§27. Frictional Characteristics and Instability of Conductors in Large-scale Superconducting Coils

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i) Introduction

Frictional heating by abrupt conductor motion in a winding is one of main origins of instability of superconducting coils. We measured coefficients of friction and frictional heating on contacting surfaces between copper (Cu) and glass fiber reinforced plastics (GFRP) at liquid helium (LHe) temperature which simulated conductors in the superconducting windings with GFRP spacers between the layers[1].

ii) Experiments

The GFRP plate (10 × 28 × 5 mm) is held between the two Cu bars (3 × 3 × 15 mm) with 20 N of holding force. The shapes of the Cu bars at the contacting place to the GFRP plate are flat or spherical. Therefore, the contacting configurations between GFRP and Cu are plate or point contacts. The GFRP plate moves up and down sinusoidally (frequency = 8 Hz, amplitude = 0.25 mm). Since the Cu bars are fixed, frictional force is generated at the contact points between the GFRP plate and the Cu bars. These specimens are immersed in LHe. Evaporated gas helium (GHe) due to the frictional heating is measured by the GHe flow meter. Decreasing of LHe level during the experiment is also measured. Furthermore, the frictional heating is calculated by the product of the frictional force and the moving length of the GFRP plate. The contacting stresses between GFRP and Cu are listed in Table I.

Table I. Contacting stresses between GFRP plate and Cu bars.

Shape of Cu	Stress (MPa)
Flat	2.2 (mean)
Spherical (R=150 mm)	25 (max)
Spherical (R=4.5 mm)	260 (max)

The dependence of the number of oscillating cycles on the frictional coefficients is shown in Fig. 1. Fig. 2 shows the measured frictional heating using the flat shape of the Cu bars by the three measuring methods.

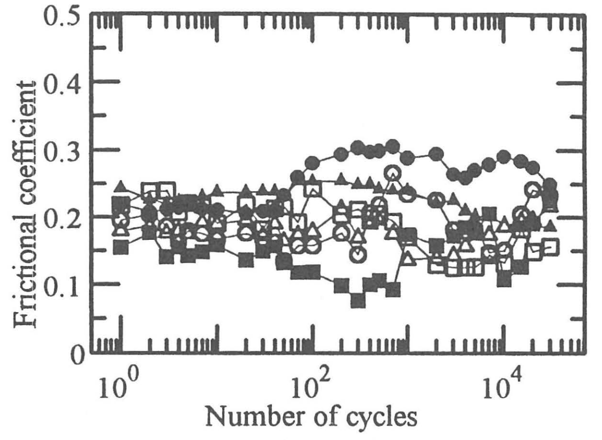

Fig. 1. Measured frictional coefficients.
(260 MPa : 1st = ○, 2nd = ●)
(25 MPa : 1st = □, 2nd = ■)
(2.2 MPa : 1st = △, 2nd = ▲)

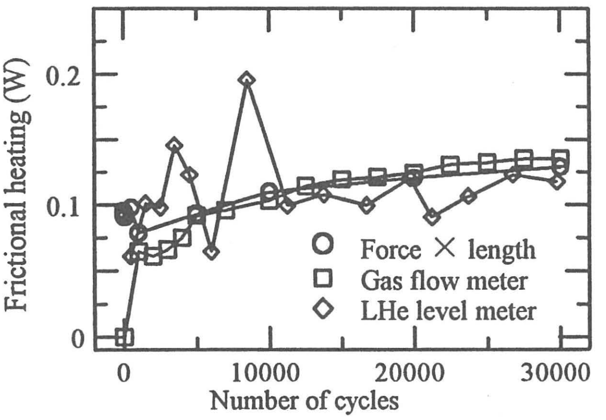

Fig. 2. Measured frictional heating.

iii) Concluding remarks

As shown in Fig. 1, changes of frictional coefficients are small in spite that the difference of the contacting stresses is 2.2 to 260 MPa and the number of oscillating cycles are 30,000 cycles.

The agreement of frictional heating in Fig. 2 obtained by the three methods are reasonably good. We think that it is possible to estimate the frictional heating using the methods.

Reference

1) Takao, T., et al., 56th Meeting on Cryogenics and Superconductivity, D1-10, Tsukuba, Japan, May (1997) (in Japanese).