2</sub> (Alumina) seemed to show a good characteristic since it has a low thermal contraction, low thermal conductivity, and high strength<sup>3)</sup>. In this paper, a design of a current lead using the Bi-2212 tubular bulk was studied with conventional heat exchanger part and low-Tc superconducting bus line.

The HTS bulk used for a transport current performance test has a cylindrical tubular shape with 200 mm length and 38/30 mm in outer/inner diameter, respectively. AlO<sub>2</sub> fiber was wound around the outside surface of the HTS bulk to strengthen mechanical characteristics. The filament winding method was adopted and the winding angle was decided as  $\pm 40$  degree according to the relationship between the angle and the thermal contraction of each direction.

The bulk was immersed into liquid helium up to the warm end section. When the whole HTS section was immersed in the liquid helium, the maximum transport current of 8 kA was achieved. As the temperature of the warm end section increased, the quench current decreased. The quench current of 3 kA was observed at 40 K.

From the result of the transfer current tests of the cylindrical sample, the maximum transfer current can be 2 kA and a warm end of the HTS should be lower than 60 K. Under this condition, the cross section of the warm end must

be 38 mm/30 mm in outer/inner diameter. On the other hand, the cross section of the cold end can be smaller. 14 mm/6 mm is large enough to transport the current at 4 K. If a conical shaped HTS bulk was made, it could be an advantage for heat leakage. To confirm this effect, we calculated heat leakage of the prototype current lead. The current lead consists of 3 parts; conventional normal resistive current feeder part, HTS part, and low Tc superconductor part. The conventional feeder part was assumed that it consists of 114 bundle copper wires which is 1.5 mm in diameter. HTS part was divided virtually into 10 cylindrical sections in the analysis. In this calculation, the warm end of the HTS part was assumed to be cooled by 60 K helium gas and 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 Bi-2212 plate with 2 mm thickness. CURLEAD<sup>4)</sup> analysis code was used for the calculation. Fig. 1 shows the results of calculations. We fixed the outer/inner diameter at the warm end to 38 mm/30 mm the outer/inner diameter at the cold end of the cylindrical and conic model were set to 38 mm/32 mm and 14 mm/6 mm, respectively. Then the length of the HTS part was changed to investigate a heat leakage to the cold end. From the result, the heat leakage of the conical shaped HTS was almost half of that of the cylindrical one.

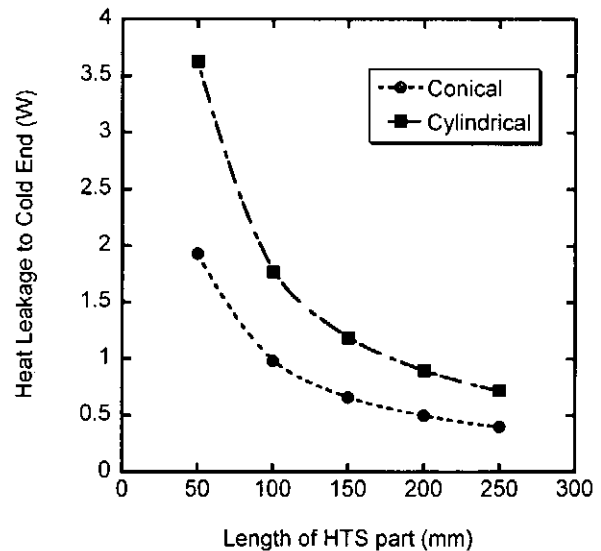


Fig. 1. Heat leakage from the warm end to the cold end of the Bi-2212 bulk in shape of conical and cylindrical.

### References

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