§20. Research on Quench Detection and Protection of Superconducting Magnet

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In a large superconducting coil system like LHD, it is very important to operate the coils safely by an improved quench detection and protection technique. While, the minimum quench energy during a mechanical disturbance is important essentially on a practical point of view. And, for a future improvement of higher magnetic field, the introduction of oxide superconductors should be investigated. So, in fiscal year 1996, we have carried out; (1) investigation of an on-line monitoring, control, and protection system for the LHD introducing a fuzzy theorem, (2) artificial quench experiment of superconducting coil induced by mechanical disturbance using impact hammer, (3) monitoring of degradation of oxide superconductor tape using ultrasonic wave.

The obtained results are shown as follows:

(i) On-line monitoring, control, and protection system for LHD using fuzzy theorem

In the LHD system composed of many helical and poloidal coils, the quench detection is considerably difficult because of the effect of the magnetic induction voltage induced not only by the self-inductances but also by the mutual inductances. Therefore, we investigated the hierarchical fuzzy monitoring, control, protection system for the LHD superconducting coil system. In this system, the voltage, current, strain, temperature signals of each independent superconducting coil are transferred to each signal processing computer, and the data are synthesized to the first level "dangerous rate" using fuzzy theorem. In the next step, the first level "dangerous rates" of each coil are transferred to the upper level decision-making computer. It calculates the whole system "dangerous rate", and makes the overall decision. We investigated the necessary devices and data-processing speed of this system.

(ii) Artificial quench of superconducting magnet by mechanical disturbance

We carried out an experiment of artificial quench of a small superconducting magnet induced by mechanical disturbance using impact hammer. From the investigation on the relation between the injected mechanical energy and the quench, it is confirmed that when the injected disturbance energy exceeds one definite value the magnet induces a quench.

(iii) Non-destructive test of degradation of oxide superconductor tape induced by bending stress using ultra-sonic wave

For the realization of a future fusion testing device with higher magnetic field, the introduction of oxide superconductor would be an alternative. For the fundamental study of this matter, we investigated experimentally the degradation of the oxide superconductor tape by bending stress. The experimental result shows that if the tape conductor suffers the bending strain of more than 0.2%, it can be detected at room temperature as the change of the acoustic transfer function for an ultra-sonic wave. As the oxide superconducting tape doesn't exhibits degradation for the bending strain of less than 0.3%, the bending with a radius of more than 50mm generates no degradation for the tape conductor with thickness of 0.2mm. Therefore, it becomes clear that fundamentally the oxide superconductor can be applicable to the large superconducting coil like LHD.

References

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