Investigation of Electrode Erosion in Gas-Filled Spark Gap Switch

A. R. Baba, A. Mohanta, J. J. Pantoja, M. Alkaabi, A. Alebri, F. Vega, G. Matras, S. Al Marzooqi, A. Dubey, A. Alteneiji, R. Al Ameri, and C. Kasmi
Directed Energy Research Center,
Technology Innovation Institute,
Abu Dhabi, United Arab Emirates
abdul.baba@tii.ae

Abstract—In this work, erosion on electrodes used in gas-filled spark gap switches is experimentally investigated. Two different electrode profiles, including a new profile with axial holes proposed here for laser-triggered gas-filled spark gap switch, are considered. Based on experimental results, the life span of the electrodes and the degradation of main parameters, including rise time, and hold-off voltage, are estimated.

Keywords: Spark gap, Electrode profile, Streamer, Gas-filled spark gap switch, Electrode erosion

I. INTRODUCTION

Gas-filled spark gap switches have widely been used in pulsed power technology due to their simple construction, low cost, and ease of operation [1]. The reliability of gas-filled spark gap switches is based on the surface quality of the electrodes, gas decomposition and dissociation, and the insulator damage that occur as the energy is dissipated in the switch [2]. Different studies have been conducted to investigate the chemical and physical processes responsible for the erosion of the spark gap electrodes [2]. In this study, different electrode materials and profiles are considered. One of the profiles includes axial hole through which a femtosecond laser can be coupled axially between the two electrodes to trigger and achieve a lower jitter compared to the self-breaking spark gap switches.

II. ELECTRODE PROFILE

Erosion rates are determined by material, electrode profile, dimensions, gap length, polarity, voltage, and current. The profile with axial hole is shown in Fig.1. Due to the geometry and the field enhancement between the electrodes, it is important to investigate the erosion on the surface. The erosion rate of the electrodes is substantial around the tip of the electrodes in accordance with the electric field distribution shown in Fig. 2. Similar behavior has been reported for hemispherical and Rogowski electrodes [1] since discharges are confined around the center of the electrodes.

III. EXPERIMENTAL SETUP

Different electrode profiles and materials have been considered. The gap between the electrodes can be varied from 0.5 to 2 mm and nitrogen gas is used as a spark gap medium. The spark gap is connected to a charging capacitor through a resistor. The capacitor is charged by a DC voltage source capable of delivering up to 60 kV. The accurate distance between the two electrodes is measured with a feeler gauge. Erosion surface area is estimated by microscopic measurements of pits on the tips of the electrodes.

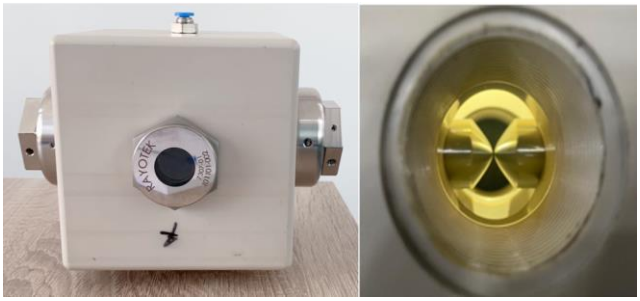

Fig.1 Laser-triggered gas-filled spark gap prototype design.

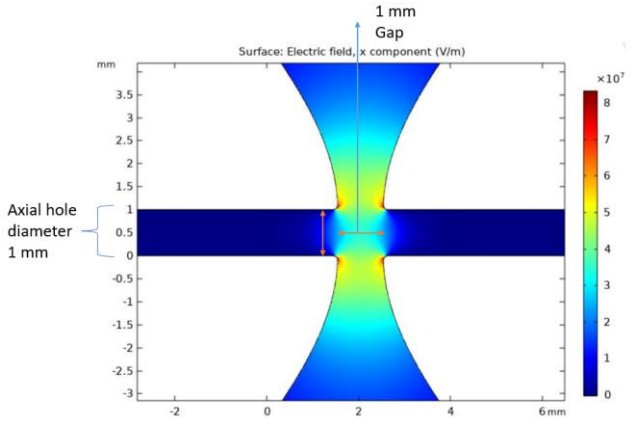

Fig. 2 Electric field simulation of electrodes with 1 mm gap distance for 50 kV.

IV. DISCUSSION

Electrode erosion after a certain number of pulses results in field distortion that degrades and deteriorates the hold-off voltage and rise time for high voltage applications. Electrodes have been subjected to high local pressure from the arc area due to the expansion of plasma which could lead to the pit formation on the tips of the electrodes. Appropriate selection of electrode profile along with material can reduce the electrode erosion rate, which can lead to higher reliability of the switch.

REFERENCES

[1] V. Gandi, R. Verma, M. Warrier, and A. Sharma, “Effect of Electrode Profile and Polarity on Performance of Pressurized Spark gap Switch,” Plasma, vol. 5, pp. 130–145, 2022.

[2] L. B. Gordon, M. Kristiansen, M. O. Hagler, H. C. Kirbie, R. M. Ness, L. L. Hatfield, and J. N. Marx, "Material Studies in a High Energy Spark Gap," IEEE Trans. Plasma Sci., vol. PS-10, pp. 286–293 (1982).