§20. Degradation Mechanism of Solid Insulator System in Pool-Cooled Superconducting Coils

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1. Introduction

Electrical insulation in large superconducting (s.c.) coils is subjected to uncommon synergetic conditions in addition to all stresses in conventional coils.

The electrical insulation degradation in pool-cooled sc. coils is thought to be due mainly to particle contamination and to partial discharges (PDs) within the solid insulator at cryogenic temperatures. This is thought to be so because particles are accumulated inside the cryogenic vessel over the coil operation time, owing to no particle exhaust from the insulation space, and a defect such as a crazy crack in the solid insulator causes increasing with electromechanical load cycle and heat cycle during the coil life.

In the present work, the effect of free conducting particle on the prebreakdown phenomena in LN_2 and the PD inception characteristics in artificial air-filled voids at LN_2 temperature are studied experimentally.

2. Breakdown Characteristics in the Presence of Free Conducting Particles in LN_2[1-2]

Particle behavior, microdischarge between particle and electrode, and breakdown voltage characteristics in the presence of particles in LN_2 are investigated experimentally. The results show that 1) a free conducting particle is lifted off at a lower voltage than the dc breakdown voltage, 2) a microdischage triggers a complete breakdown of the gap, and 3) the breakdown voltage with free conducting particle becomes lower than the minimum measured breakdown voltage of a point-to-plane gap without particle in LN_2. **Fig.1** shows the typical breakdown characteristics when the parallel plane gap was contaminated with copper powder by sieve opening of 175 μm. This suggests that the electrode system having horizontal spacer surface (vertical arrangement) is the most severely affected by the particle contamination in the pool cooled s.c. coils.

3. PD Inception Characteristics in Artificial Air-Filled Voids at Room and Liquid Nitrogen Temperatures[3-4]

PD inception voltage and PD characteristics around the PD inception voltage in artificial air-filled voids are investigated experimentally at room and LN_2 temperatures. The results may be summarised as follows, 1) the PD inception voltage decreases with decrease in ambient temperature due to liquefaction of oxygen in air inside the void, 2) the PD intensity just after the PD inception at 77K is affected by the orientation of the void with respect to gravity, owing to the dependence of the vaporization (by PD heat) rate of condensed oxygen on the orientation, 3) three types of PD current waveforms (PD modes) were recognized both at 298K and 77K: streamer, Townsend and pulseless glow and, 4) the PD mode at 77K strongly depends on elapse time. **Fig.2** shows the change in PD mode with time at 298 and 77K. From these results, it is suggested that the degradation machanism of solid insulator at cryogenic temperatures differs from those at room temperature and that father more detailed research is necessary to improve the reliability of s.c. coils.

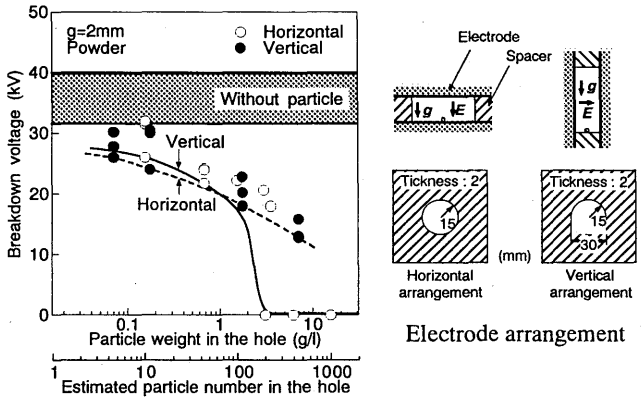

Fig. 1 Breakdown characteristics as a function of particle weight in the hole with powder, g=2mm.

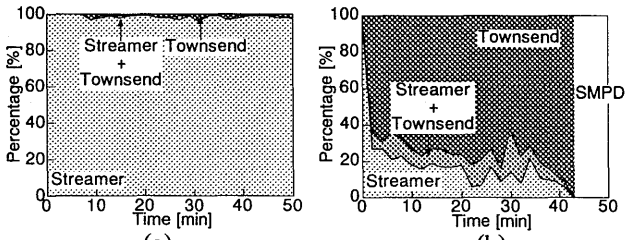

Fig. 2 PD mode dependence on elapsed time (Applied voltage 4.0kV). (a) At 298K(V_i=2.3kV). (b) At 77K(V_i=2.0kV).

Publications

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[3]S.Tsuru, et al.:Proc. of IEEE ISEI **2**, p.153 (1998)

[4]S.Tsuru, et al.:IEEE Trans. on DEI **6**, p.43 (1998)