§11. Stability Analysis of a Curved Saddle Shaped Superconducting Coil with Conduction Cooling

Obana, T.,
Ogitsu, T. (KEK)

Conduction cooling system has much attention in the development of the superconducting accelerator magnet for medical application. In the conduction cooling system, a superconducting coil is cooled with a refrigerator through cooling plates. Compared with immersed cooling and forced flow cooling, the conduction cooling tends to cause large temperature distribution in the coil. It is necessary to evaluate the thermal stability of the superconducting coil in the coil design. Hence, the thermal stability of the conduction cooled superconducting coil was examined using the developed quench code.

Fig.1 illustrates the schematic view of the coil configuration used in the analysis. The coil configuration is a saddle shaped coil which is curved along the longitudinal direction. The coil is wound with NbTi/Cu wires of Φ1 mm, and the gap between wires is impregnated with epoxy region. The specification of the coil is as follows: the coil bore is 100 mm, the number of the turn is 15, coil bending angle is 45 degree, and the coil bending radius is 5 m. The cooling plates of pure Al cover the coil along the longitudinal direction.

In the initial condition, the temperatures of the coil and cooling plates are 5.0 K. In addition, the coil current is 500 A and the heat input is 1.4 kJ/m^3 at the innermost turn during 1.0 ms, as the simulation of thermal disturbance in the coil. In the boundary condition, the heat transfer coefficient of the epoxy region is used at the boundary between the coil and cooling plate, and other boundary is adiabatic. Fig.2 illustrates the quench protection circuit which includes a external resister of 10 mΩ and active switch.

Fig.3 shows the maximum coil temperature after quench in the cases that the coil is covered with the cooling plates and the coil is not covered with the cooling plates. As shown in Fig.3, there is no difference in each case until 0.05 sec. However, the cooling plates have an effect on the maximum coil temperature after 0.05 sec. Heat transfer of the coil without the cooling plates is a problem because of large thermal resistance between coil turns. On the other hand, the heat transfer improves with the cooling plates. As a result, the thermal disturbance can diffuse in the whole of the coil by using the cooling plates. The cooling plates enable the coil to increase the thermal stability.

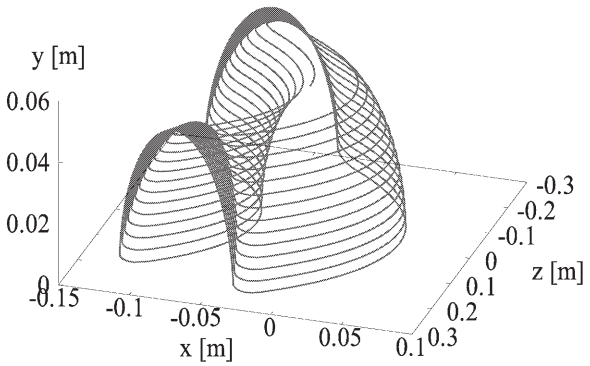

Fig. 1. Curved saddle shaped coil.

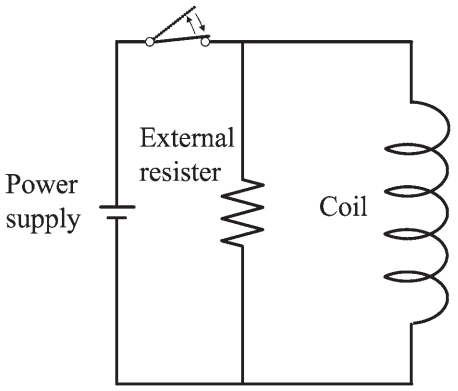

Fig. 2. Quench protection circuit.

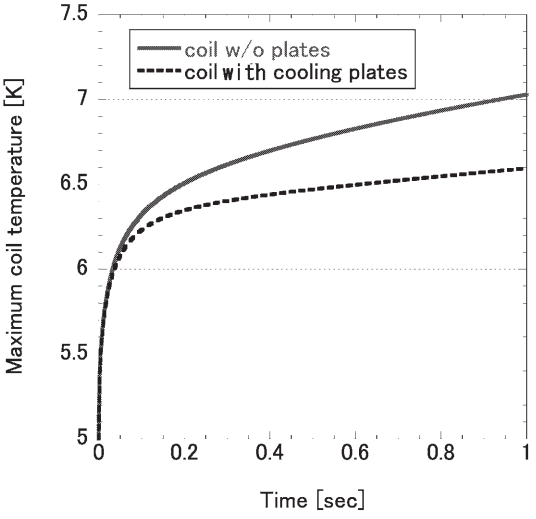

Fig. 3. Maximum coil temperature after quench.