§9. Establishment of Partial Discharge Protection Technology for Improvement of Electrical Insulation Reliability 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 bubbles at cryogenic temperature. In these bubbles, partial discharge (PD) easily occurs and would lead to the electrical breakdown. We already detected electromagnetic (EM) wave emitted from PD using an antenna. However, the radiation of EM waves may be detected directly from the PD source and indirectly from the circuit current around the PD source. In this paper, it is investigated the influence of the PD signal source on the frequency spectrum and the radiation intensity of EM waves. In addition, the influence of PD type on frequency spectrum and radiation intensity of EM waves was also investigated.

Figure 1 shows the PD generation and measurement circuit system. The arbitrary pulse voltage was applied to two needle - plane electrode systems in the detection side and the voltage source side. During the measurement of the EM wave radiation from the PD source, the electrode in the voltage source side was shorted, and PD was generated at the electrode in the detection side. On the other hand, during the measurement of the radiation of EM waves from the circuit current, PD was generated at the electrode in the voltage source side, and the electrode in 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 at 15 cm from the needle - plane electrode 2.

Figure 2 and Figure 3 show the frequency spectrum of radiation intensity of EM waves from the PD source or that from the circuit current in creeping discharge and gap discharge, respectively. From the result in creeping discharge, the radiation intensity of EM waves from the PD source is smaller than that from the circuit current. In addition, the radiation of large EM waves from the PD source contained several frequency components in creeping discharge. It is considered that the creeping discharge of different intensity may occur in the different direction on the sample film surface at almost the same time. On the other hand, the radiation of large EM waves from the circuit current occur around one frequency. This may be because the circuit current flows to one direction in the circuit or the resonance of circuit is involved.

From the results in gap discharge, the radiation intensity of EM waves from the PD source is larger than that from the circuit current. Further, the radiation of large EM waves from the PD source and from the circuit current showed the same tendency to concentrate around one frequency. This is because gap discharge occurs in one direction between needle-plane electrodes. Furthermore, the radiation intensity of EM waves from the PD source was large compared with that from the circuit current. Thus it is suggested that the discharge type affects the frequency spectrum of EM wave. Therefore, it may be possible to separate the partial discharge of liquid coolant and vaporized gas coolant based on the difference in the frequency spectrum of EM wave from the PD source.

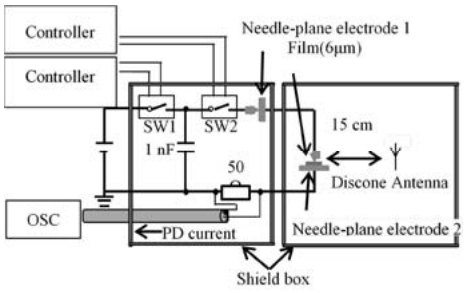

Fig. 1. PD generation and measurement circuit system

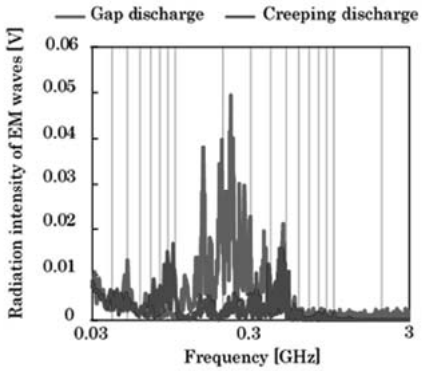

Fig. 2. Effect of the discharge type on frequency spectrum of the radiation of EM waves from the PD source

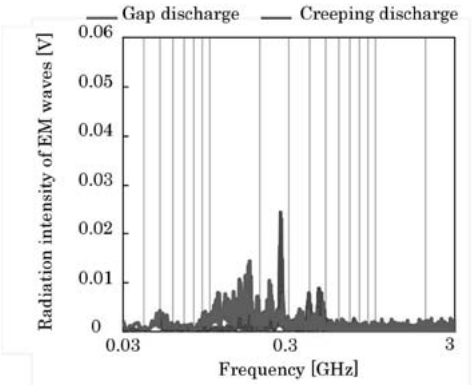

Fig. 3. Effect of the discharge type on frequency spectrum of the radiation of EM waves from the circuit current