§6. 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. In these bubbles partial discharge (PD) easily occurs and would lead to the breakdown. So it is required to clarify the influence of the PD on the insulation performances.

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 (or GN_2) in Fig.1, to investigate the PD phenomena at cryogenic temperature.

Figure 2 shows typical PD current waveform in (a) (b) LN_2 under the atmosphere pressure and (c) GN_2 at 77 K. The bandwidth of short type and the bandwidth of long type on the PD current waveform were typically observed in LN_2 under the atmosphere pressure while the PD current of long type was only observed in GN_2 at 77 K. After the higher frequencies than 6 dB in the power spectrum in Fig.2 on the frequency domain were eliminated by low-pass filter, the bandwidth was estimated by the inverse Fourier transformation.

Figure 3 shows classification of the PD current waveform by the half bandwidth. In Fig.3, the horizontal axis and vertical axis indicate the phase of applied voltage and the half-bandwidth, respectively. In LN_2 under the atmosphere pressure, the PD pattern was clearly separated into two clusters as open circles shown in Fig3. The half bandwidth, being larger in the two clusters, also agreed with that in GN_2 at 77K. It is thought that the larger half-bandwidth and smaller half-bandwidth in Fig.3 indicate the PD in micro bubble and in LN_2, 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. And a frequency analysis of PD current waveform also leads to the appropriate separation between the PD in LN_2 and that in micro bubble.

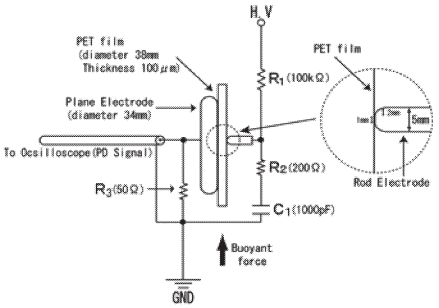

Fig.1 Schematic diagram of electrode

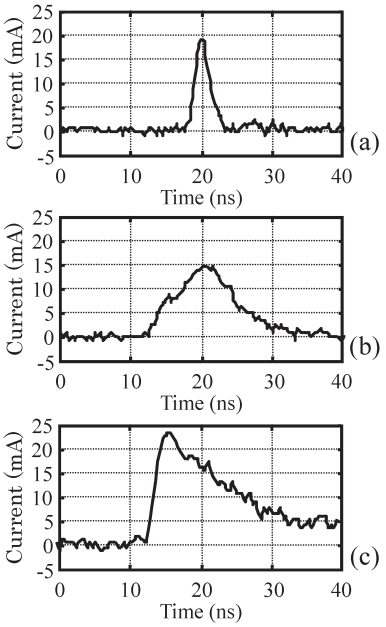

Fig.2 Typical PD current waveform

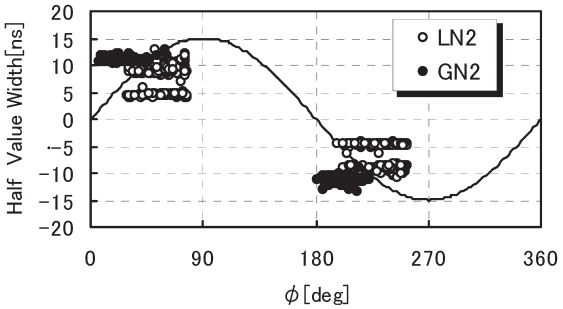

Fig.3 Classification of the PD current waveform by the half bandwidth

Reference

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