Three-Dimensional Numerical Simulation of Arc Motion Between Bus-Bar Electrodes

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Abstract

The knowledge of the behavior of electric arcs between plane electrodes is in high interest due to their presence in industrial applications such as low voltage circuit breakers. In this contribution, numerical simulations of an electric arc displacement due to electro-magnetic forces are shown. These calculations are supported with experimental investigations.

It is generally difficult to establish theoretical model, of any kind of plasmas, and find its numerical solution. Electric arcs are thermal plasmas which could be described with system of magneto-hydrodynamic equations (MHD), while the plasma assumed to be in so-called local thermodynamic equilibrium (LTE). Ready-to-use Equilibrium Discharges physics interfaces are already present in COMSOL Multiphysics® for thermal plasma description. It contains Navier-Stokes equation, the equation of energy conservation, the one of current continuity supplemented with Ohm's law and the equation for vector potential.

The original part of our work concerns plasma-electrode interaction, where the high gradients of plasma temperature are taking place. In order to avoid discontinuities, the plasma calculation domain is interacting with the solid electrodes via zero-dimensional interfaces, which are realized in COMSOL Multiphysics® via a mapping tool.

High attention must be paid to the meshing procedure and a compromise needs to be found between discretization of the plasma domain near the electrodes and far away from it, since the calculation domain should be large enough to resolve magnetic field, which is a reason of arc displacement.

Mathematical complexity of the problem and the difficulties of its numerical realization are a stumbling block of many industrial researches. The calculation domain is 60x60x30mm, including the bus-bar electrodes (copper) and surrounding gas (argon at 1 atmosphere). The electrodes have a length of 40 mm, a 3x3 mm square cross section, and the gap between them is 20 mm. The arc is supplied with a DC current of 200 A and 4 milliseconds duration. Temperature distributions of the plasma in different time moments are presented on figure 1. The arc behavior shows good agreement with the experiment. In the authors' knowledge, such calculations were not made in such large scope using COMSOL Multiphysics® before.

Figures used in the abstract

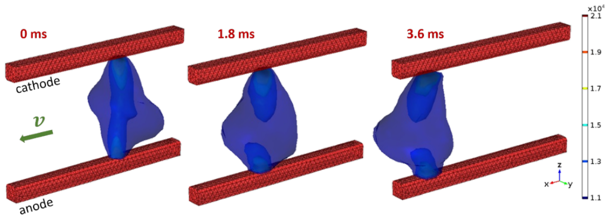

Figure 1: Three-dimensional temperature evolution of the arc plasma displacement along the electrodes.