§22. Three-dimensional Transient Stability Analysis of Large Current Aluminium Stabilized Superconductors

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Very large current composite superconductors have been considered and planned for use in SMES and LHD (Large Helical Device) magnets. These superconductors have large cross-sectional area of high purity aluminium stabilizer to improve their stability and to enhance the overall current density. Once a normal-zone is initiated in such a composite superconductor, current transfers to the aluminium stabilizer according to the temperature distribution. The time constant of current diffusion in the stabilizer, however, is very long due to the low electrical resistivity of aluminium and the large conductor size. Therefore, the excess Joule heat is generated in a small area near superconducting strands and the temperature increases locally. The front of the normal zone is propagating, while the back of the normal zone is recovering as current diffusion in the cross-sectional direction proceeds. The phenomenon is called " traveling normal zone" [1]. To investigate these phenomena, we have been developing a computer code based on a three-dimensional finite element analysis of the transient thermal and electromagnetic behaviors of large aluminium stabilized superconductors. The analysis focuses on the minimum disturbance energy required to drive the conductor normal, and on the effects of RRR values of aluminium and the cross-sectional conductor geometry .

Figure 1 shows the cross section of conductor model used in analysis. Figure 2 shows the time variation of calculated temperature in NbTi/Cu region at the center of disturbance. The line of "Quench" shows the case when MQE (Minimum Quench Energy) is applied. The line of " Recovery" shows the case when the disturbance energy slightly below the MQE (*i.e.* maximum permissible energy) is applied.

The temperature rises instantaneously during the disturbance and the maximum temperature rises over the critical temperature, *Tc*. As soon as the disturbance disappears , the temperature drops temporarily. Afterwards the temperature rises again, as the joule heat generates . After 3 ms the temperature drops. It is thought that the back of the normal zone is recovering after the front of the normal zone propagates.

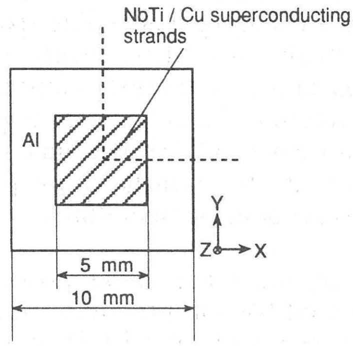

Fig.1 Cross-section of model conductor

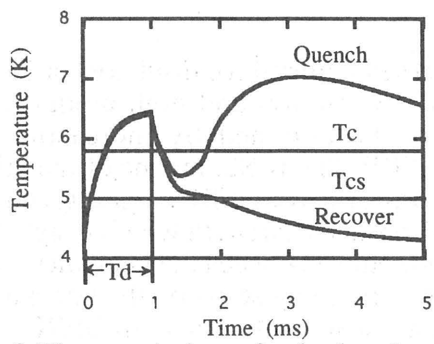

Fig. 2 Time variation of calculated conductor temperature at the center of disturbane

From these investigations, we can conclude that:

1. The efficiency of taking the current diffusion into account was shown.
2. The occurrence of traveling normal zone was confirmed.
3. The transient stability is improved by using the aluminum stabilizer compared with the copper stabilizer.
4. The effects of RRR and the cross-section area of aluminium stabilizer on the transient stability were examined.

Reference
[1] L.Dresner; " Superconducting stability '90 : a review " , Cryogenic, Vol.31, p489 (1991)