Ablated mass in high-voltage circuit breakers following the nature of electrode material

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In high-voltage circuit breakers (HVCB), the electrical arc created by the contacts opening, interacts with the device materials (PTFE walls and electrodes). The interaction of the arc with the electrodes leads to the presence of metallic vapours within the plasma due to ablation. These vapours greatly influence the behaviour of the arc as they modify the radiative transfer, as well as the plasma properties. We have been interested in electrode's composition. Indeed, depending of the electrode's material, the quantity of ablated metal differs changing the plasma behaviour. In this study two distinct electrode compositions: pure copper and copper-tungsten mixture are considered.

1. Introduction

During contact opening in HVCB, the arc interacts with the surrounding walls and the electrodes. The interaction with the Teflon nozzles (by radiation and conduction) must be considered as it allows the flow of gas to increase the pressure in the heating volumes. The PTFE wall ablation is taking into account in many models of arc in HVCB. In our study, we use the Christen's approach [1]. The second interaction which must be considered is related to the plasma with the electrodes. Due to its complexity and lack of experimental results this interaction is less considered in the literature. Its description requires the development of anode and the cathode models. In a thin layer near electrodes the plasma is out of equilibrium. Consequently, a hydrodynamic description is no longer suitable. To overcome the complexity of a kinetic approach, we chose to use Benilov's ablation model [2] to take into account the thin layer and the ablation of electrodes. It allows determining the properties at the layer/plasma boundary without resolving the non-equilibrium area.

A global description of the plasma with the electrodes interaction is realized using the @Fluent software. Depending on the current level vapours proportion change the plasma properties and the pressure increase in the heating volume.

2. Results

Considering pure copper electrodes we have previously studied the influence of the presence of metallic vapours on temperature field, radiation, electrical conductivity, on the ablated mass of PTFE or on the pressure rise in the heating volumes. In order to get closer to real configuration, we propose simulation results obtained with 20%Cu–80%W electrodes. We can see in the figure 1 versus time the copper mass ablated assuming a pure copper electrode and a Cu-W mixture. In the presented cases the alternative current is I=25kA.

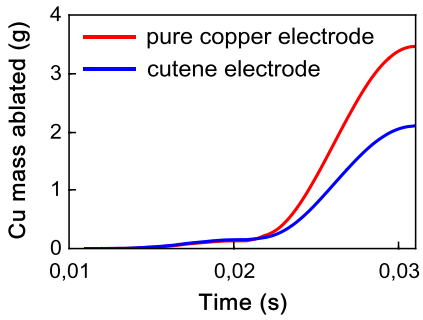

Figure 1: Copper quantity ablated from the electrode

Depending on the metallic vapours quantity the plasma properties are modified changing the HVCB behaviour. These results will be presented in a two dimensional (2D) configuration including pin and valve motions.

3. Conclusion

One transient turbulent 2D model is developed to describe the plasma behaviour in a HVCB. The interaction with the PTFE walls is considered (Conduction and Radiation by DOM and P1 models). The thin layers close to the electrodes are considered and the metallic vapour distribution calculated. Following the nature of the electrodes, the copper mass fraction field differs changing the plasma properties and the HVCB characteristics. These results will be presented and discussed.

4. References

[1] T. Christen. J. Phys. D: Apll. Phys. (2007).
[2] M.S. Benilov, S. Jacobsson, A. Kaddani, S. Zahrai. J. Phys. D: Apll. Phys. (2001).