INVESTIGATION OF THE ELECTRICAL DISCHARGE BEHAVIOUR OF INSULATORS IMMERSED IN LIQUID NITROGEN

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Abstract: The flashover voltage of different materials in liquid nitrogen was investigated. Therefore cylindrical insulators, with a diameter of 20 mm and a height of 5 mm, 10 mm and 20 mm, were stressed with a 50 Hz sinusoidal voltage ramp which was raised with 1000 V/s. The degradation of the insulators and the influence of the gaseous nitrogen on the discharge voltage were investigated. Thereby, it could be seen, that the flashovers along the insulator surface were triggered by gaseous nitrogen bubbles, which could adhere to the insulator. Moreover the bubbles were deformed by the electric field before the breakdown occurred.

1 INTRODUCTION

For superconducting applications in the sector of power systems, it is essential that the insulation of conductors can withstand high voltages. Unlike discharges in liquid nitrogen, discharges in or on solid insulators could damage the insulators. Because of this the original insulation level can not be guaranteed anymore. This work investigates surface discharges along cylindrical specimen in liquid nitrogen to estimate the degradation effect of insulators.

2 EXPERIMENTAL SETUP

The examined specimens have a cylindrical shape and a diameter of 20 mm. The heights of the specimens were 5, 10 and 20 mm and they were made of PMMA with a turned surface and G10, a fibre reinforced plastic, with a fibre strand orientation parallel to the electric field. These specimens were clamped between two plate electrodes so that a homogeneous electric field can be guaranteed in the section of the specimen. An AC voltage ramp was applied on the configuration.

3 RESULTS

The resulting breakdown field strength in the reduced gap, due to the shrink of the materials, shows Figure 1. Thereby the breakdown field strength lies between 9.3 kV_{Peak}/mm and 12.9 kV_{Peak}/mm. A strong reduction of the breakdown field strength, due to the presence of an insulator between the electrodes can not be observed.

The behaviour of bubbles between the electrodes in the electric field was observed. Due to the electric force on boundary layers the bubbles are deformed in that way, that they get a conical shape. If the electric field is high enough, the cone becomes a cylindrical channel which bridges the gap between the plate electrodes and triggers the breakdown.

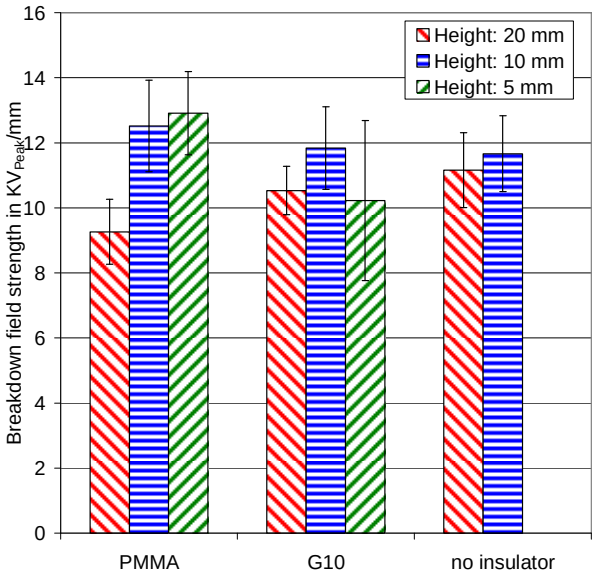

Figure 1: Electric field strength in the reduced gap, due to thermal contraction

4 CONCLUSION

Measurements of surface discharges in liquid nitrogen were carried out, using different insulating materials with different heights. It could be shown that no destruction of the small insulator occurs, but the long G10 got broken only after four discharges. The discharges along the specimens were triggered by gas bubbles which were created because of previous discharges. It could also be shown that the breakdown field strength of liquid nitrogen at its boiling point is limited by the breakdown field strength of gaseous nitrogen. This is a result of the deformation of the bubbles by the electric forces on boundary layers in that way, that a gas channel is build up between the electrodes.