§13. Composite Electrical Insulation and its Reliability at Cryogenic Temperature for LHD

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The world's largest class superconducting coil is used for the "Large-scale Helical Device". Its electrical insulation system might be exposed to considerably severe multiple stresses including cryogenic temperature, large mechanical stresses and strong magnetic fields. It is therefore very important to study its electrical insulation performance in order to establish the reliability of the coil. If a superconductor quenches from superconducting state to normal state, the liquid coolant vaporizes very easily and turns into high-density gas at cryogenic temperature, which may reduce its withstanding voltage. Furthermore, it is very difficult to completely remove foreign particles from the insulated space. So it is required to clarify the influence of foreign particles and electrification on the insulation performances.

1. Breakdown characteristics of spacer surface in liquid helium

This research was conducted using electrode system that simulated the insulation system to investigate the behavior of small gaps and foreign particles with the breakdown characteristics of insulation. The breakdown voltage of insulation system that has a small gap in liquid helium is shown in Fig.1. The breakdown voltage increased with decrease of voltage rising rate when the polarity of voltage was positive, but the breakdown voltage was almost constant with decrease of voltage rising rate when the polarity of voltage was negative. Assuming that positive charge can move along the spacer surface that is in contact which the metallic electrode, lower rising rate of applied voltage would bring more significant charge accumulation on the spacer, leading to the field enhancement which reduces the breakdown voltage. It became also clear that conductive foreign particles affect the breakdown voltage while dielectric foreign particles do not.

2. Electrification of cryogenic liquid flowing electrical insulating pipe

It has been considered that liquid nitrogen is not electrified because it is an inert liquid. However, the electrification of liquid nitrogen flowing through a straight insulating pipe was found by the previous experiments. Relation between number of filters (20meth) in a PVC pipe and the amount of charge of liquid nitrogen is shown in Fig. 2. The PVC pipe was 1m in length, 18mm in outer diameter and 13mm in inner diameter. Filers also were made from PVC. The filters were placed inside the pipe, each filters being vertically. The amount of charge of liquid nitrogen increased with increasing the number of filters. It is suggested that increase of contact area between liquid nitrogen and filters results in increase of amount of charge. In addition, it was found that the electrification was more intense when the filter was placed closer to the inlet of liquid nitrogen.

Reference
1) Ishizuka, T., Murakami, Y., Hozumi, N, Nagao, M., Minoda, A., Muramoto, Y., Kosaki, M. & Yamada, S., 2004 National Convention Record I.E.E. Japan, No. 1-011 (2004)
2) Noda, T., Okada, H., Mizuno Y. & Minoda, A. , 2004 National Convention Record I.E.E. Japan, No. 2-026 (2004)

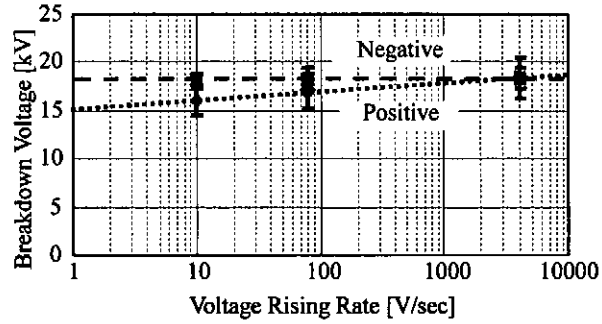

Fig.1 Dependence of breakdown voltage on voltage rising rate in composite insulation system containing a small gap.

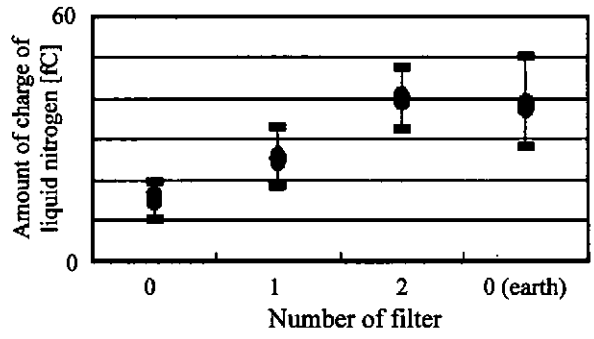

Fig.2. Flowing electrification of liquid nitrogen