§14. Establishment of Partial Discharge Protection Technology for Reliability Improvement of Electrical Insulation of LHD

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The world's largest class superconducting coil is used in the "Large-scale Helical Device" in NIFS. Its electrical insulation system is 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, 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 electrical breakdown. The PD detection by impedance is often used but it is difficult to connect the detecting impedance into the actual equipment. So, PD detection using an antenna has more advantage than that using the detecting impedance in some cases. However, the radiation of EM waves may be detected directly from the PD source and indirectly from the circuit current around the PD source. We already detected radiation of EM waves from the circuit current and investigated the effect of the discharge type on frequency spectrum of the radiation of EM waves. In this paper, for the creeping discharge or the gap discharge, it is investigated the voltage application dependence of radiation intensity of EM waves from circuit current

Figure 1 shows the PD generation and measurement circuit system. The arbitrary pulse voltage was applied to two needle - plane electrode systems with the detection side and the voltage source side. During the measurement of the EM wave radiation from the PD source, the electrode with the voltage source side was shorted, and PD was generated on the electrode system with the detection side. Further, when the EM wave radiation from the circuit current is measured, PD was generated on the electrode with the voltage source side, and the electrode with the detection side was shorted. The radiation of EM waves was measured using discone antenna with frequency band from 30 MHz to 3 GHz. The discone antenna was placed 15 cm from the needle - plane electrode 2. In this circuit, we connected 50 Ω to measure the PD charge amount.

Figure 2 shows the PD current waveform. In Fig.2, the PD current waveform is also changed by PD characteristics not only by the circuit constants. In this study, we estimated the charge amount by using the area of the internal envelope as shown in Fig.2. Figures 3 and 4 show frequency spectrum of the radiation of EM waves for two discharge types and the voltage application dependence of EM intensity or charge amount, respectively. In Fig.4, the used EM intensity was the maximum value near 0.2GHz in which significant increase of EM intensity can be found under voltage application in Fig.3. In this result, the EM intensity and charge amount increased with increasing of applied voltage regardless of the discharge type. In general, an antenna was set the near the PD source. Form the above result, it is suggested that it is possible to detect the PD by leaked EM radiation form the connecting electric circuit.

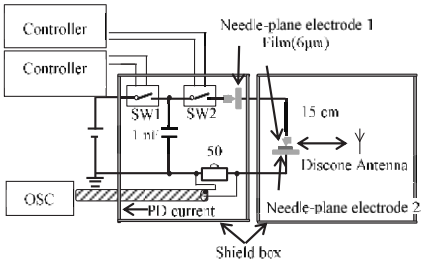

Fig. 1. PD generation and measurement circuit system

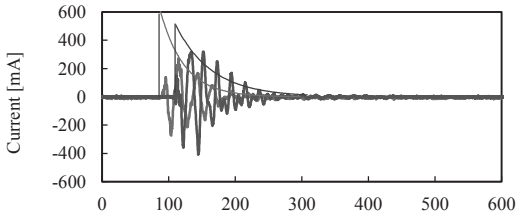

Fig.2. Example of measured PD current

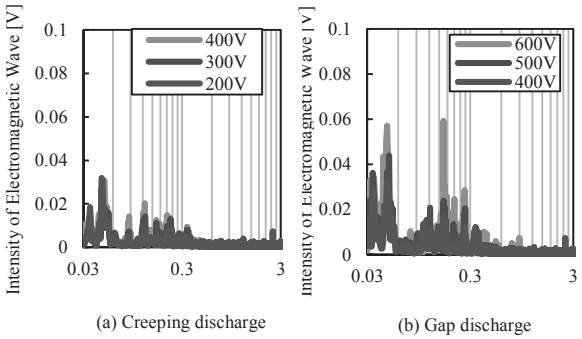

Fig.3. Frequency spectrum of radiation EM

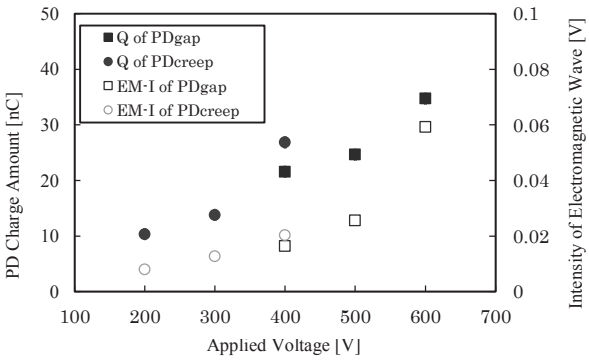

Fig. 4. The applied voltage dependence of EM intensity and PD charge amount by different discharge type