Dynamic Breakdown Characteristics of Pancake Coil Model for Resistive Superconducting Fault Current Limiters

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***Abstract*—During the fault current limitation of resistive superconducting fault current limiter (RSFCL), a transient bubble disturbance in LN_2 due to the quench of HTS material is generated, which may induce an electrical breakdown in LN_2 even under the rated voltage of RSFCL. Toward the reliable and rational insulation design of RSFCL, we have been investigating not only the intrinsic breakdown characteristics of LN_2 without bubbles but also the dynamic breakdown characteristics of LN_2 under the transient bubble disturbance, where a fundamental model such as sphere-plane electrode system with quasi-uniform electric field has been adopted. However, when RSFCL will be introduced in a future electric power network, a stack of pancake coils with non-uniform electric field will be adopted for the practical development of RSFCL. Thus, it is necessary to investigate the intrinsic and dynamic breakdown characteristics of LN_2 using the pancake coil model with non-uniform electric field.**

In this paper, we designed and fabricated a pancake coil model for RFSCL using the bifilar nichrome tapes (4 mm width x 0.3 mm thickness) instead of superconducting tapes. The coil was composed of the high voltage side and grounded side alternately with 3 turns each and the gap length of 2 mm or 6 mm between the adjacent tapes, concentrating the electric field at the tape edges. Using the similar method with sphere-plane electrode system, we measured the intrinsic and dynamic breakdown characteristics of the pancake coil models in LN_2 for different conditions, e.g. gap length, LN_2 pressure, stack number of pancake coils in parallel or series connection, vertical or horizontal arrangement of stack. Experimental results revealed that both of intrinsic and dynamic breakdown strength of the pancake coil models decreased with the increase in the stressed LN_2 volume, which was discussed and systematized in terms of the volume effect. The dynamic breakdown strength increased and asymptotically approached the intrinsic breakdown strength with the increase in the gap length and LN_2 pressure. In addition, the dynamic breakdown strength in the vertical arrangement of the pancake coil models was higher than that in the horizontal one. The intrinsic and dynamic breakdown mechanisms under non-uniform electric field of pancake coil models were discussed in consideration of the bubble behavior around the tape edges and between the coil turns. These experimental results and physical mechanisms on dynamic breakdown characteristics in LN_2 will contribute to the reliable and rational insulation design of RSFCL.

***Keywords (Index Terms)* — Bublle, electric insulation, pancake coil, quench, superconducting fault current limiter.**

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