Behaviour of a short electric arc between bus-bars electrodes: numerical and experimental study

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The behaviour of the 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 are shown. The calculations are supported with experimental investigations. Magneto-hydrodynamic approach has been chosen for the arc description, while the plasma is assumed to be in local thermal equilibrium. The arc movement is realized by displacement of the electrodes attachments, which is determined experimentally. The calculations are performed using commercial software COMSOL Multiphysics. The simulation results have been compared with the experiment, and show similar arc behaviour.

1. Introduction

Study of the electric arc displacement between bus-bar electrodes is of high interest due to many industrial applications, such as low voltage circuit breakers (CB) [1]–[3]. Understanding of the arc displacement behaviour helps to predict and control successful switching capability of the CB. The interest of the present work is to investigate similar phenomena in the context of its appearance in electrical networks of aircrafts, while an arc fault takes place. In this work, numerical simulations of the electric arc are performed and supported with the experimental investigations.

System of magneto-hydrodynamic equations provides mathematical description of the electric arc phenomena, while the arc plasma is assumed to be in local thermal equilibrium (LTE). The complexity arises with the arc displacement description, while there is still no universally accepted opinion about the underlying mechanisms.

Numerically the model has been realized using the commercial software COMSOL Multiphysics®.

2. Results

A three-dimensional modelling of a moving arc between the bus-bars electrodes is performed. The size of the calculation domain is 60x60x30mm, including the bus-bar electrodes (copper) and surrounding gas (argon at 1 atm). The electrodes have a length of 40 mm, a square cross section with 3x3 mm, and the gap between them is 20 mm. The arc is supplied with a DC current of 200 A and 4 ms duration.

The initial values of a stationary arc with fixed positions have been used to obtain the time-dependent solution of the problem. The cathode attachment exists in spot mode, as the anode one, while the spot radius and the temperature is introduced in the model as fixed parameters. Arc displacement along the electrode is realized by displacement of the cathode and anode attachments with fixed velocity. The different arc behaviour is observed for different displacement velocities. The example of the simulation results is presented in figure 1 for the fixed arc displacement velocity 5 m/s.

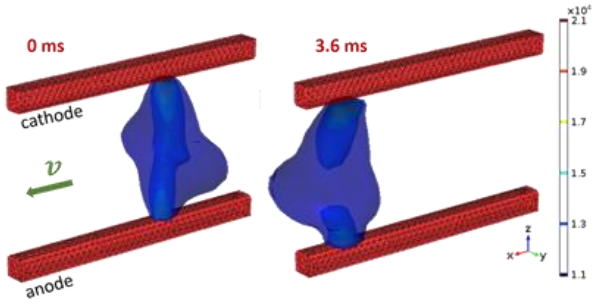

Figure 1: Temperature evolution (K) of the arc plasma.

The simulation results are supplied with the experimental investigations, which gives an estimation of the arc displacement velocity. High speed video-images of the arc emission have been compared with the computed arc temperature distributions and show similar arc behaviour.

3. References

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