Effects of switching impulse voltage on characteristics of electrical trees within silicone rubber

Baojun **HUI**, Mingli **FU;** Shuai **HOU**, Guoli **WANG**, Xiaolin **LI**, Electric Power Research Institute, CSG (China), huibj@csg.cn, fuml@csg.cn, houshuai@csg.cn, wanggl@csg.cn, lixl@csg.cn

Yunshun **Peng**, Man **XU**, Xi'an Jiaotong University, (China),ys_peng@outlook.com, xumman@xjtu.edu.cn

ABSTRACT

A number of breakdown failures occurred in 220kV *prefabricated silicone rubber cable joints in recent years, of which the reasons were attributed to development of electrical trees. Most failures happened when the circuit breaker was closing. In order to research the effects of switching impulse voltage caused by the closing action on the initiation and growth of electrical trees in silicone rubber, a series of tests were conducted during which different voltage waveforms(AC voltage，switching impulse voltage and their combination） were applied onto the samples and the electrical tree characterisstics were analyzed. The results showed that the electrical tree shapes varied depending on the applied voltage, and switching impulse voltage would destroy the silicone rubber electrical branch root channel, promoting the growth rate of electrical trees and shortening the breakdown time.*

KEYWORDS

Silicone rubber; Electrical tree; AC voltage; Switching impulse; Electrical tree shape; Breakdown.

INTRODUCTION

Silicone rubber insulations are increasingly used in high voltage (HV) and extra high voltage (EHV) extruded crosslinked polyethylene cable accessories, presenting attractive features such as excellent dielectric properties and good thermomechanical behavior[1]. However, there happened a cascade of breakdowns in 220kV prefabricated silicone rubber cable joints in recent years, most failures caused by internal electrical trees and under the case when the circuit breaker is closing. The electrical trees found in the faulty joints (shown in Fig.1) were quite different from previous laboratory studies, where most trees were branches, pine trees and stagnated trees [2].

The analysis of the electric field distribution showed that the maximum electric field strength of the joint was present in the high voltage electrode end, which was far lower than the rated value given by the manufacture. No breach of the protocol for the cable joint installation was reported, so we postulated that the impulse voltage applied onto the silicone rubber might be one of the factors that causing or promoting the growth of electrical branches.

To investigate the impacts of impulse voltage on the silicone rubber, experimental silicone rubber samples equipped with needle electrodes in this paper were investigated by the application of AC voltage, switching impulse voltage and their combination. The results of this paper can provide a technical reference for the analysis of cable joints' failures and the switching operation of the circuit breaker.

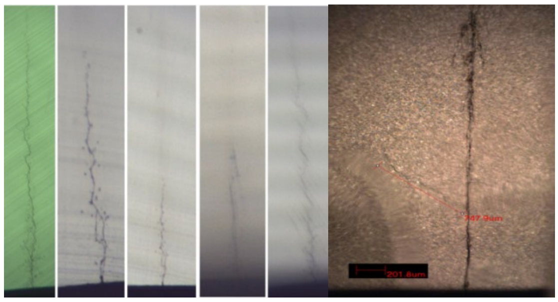

Fig. 1: Electrical branches found in anatomized faulty joints out of service

EXPERIMENTAL

Material and specimen preparation

The hot-vulcanized liquid silicone rubber(SIR) made by two-component liquid silicone rubber materials for high-voltage cable accessories was selected. Test samples equipped with steel needle electrodes were made 2mm thick slices, which were prepared by compression molding between highly polished copper plates. Steel needle of 1mm shank diameter and 20±1 μm tip radius was pre-fixed into the mold, and the two-component liquid silicone rubber was injected into the mold through the high-pressure glue gun, so as to avoid defects such as bubbles in the silicone rubber. Test samples of 2 mm thickness were made by the use of compression modling, where a 20±1 um needle tip of 1 mm length was placed within the mold, and two-component liquid silicone rubber was injected into the mold through high pressure glue gun as to prevent the bubble defects. The mold was than placed in a 393 K oven and heated for 1 hour, whereafter the mold was cooled and moved to another oven of 453 K for 3 hours to finish the secondary vulcanization and eliminate the mechanical internal stress.

The final sample is shown in Fig.2, the distance from the steel needle tip to the ground electrode of the silicone rubber sample is 2.0±0.1 mm.