§7. Transient Stability of Large Current Aluminum Stabilized Superconductors

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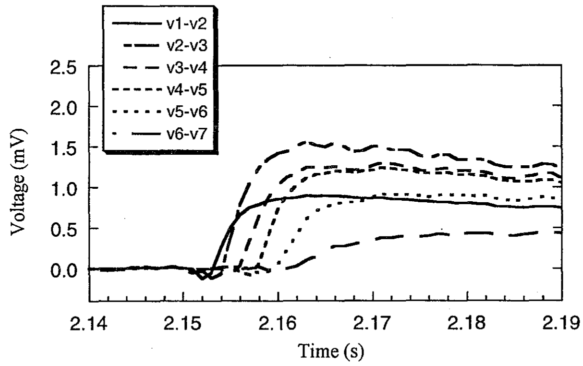
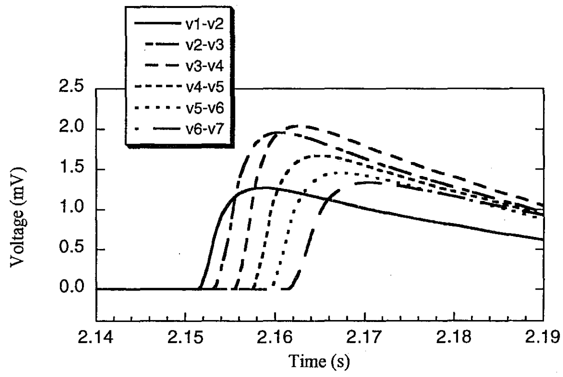
In the case of the transient stability analysis of large superconductors stabilized aluminum which electrical resistivity is much lower than that of copper, it is pointed out that the effect of current diffusion in the cross-sectional direction of the conductor can't be ignored. To investigate the phenomenon called "traveling normal zone", we have been developing computer code based on finite element method analysis of the transient thermal and electromagnetic behaviors of large aluminum stabilized superconductors. We adopted two-dimensional analysis in longitudinal direction of the conductor for thermal and current diffusion. And Cu-2%Ni clad with high electrical resistivity and low thermal conductivity, which is placed around the aluminum stabilizer to restrain the Hall current generation, affects the characteristic of normal-zone propagation.

Figure 1 a) shows a typical waveform of the longitudinal voltage measured with one of the potential taps distributed along the sample conductor surface. In the stability test, the sample current is 15kA and the external bias magnetic field is given by split coil which has a 90% flat top field region of about 250mm. As van be seen in Fig. 1. a), the voltage shows a short rise for about 100ms and then decreases to a steady state value. Fig. 1. b) shows the enlargement of this voltage rise in which all of voltage waveforms measured with potential taps are shown; the potential taps are attached at 9.0mm(v1), 40.8mm(v2), 90.4mm(v3), 141.0mm(v4), 184.3mm(v5), 224.3mm(v6), and 263.7mm(v7) from the center of initial normal zone produced by a heater input. The voltage waveforms, that are obtained by simulation under the same condition with the experiment, are shown in Fig. 2. The simulation represents the measured voltage waveforms well and the normal–zone propagation velocity estimated from the simulation is almost the same as that obtained in the experiment. From the simulation results, we can say that there is the possibility of the "traveling normal zone" occurrence in the LHD helical coil conductor.

Figure 2 shows the maximum recovery current and minimum propagation current as a function of stabilizer/superconducting strands region (Al/SC) cross-sectional area ratio under 7T external Magnetic field. The Al/SC ratio of the LHD conductor is about 1.86. There is possibility of occurrence of traveling normal zone between the recovery current and the minimum propagation current in Fig.2. The minimum propagation current of the superconductor with Cu-2%Ni alloy clad (model A) is less than that of the superconductor without Cu-2%Ni alloy clad (model B). Because Cu-2%Ni clad with low thermal coductivity disturbs the thermal diffusion from the superconducting strands region (NbTi/Cu region) to the aluminum stabilizer, and this the local temperature rise mostly transmits heat to the longitudinal direction in the NbTi/Cu region.



a) Typical measured voltage waveforms in stability test of short sample LHD conductor.



b) Computed voltage waveforms under the same condition with experiment

Fig.1. Measured and computed waveforms in stability test of LHD conductor

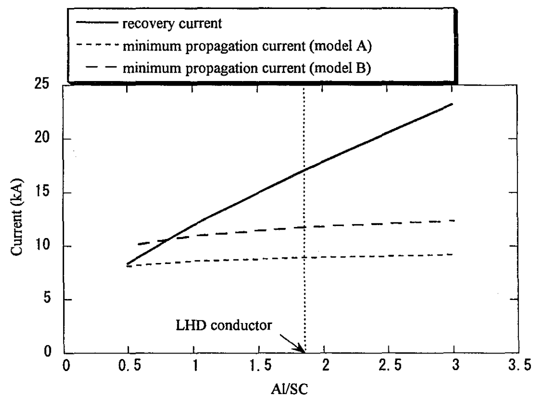


Fig. 2. Recovery and minimum propagation current.

Reference
[1] S.Noguchi et al., "Transient Stability of Large Aluminum Stabilized Superconductors", IEEE Tans. on Applied Superconductivity, to be published (1999).