§10. Study on Cryogenic Electrical Insulation for Large Scale Superconducting Coils

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The world's largest class superconducting coil is being used for the "Large-scale Helical Device". The electrical insulation system is exposed to considerably severe multiple stresses including cryogenic temperatures, large mechanical stresses and strong magnetic fields. It is therefore very important to study on its electrical insulation system in order to establish the reliability of the coil. In this study, surface flashover characteristics at cryogenic temperature were clarified in order to give information to consider the reliable operation of the coil system.

A preliminary experiment was performed at liquid nitrogen temperature prior to that at liquid helium temperature. Figure 1 shows an electrode system simulating the composite insulation system in the coil. A spacer made from acrylic resin was inserted between two flat electrodes. The flashover characteristics were measured in either gaseous nitrogen or liquid nitrogen.

In gaseous nitrogen, when the small gap spacer has good contact with electrodes, flashover occurs mostly not along the spacer surface, but at the point apart from the spacer. Flashover voltage followed Paschen's law and depended only on the product of gas density and gap distance, even though there existed the spacer between electrodes. However, when the contact between the spacer and the electrode was not good and there existed a small gap, the flashover voltage decreased and depended on the small gap area directly connected to the spacer edge rather than the total gap area.

In liquid nitrogen, flashover occured along the spacer and the flashover voltage depended on the spacer and small gap area when the spacer existed between the electrode[1]. It is shown in Fig. 2 that the flashover voltage decreases when the system includes a spacer. It would be due to the small bubbles generated by the electric field. They would be attached on the spacer surface to reduce the flashover voltage. The enhancement of electric field at the spacer edge might also influence the reduction in the flashover voltage.

Figure 3 shows the influence of contaminant. Tungsten wires with different diameters were placed on the center of the lower electrode surrounded by the spacer. The flashover voltage decreased by the existence of foreign substances, the reduction being as much as 10 - 30 %. As shown in the figure, the flashover voltage decreased with increasing the thickness or number of foreign substances. A conductive foreign substance would bring the generation of bubbles because of field enhancement, leading to the decrease in flashover voltage.

It is therefore concluded that a special care should be taken to avoid contaminants between electrodes and spacers in operating cryogenic insulation system. Further study for quantitative clarification of flashover characteristics at liquid helium temperature is being carried out.

Reference
1) Shmizu, Y., Minoda, A., Hozumi, N., Kosaki, M., Satow, T. & Nagao, M., National Convention, IEEJ, 2-045 (2000).

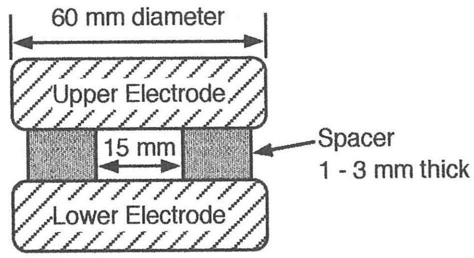

Fig. 1 Electrode system for flashover test.

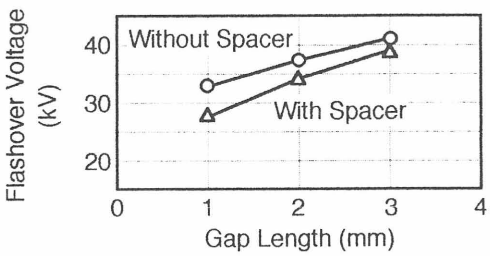

Fig. 2 Flashover voltage as a function of gap length.

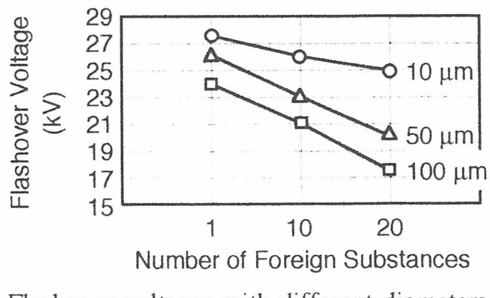

Fig. 3 Flashover voltages with different diameters of foreign substances.