§30. Losses in Lap Joints during Pulsive Energizations

Seo, K.
Kawabata, S., Nakamura, K. (Kagoshima Univ.)
Ichihara, T., Hasegawa, M. (Mitsubishi Elec. Corp.)

Lap joint between superconducting cable-in-conduit-conductors (CICC) was evaluated under transport current (in other word, self-field) and external transverse -field conditions. The joint between the superconducting conductors is the key technology of the large magnet system [1]. DC resistance of the joint is typically designed as 3 ~ 5 nΩ. The lap joint is the simplest joint and mechanically strong; however, it causes the larger AC loss and it depends on the angle of external field. When we design the magnet system, the operation limit of the joint must be identified and it is mainly governed by the AC loss. AC loss measurements under current transport condition or external transverse-field were performed.

Fig. 1 shows the schematic illustration of the sample [2]. The lap joint was fabricated between two Nb_3Sn CICCs. Number of the Nb_3Sn strands is 216. Hall probe array and pick-up coils are attached to evaluate magnetic field distributions. Both alternative transport current and external transverse magnetic field can be applied to the joint. By means of magnetic measurement and helium boil-off, frequency dependence of AC loss was observed and the time constant of each mode was identified. The joint is the composite of superconductor, resistive copper, solder, bronze and so on, therefore it has a unique magnetic diffusion time constant (τc). When the changing rate of B is small, AC loss Q [J] is described as eq. (1). Q^* denotes the factor determined by the shape of the object, $\dot{B}$ is changing rate of magnetic field and V represents the volume of the joint.

$$Q = Q^* \int \frac{\dot{B}^2}{\mu} dV \qquad (1)$$

Fig. 2 shows the time constants in various modes. The time constant under the self-field is 16 s. For the transverse-field conditions, those are 3.2 s and 0.2 s, respectively.

For large tokamak, e.g. ITER, the ramp rate for plasma ignition is +13T~-11T / 100s; however, for the smaller tokamak, the ramp rate is larger and the AC loss in the joint is large.

AC loss in the lap joint during pulsive operation is evaluated. The modes with larger time constants, such as Mode-1 and Mode-2 regulate the operational limit of the lap joint When the ramp rate is large, we should consider this supplemental losses to DC joule loss.

Refereneces
1) Bruzzone, P., Mitchell, N., Ciazynski, D., Takahashi, et al., IEEE Trans. on Applied Supercond., 7(199)461-464
2) Kawabata, S., Nakamura, K., Seo, K. and Ichihara, T., "Characteristics of joints in CIC conductors for fusion device", Presented at MT-18 (2003)

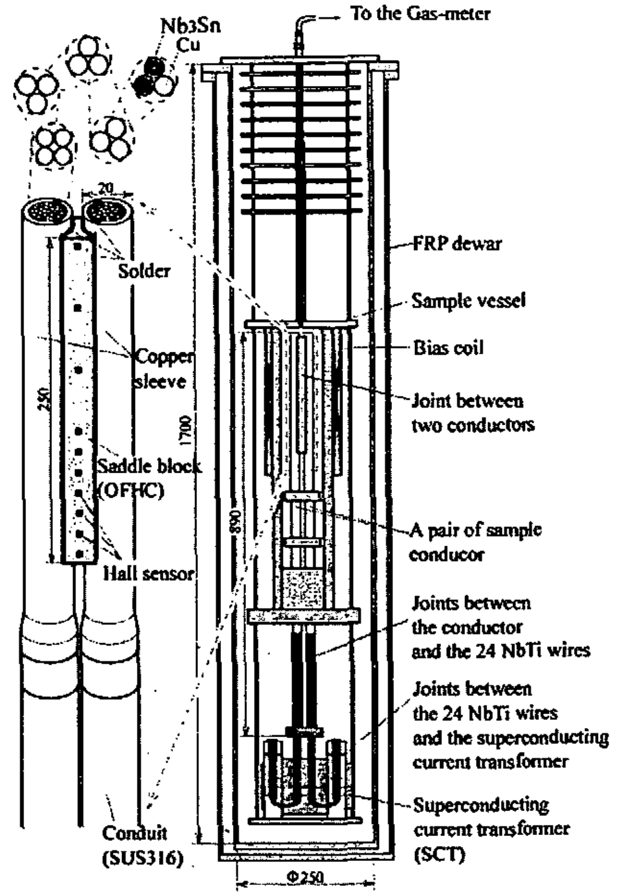

Fig. 1. Schematic illustration of the lap joint sample. Transverse-field coils and pickup coils are neglected.

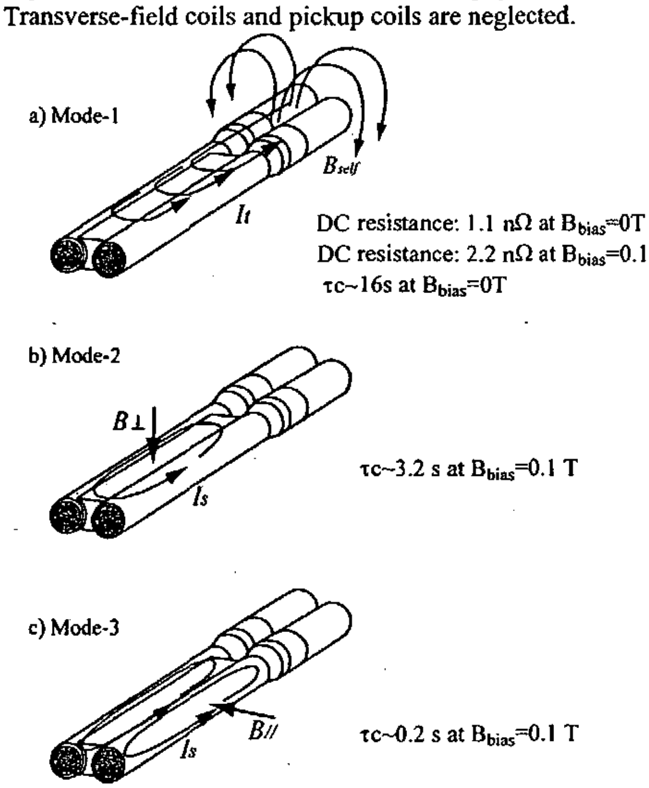

Fig. 2. Time constant of the sample in each mode. a) self-field, b) transverse-field in the perpendicular direction (B⊥) and c) transverse-field in the parallel direction (B//).