A.3.6.

V-t Characteristics of PD inception for LN_2 Impregnated HTS Cable Insulation System

Naoki Hayakawa, Moriyuki Hazeyama, Tsuyoshi Kobayashi, #Toshihiro Takahashi, †Kenji Yasuda, Hitoshi Okubo
Department of Electrical Engineering, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, 464-8603, Japan
#Central Research Institute of Electric Power Industry, 2-6-1, Nagasaka, Yokosuka, 240-0196, Japan
†Super-GM, Umeda UN Bldg., 5-14-10, Nishitenma, Kita-ku, Osaka, 530-0047, Japan

In the last ten years, high temperature superconducting (HTS) cables have been developed in the world from the viewpoints of compactness and environmental compatibility. For the practical development of the HTS cables, it is inevitable to establish the electrical insulation techniques in liquid nitrogen (LN_2) / polypropylene (PP) laminated paper insulation system. Especially, V-t characteristics are quite important for the reliable insulation design and the testing for lifetime estimation of the HTS cables. V-t characteristics at breakdown (BD) in LN_2/PP laminated paper insulation system have already been investigated. However, few studies have so far focused on V-t characteristics at partial discharge (PD) inception as the precursor of BD, which can be more crucial to understand the insulation deterioration mechanism of the HTS cables.

From the above background, this paper discusses V-t characteristics at PD inception in LN_2/PP laminated paper insulation system. Sheet samples with different PP layers and butt gap conditions were used in this experiment. Experimental results revealed that, firstly, PD inception belonged to the initial failure category for each butt gap condition. Secondly, as shown in Fig.1, the lifetime indices n of V-t characteristics at PD inception were estimated to be about 100, irrespective of the butt gap condition. The difference in PD inception strength for different butt gap conditions was attributed to the volume effect, which can be evaluated by the statistical stressed liquid volume (SSLV) with consideration of the breakdown probability not only in the butt gap but also in the other thin layers between PP laminated papers. Thirdly, V-t characteristics at PD inception could be theoretically calculated in terms of Weibull distribution with scale and location parameters.

Furthermore, n values for V-t characteristics were compared between at PD inception and at BD, where n at BD was lower than n at PD inception. The reason may be attributed to the difference in the discharge mechanism. PD inception occurs mainly in the thin layers between PP laminated papers rather than in the butt gap, which was verified by the observation of PD light emission using a transparent electrode and an image intensifier. On the other hand, BD occurs via the butt gap filled with bubbles, which was suggested by the facts that the PD light emission moved to the butt gap region after the PD inception and was observed brightly in the whole area of the butt gap, and that a BD trace was found in the butt gap region. Thus, the lower n value for V-t characteristics at BD can be interpreted by the following discharge mechanism; PD in the butt gap generates bubbles with the lower dielectric strength than LN_2, which can accelerate the PD development in the butt gap and easily result in BD. Further discussions on the discharge transition mechanism from PD inception to BD are now in progress.

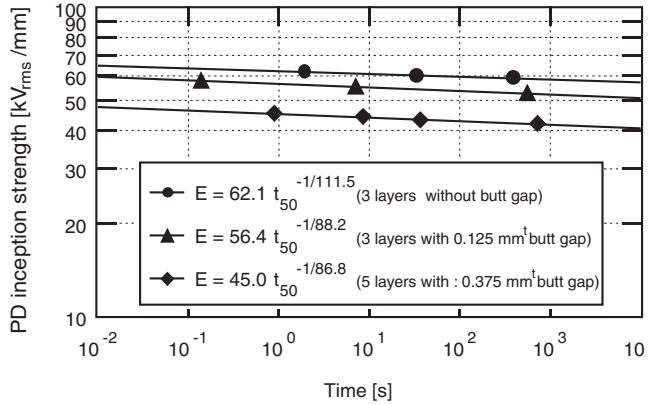

Fig.1. V-t characteristics at PD inception for different butt gap condition.