§1. Surface Characteristics on Strand in CIC Superconductors

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i) Introduction

Large electromagnetic force is applied to strands in cable-in-conduit (CIC) conductors such as the LHD poloidal coil, and the strands are moved to one side in the conduits[1]. Therefore, friction occurs at contacting segments between the strands and the conduits, and frictional heating generates locally normal parts in the strands.

In the study, to obtain fundamental data of the friction we experimentally analyze frictional coefficients under the condition of the two temperatures and the several contacting forces between the specimens.

ii) Experimental Setup

The experimental arrangement is the schematically illustrated in Figure 1[2]. The specimens are made of Cu and stainless steel (SUS) which simulate the strands and the conduits respectively. As shown in the figure, the Cu bar is horizontally placed, and the two cubic blocks made of SUS clamp the Cu bar. The Cu bar moves up and down by the driving machine which is connected to the Cu bar.

Since the SUS blocks are fixed and the Cu bar moves, friction occurs at the two contacting points between the Cu bar and the SUS blocks. The frictional force and the contacting force are measured by strain gauges. The both end of the Cu bar are processed spherically and hence the contacting conditions are point contactings.

The experimental conditions are summarized in Table 1.

iii) Results and Summary

The obtained frictional coefficients, which are calculated by the ration of the contacting force and the frictional force, are shown in Figure 2. In the given range of the contacting force, the frictional coefficients tend to decrease with increasing of the contacting force. And the coefficients measured at the liquid nitrogen temperature equal to or slightly larger than those at room temperature.

The frictional coefficients are not a constant value of a material but generally depend on temperatures, contacting forces, surface conditions and so on. So, we have a plan to simulate the conditions of CIC conductors and measure the frictional coefficients under the conditions.

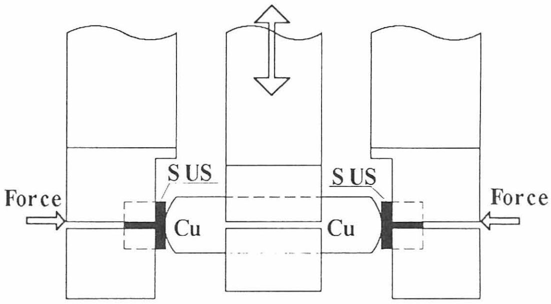

Figure 1: Experimental arrangement.

Table 1: Experimental conditions.

Moving specimen	Bar (Cu) ($\ell = 40$ mm, $\phi = 10$ mm)
Fixed specimen	Cubic (SUS) ($9 \times 9 \times 9$ mm)
Moving condition	Sinusoidal waves ($f = 0.2$ Hz, Amplitude = 0.2 mm)
Contacting force	8 ~ 55 N
Temperature	Room (in air), LN_2 (immersed)

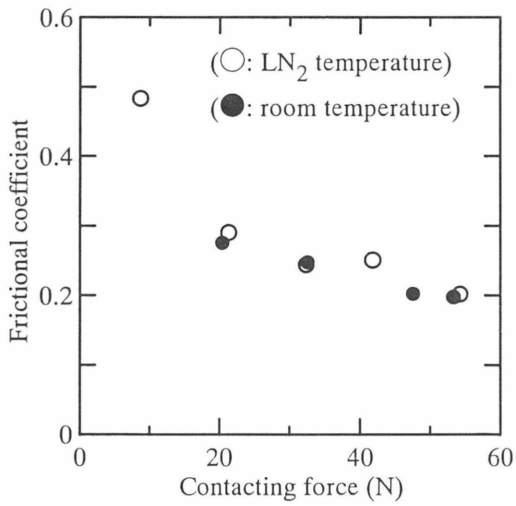

Figure 2: Measured frictional coefficients.

Reference

1) T. Sasaki, et al., 'Monte Carlo simulation of strand motion in CIC conductor, IEEE Trans. on Applied Super., vol. 10, no. 1, pp. 1094-1097, 2000.

2) T. Takao, et al., 'Influence of sliding directions on frictional properties of GFRPs and DFRPs', Presented at CEC/ICMC, Canada, 1999.