§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 under these severe conditions 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 minute gaps from the insulated space. So it is required to clarify the influence of minute gaps and electrification on the insulation performances.

1. Influence of Micro-bubble on Breakdown Voltage of Electrode System Imitated Minute Gap in LN_2

This research was conducted using electrode system that simulated the insulation system included minute gaps to investigate the behavior of micro-bubble with the breakdown characteristics of insulation in LN_2. Fig.1 shows electrode system arrangement.

The breakdown voltage of insulation system that has a minute gap is shown in Fig.2. The breakdown voltage was measured by changing the angle of electrode to buoyant force with minute gaps and without minute gaps. The breakdown voltage increased with increase of the cooling time in all cases. When an angle is 0-degree that buoyant force direction and electric filed direction are the horizontal, the breakdown voltage with minute gaps is smaller than it without minute gaps. The tendency is also same with an angle of 90-degree that buoyant force direction and electric filed direction are the perpendicular. It is consider that micro-bubble agglomerates in minute gap and the agglomeration of the micro-bubble encourage the electric breakdown.

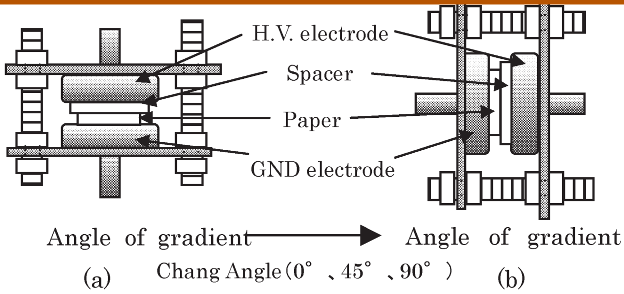

Fig.1 Electrode system arrangement

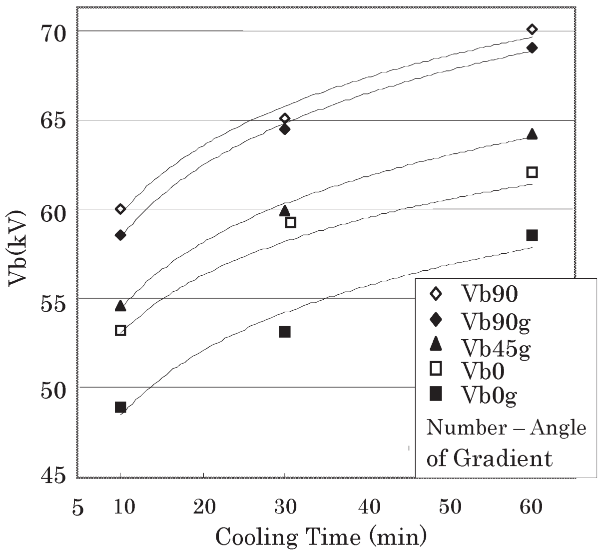

Fig.2 Influence on breakdown voltage by difference between gap position and angle of gradient

2. Effect of surface electrification on flashover voltage of polymeric rod immersed in liquid nitrogen

Flashover voltage of acrylic rod (20mm in diameter and 5mm in length) between disk electrodes of 30mm in diameter was measured in liquid nitrogen by increasing applied ac voltage till flashover occurred.

Two kinds of pre-treatments were made for the rod. One is cleaning of a rod surface with alcohol in order to remove surface charge, which was confirmed with surface potential meter. The other is rubbing a rod witha cloth in order to produce surface charge artificially.

Flashover voltages of alcohol-cleaned samples were higher than those of rubbed ones. The result may be attributed to enhancement of local electric field caused by surface charge of the sample.

Reference

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