## §18. Study on Optimization of High Temperature Superconducting Magnet

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### 1. Introduction

The DC current and voltage (*I-V*) relation of the high temperature superconducting (HTS) tape wire strongly depends on the flux angle to tapes. The purpose of this study is to establish a method to evaluate the current transport characteristics of a HTS magnet by using the *I-V* relation of the short tape wire. The *I-V* relation of HTS coil was analyzed using the approximate formula of $I_c$ and $n$ obtained from the short sample data and compared with the measurement result for the HTS coil working at 20K

### 2. Analysis and measurement of *I-V* characteristics

The *I-V* relation of the Bi-2223/Ag tape wire firstly measured in the external magnetic field with various field angle to the tape. The measurement was performed at 20K. The specification of the test tape wire is listed in Tab.1. Fig.1 shows the measured $I_c$ defined at 0.5μV/mm as a fuction of the external magnetic field angle to the test tape. Based on the measured data, we obtain the approximate formula of the critical current ($I_c$) and the n value. Tab.2 lists the specification of the test HTS coil wound by the same Bi-2223/Ag tape wire as used in the above measurement. The HTS coil was directly cooled by a small GM refrigerator. The I-V relation of the HTS coil was measured at 20K.

From the results, the calculated $I_c$ was 59.9A, although the measured $I_c$ was 35.0A. It is considered that the reason of the discrepancy between the calculated and measured $I_c$'s is inhomogeneous temperature distribution in the coil winding and the mechanical damage in the HTS wire during the winding process.

### 3. FEM Analysis of Temperature Distribution in Conduction Cooled HTS Coil

The temperature distribution in the cross-section of the conduction cooled HTS coil was numerically calculated by FEM analysis. In the analysis, the flux flow loss and the Joule heating caused by the connection resistance between the pancake coils were taking into account. Fig. 2 shows the numerical results of the temperature rise at the edge of the coil when the DC current of 36A continuously flows at the virgin temperature of 20K. In Fig. 2, the measured temperature of the conduction cooled HTS coil wound by Bi2223/Ag tape was also shown. The measured critical current of the test HTS coil was 35A. Fig. 3 shows the calculated temperature distribution in the coil cross-section at $t$=60 sec. As shown in Fig. 2, the temperature rise at the edge of the coil is very small after 60 sec. However as seen from Fig. 3, the temperature at the center of the coil cross-section is larger than 35K. It is considered that this temperature rise is due to the Joule heating caused by the connection resistance. Therefore, depending on the operating current, the Joule heating caused by the connection resistance together with the flux flow loss should be taking into consideration.

Tab.1 Specification of test Bi2223 tape wire

| | |
|---|---|
| Width (mm) | 3.2 |
| Thickness (mm) | 0.21 |
| No. of filament | 55 |
| Ag ratio | 2.8 |

Tab.2 Specification of test HTS coil

| | |
|---|---|
| No. of turns | 7365 |
| Inner radius (mm) | 25 |
| Outer radius (mm) | 80 |
| Height (mm) | 100 |
| No. of layers | 15 |

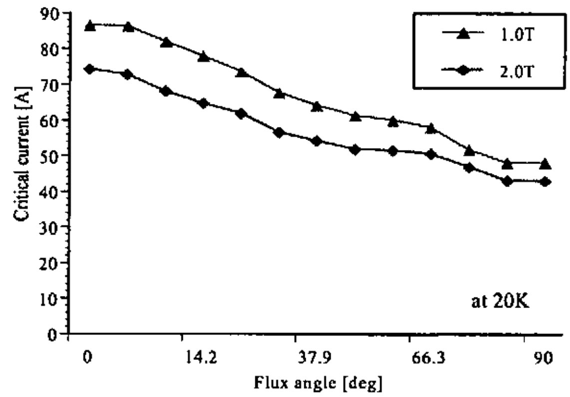


Fig. 1. Measured Ic of test tape as a fonction of fiels angle.

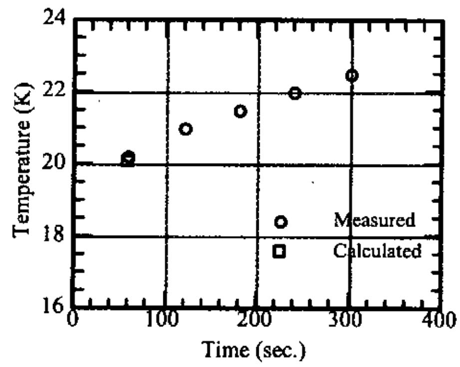


Fig. 2 Calculated and measured coil temperature.

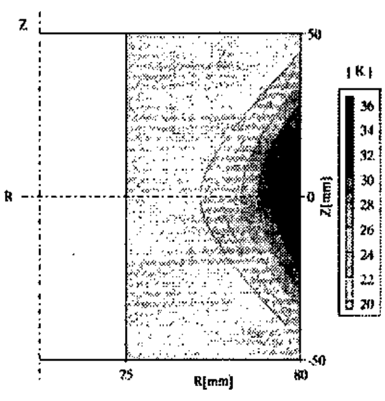


Fig. 3 Temperature distribution in coil cross-section.

### Reference

[1] Yamaguchi, N., Fukui, S., Presented at EUCAS 2001.
[2] S.Ishiguri, M.Yamaguchi, S.Fukui et. al., Presented at MT-18.