§ 17. Study on Electrical Insulation under Practical Condition of a Superconducting Coil Operation

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1. Introduction

A superconducting coil of LHD is exposed to various stresses, such as a thermal, electrical or mechanical one. The LHD coil should be stably operated even under these stresses. In this project, the authors studied electrical insulation under practical coil operation conditions. This year, special efforts were made to clarify [1] residual charge distribution generated by partial discharge (PD) in a solid insulator void and [2] behavior of cylindrical metallic particle under high electric field in pool boiling liquid helium. Data obtained in this project would be useful for electrical insulation design of LHD coils in Phase II, in which HeII will be employed as liquid coolant as well as electrical insulation medium.

2. Results

2.1 Electrical charge distribution generated by void PD [1)]

Dc superconducting coils used in the LHD are energized by power source equipments which contain a lot of power electronics circuits such as an inverter. Transient surge voltages, which are generated by the inverter circuit, may influence PD characteristics and resultant electrical degradation process of solid insulation system. In this study, visual observation of PD charge distribution within an artificial air-filled void were conducted at liquid nitrogen temperature (77K) and room temperature (298K). At 77K, a special technique called "frost figure method" was employed. The results showed that charged area S_{PDch} created by each PD became smaller at 77K than that at room temperature (Fig.1). A theoretical consideration revealed that the smaller charged area were related to smaller PD charge magnitude at 77K.

2.2 Behavior of cylindrical metallic particle under high electric field in pool boiling liquid helium [2, 3)]

We have already investigated behavior of a spherical conducting particle in liquid helium to understand electrical insulation environment in pool cooled superconducting devices under particle contamination conditions. In this project, we newly investigated behavior of a cylindrical conducting particle, which might be more realistic and general shape. Experiments were conducted with dc stressed parallel plane electrodes containing a metallic particle of various materials (Al or Cu) and sizes. Experimental results showed that a cylindrical particle showed a complex behavior with a random rotation. Bubble was generated at every moment of the particle end hit the electrode. Although bubbles were generated at every collision, micro discharge was generated only at the first collision. This implies that kinetic energy of a moving particle is larger than the micro discharge energy injected into liquid helium.

References

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3) Hara, M., Nakagawa, H., Shinohara, T. and Suehiro, J.: "Generation, growth and collapse of bubbles on collision of particle with electrode in dc electrically stressed liquid helium", IEEE Trans. on Dielectrics and Electrical Insulation **9** (2002) 921

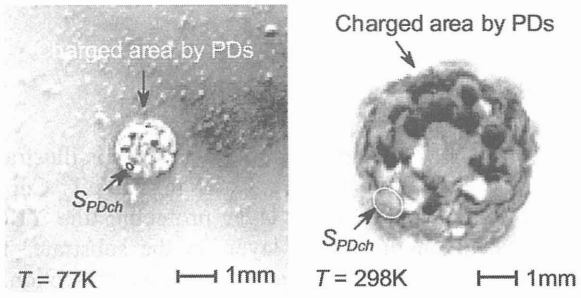

Fig. 1. Residual charge distribution on a surface of an artificial air-filled void due to partial discharges at liquid nitrogen temperature.

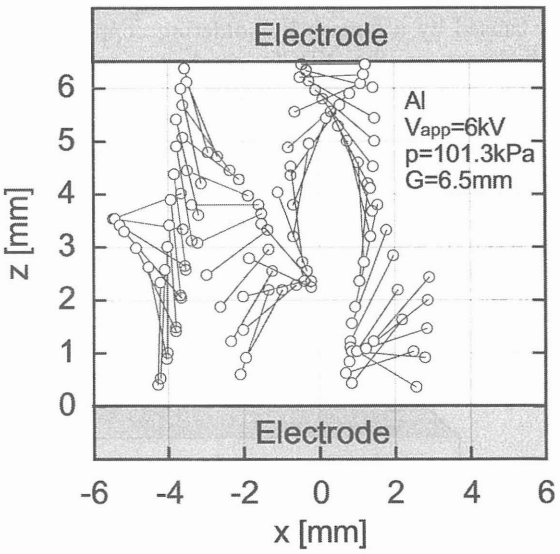

Fig. 2. Motion trajectory of a cylindrical Alminium particle in HeI.