§16. Study on Quench Current Distribution in Strands of Conduit Superconductors and their Stability

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Cable-in-conduit superconductors (CCSC's) are the most compatible with large scale coils for fusion devices and will be principal superconductors in the next generation LHD. The purpose of our study is to develop a technology to stabilize the conductor suffering from the uneven current distribution in the strands. In our work of this fiscal year, 1) we analyzed the stability of CCSC assuming that a quench in the CCSC was started by a quench of single strand of the conductor and measured the transient heat transfer from a single strand to supercritical helium (SHE), and 2) we observed behaviors of normal zones in a three-strand-cable using high speed video camera.

i) Stability analysis and transient heat transfer measurement.[1), 2)]

To measure the transient heat transfer from a single strand to SHE in a narrow channel, a 20μm dia. Pt-Co wire was placed in a channel among copper wires packed in a SUS tube and used as a heater and temperature sensor. The data showed that the transient heat transfer was weakly dependent on the SHE pressure. Fig.1 shows the time dependence of the heat transfer coefficient for step heating of various heat fluxes. The transient heat transfer coefficient did not depend on the heat flux for about 1.5ms from the start of the heating. The data during this time range well coincide with theoretical values calculated considering that the heat transfer follows the heat conduction model where it is assumed that the heat is transferred to SHE by heat conduction. In the range of our experiment, there was no evidence of induced SHE flows in the channels affecting the heat transfer caused by expansion of the SHE.

We performed the stability analysis of the CCSC using the measured heat transfer data and the analysis shows that recovery of the superconducting state or quench of the conductor is determined within 1.5ms when the disturbance occurs. Therefore, it is valid to use the heat transfer data calculated based on the conduction model in the stability analysis of CCSC.

ii) Observation of behavior of normal zone

We observed, with a high-speed video camera, the behavior of normal zone which was started in one strand in a three-strand-cable by a heater. We observed that there was a threshold current below which the normal zone propagated in only one strand and above which the normal zone propagated to other two strands. We consider that this threshold value gives information about thermal conduction between the strands which is difficult to estimate by other methods. Though the experiment is preliminary at the moment, we obtained an evidence that the cable conductor can be fully stabilized in a certain condition. In the next step of this study, we plan to continue the observation of the normal zone behavior in various conditions and investigate the possibility of fully stabilization of the CCSC.

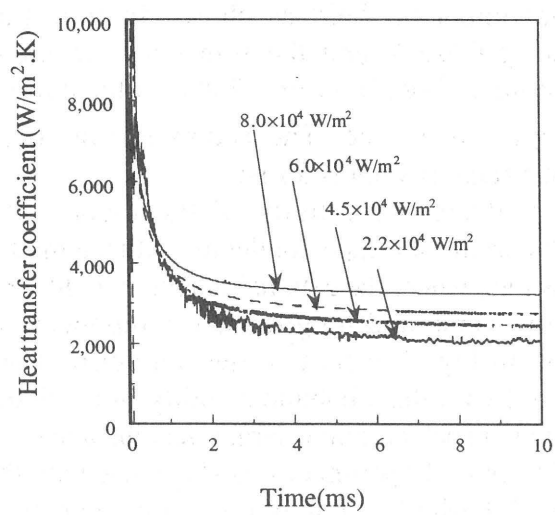

Fig. 1. Heat transfer coefficient in narrow channel vs. time for several initial heat fluxes at 8atm SHE pressure.

References

1) K. Ryu, O. Tsukamoto etal, "Stability of CCICS subject to local disturbance", *Cryogenics* 34 (1994), pp603-607.
2) K. Ryu, O. Tsukamoto etal, "Stability of CCICS subject to local disturbance", *IEEE Trans. on Magn.* 30 (1994), pp2312-2315.