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Measured data and model for erosion of a spark gap at continuous 800 Hz, 10 J pulsed operation

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Spark gap closing switches feature superior switching characteristics in switching speed, current handling and voltage hold-off capability. Unfortunately these switches suffer from electrode erosion and the switching medium has to recover after each pulse, limiting the life-time and repetition rate of the switch. The recovery can be improved by purging the gap to remove heated and ionized gas and to cool the electrodes. The performance of the spark gap system of our pulsed corona demonstrator will be described on the aspect of erosion. The operation is a continuous train of short pulses at high repetition rate. The durations of each pulse is 100 ns, the peak current 3 kA, and repetition rate up to 800 Hz. The experimental erosion results for multiple electrode materials are presented. An analytical and a numerical thermal erosion model is proposed to estimate electrode evaporation rates. Electrode erosion during continuous operation was determined for six materials after 65 million shots. The investigated materials rank, at decreasing quality of performance, as follows: copper > brass > copper/tungsten > stainless steel > tungsten > aluminium. The copper cathode didn't show any erosion and gained some weight. Detailed SEM images are provided of all tested electrode materials. The developed analytical and a numerical models are both based on the heat equation. The 1D analytical model assumes a static spark radius, and estimates evaporation at a boiling surface. The 2D (rz-plane) FDM (Finite Difference Method) numerical thermal model features a more realistic spark radius which expands according to the trajectory of a shockwave. Time and space resolved heating of the electrode can be simulated, including evaporation and melting. The power input of the models is the product of the measured discharge current and estimated Veff (effective fall voltage) near the electrode. Comparison between modeled and experimental data give insight in the erosion behavior of the tested materials.

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