§7. Reliability of Cryogenic Composite Electrical Insulation 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. The partial discharge (PD) or electrification would become the cause of this quench. So it is required to clarify the influence of the PD and electrification on the insulation performances.

1. Measurement of PD characteristics and PD current waveform in composite insulation system of LN_2 and solid insulator

This research was conducted using electrode system that simulated the insulation system included triple junction, which is consisting of the electrode, solid insulator and LN_2, to investigate the PD phenomena.

Figure 1 shows typical current waveform of PD under the condition of the super cooling. Under the super cooling, the half band width is about 12 ns because micro bubble was not generated by the PD. The current waveform of PD under atmosphere pressure is shown in Fig.2. The half band width is about 20 ns and is longer than that compared with Fig.1. Under the atmosphere pressure, both of Fig.1 and Fig.2 were observed as the current waveform. It is considered that longer half band width is observed due to the generation of the micro bubble.

Figure 3 shows classification of the PD by the half band width under the atmosphere pressure. The PD pattern was clearly separated into two clusters. It is thought that the open circles and solid circles in Fig.3 indicate the PD in LN_2 and in micro bubble, respectively. Therefore, it is suggested that the current waveform measurement with the measurement of the PD pattern brings the possibility to ascertain presence of the micro bubble in LN_2.

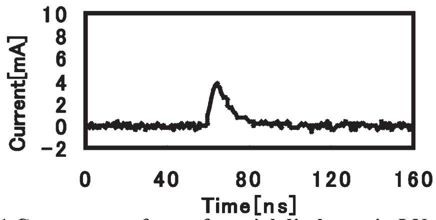

Fig.1 Current waveform of partial discharge in LN_2 (12[ns])

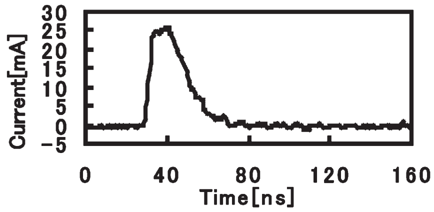

Fig.2 Current waveform of partial discharge in bubble (20[ns])

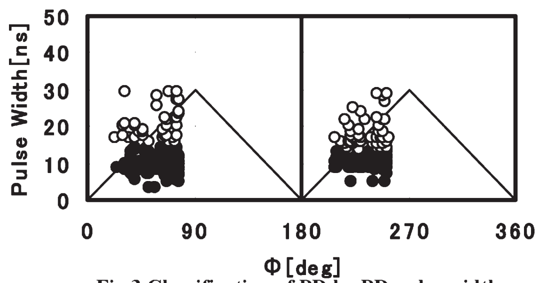

Fig.3 Classification of PD by PD pulse width

2. Electrification of liquid nitrogen flowing electrical insulating pipe

The measurement system of electrification of nitrogen was improved by using an instrument with higher internal resistance. Amount of charge of liquid nitrogen was measured with a so-called Faraday cage, which passed inside a PVC pipe of 1 m in length and 13 mm in inner diameter. The measured charge lay in the range of 100-300 pC for 1000 cm^3 liquid nitrogen, which was much bigger compared with charge measured in a former system.

When a joint was introduced in a straight PVC pipe at its center length, the amount of charge increased. When a cylinder of acrylic resin was placed in the space of liquid nitrogen flowing in the PVC pipe, the amount of charge was also increased. Uneven inner surface at the joint or increase in surface area by the cylinder may result in increase in charge.

Reference

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