Interaction between arc and granular field during a ultra high speed short circuit in a fuse

Xavier JUST

Supervisors: Jean-Marc Chaix, Rémy Dendievel et Olivier Bonnefoy (Mines de Saint Etienne)

Monday, November 21st at 10:30 am

Amphitheater A022 "Louis Neel" - site Ampère

Abstract: The studied fuses are silver blades embedded in agglomerated silica sand. In case of short circuit, an electric arc appears in shrinked parts (“notches”) of silver blades. The structure formed after the cut (fulgurite) consists in an arc channel surrounded by amorphous silica. Extremely fast cuts (less than 100 microseconds) have been poorly studied.

After a bibliographical review, an experimental work was performed to understand how the arc power is absorbed by the surrounding material. Power cuts observations using in situ radiography performed at the ESRF allowed to establish links between fulgurite formation phenomena and electric measurements. Observations and measurements led to correlations between volume, nature and structure of the insulating mass generated during the power cut and electrical characteristics of the arc. In particular, these measurements provided characteristic sizes and shapes for heat affected zones during power cuts at high di/dt.

Numerical models were developed on this basis for describing the arc channel formation and determining the role of silica sand containment. 1D then 2D axisymmetric geometries were used. The electric arc was considered as a power source and the sand as an equivalent continuous medium. Two extreme cases were tested: when the vaporized material was confined to a closed arc channel and when it escapeed immediately from the arc channel. The results helped identify the consequences of gas containment in the arc channel during power cut.

Modeling vs experience correlations led to a simple model which gives information for optimizing new fuses. Some phenomena to be taken into account in future works have been identified, such as the liquid silica penetration and gas flow in the granular packing and the early stages of arc formation.

Keywords: fuse, arc/matter interaction, finite element modeling, ultra-fast radiography, X-ray micro-tomography