§22. Estimation of Current Leads in Large Superconducting Systems

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Fusion energy is expected as a new clean energy without CO_2 emission. For the nuclear fusion, plasma should be confined by large superconducting magnets, for which large current is fed by huge bus lines. For such large current transmission, superconducting distribution systems seem to be effective. And also, future large energy generation by fusion systems would require highly effective transmission systems for actual use of electric power. Thus, we should develop high performance superconducting systems with low thermal loss. In this report, we discuss about the thermal performance of terminals in 200 m-class superconducting direct current (DC) transmission test device of CASER-2[1)]. We consider the time dependence of temperature change in the terminals with several feeding currents[2)].

Figure 1 shows time dependence of temperature rise of liquid nitrogen in the terminals with several feeding currents. Initial time dependence just after the current feeding varies for all conditions and it with I = 200 A seems to be stable. But it with I = 1500 A is not stable, and it with I = 400 A has the effects of the previous large feeding current of 1500 A. Therefore, we need to measure for long time depending on the feeding current to obtain the heat leak at the terminals by a calorimetry. Next, we show the time dependence of temperature rise of liquid nitrogen with I = 600 A in Fig. 1 (b). In this case, the temperature gradually increased and, after about 7 hours, it could be stable.

To check how long time is required to obtain stable temperature rise caused by the current feeding, we plot the time dependence of the estimated heat leaks with several feeding currents in Fig. 2. The time dependences at terminals A and B are plotted in Figs. 2 (a) and (b), respectively. As we used the time dependence over 24 hours, the data were normalized by the heat leak at 20 hours after current feeding. The initial normalized heat leak rapidly increases below about 4 hours depending on the feeding current, and the normalized heat leak above 10 hours might almost the same. The latter region has the circadian vibration. It means that the heat leaks are governs by the atmosphere temperature and our data are statistically precious for the heat leak estimation. Transient region between 4 and 10 hours has slow heat transfer from the terminals to the liquid nitrogen because the liquid nitrogen was not filled up in the terminals.

The transient from the fast heat transfer to the slow ones, pointed by arrows, shifts to longer time when the feeding current increases for both terminals, as the heat income is larger for the larger feeding current. On the other hand, we conclude the estimated heat leak at the longer time after the current feeding represent the performance of the terminals in CASER-2.

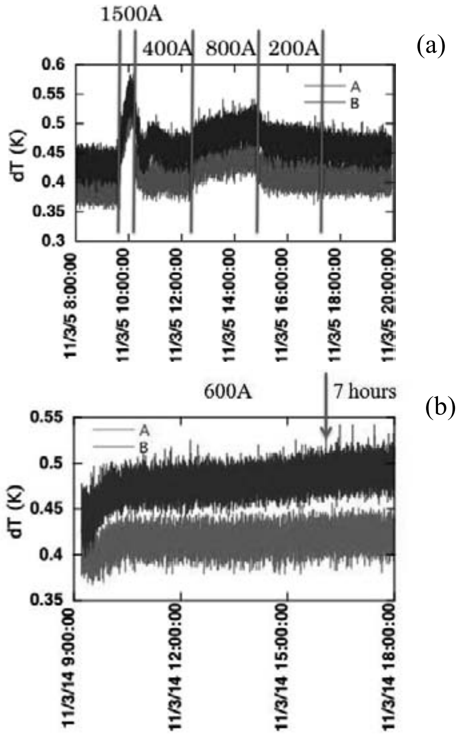

Fig. 1. Temperature change with several feeding currents. (a) is for 200 A~1500 A. (b) for 600 A. An arrow shows 7 hours after current feeding..

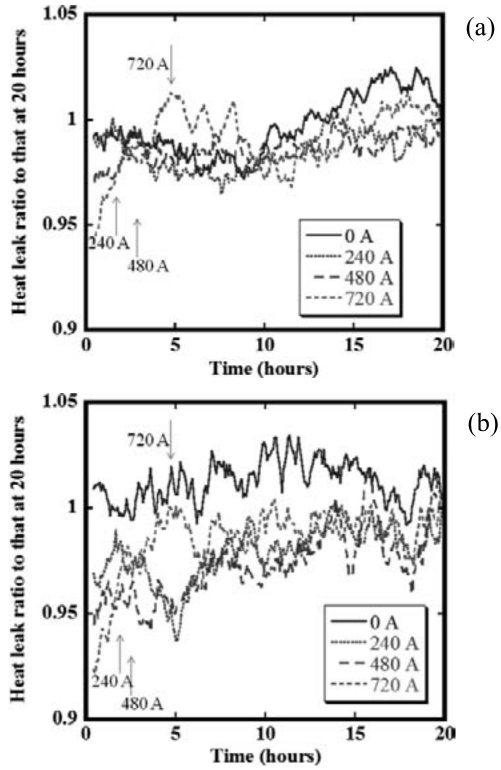

Fig. 2 Time dependence of the heat leak with several feeding current. (a) is for terminal A and (b) for B. Arrows point out the end of the initial large temperature rise.

1) S. Yamaguchi *et al.*: AIP Conf. Proc. **1434** (2012) 1959.
2) T. Kawahara *et al.*: Proc. of ICEC 24-ICMC 2012, 723 (2013).