Experimental and numerical study of electrical arc movement

J. Quéméneur[1], J-J. Gonzalez[1], P. Freton[1], P. Joyeux[2]

[1] *Université de Toulouse; UPS, CNRS, INPT; LAPLACE (Laboratoire Plasma et Conversion d'Energie); 118 route de Narbonne, F-31062 Toulouse cedex 9, France*

[2] *Hager Electro SAS, 132 boulevard d'Europe, BP3, 67210 Obernai, France*

The movement of an electrical arc between two parallel arc runners is studied by numerical and experimental approaches. The measurement setup and two methods to model the arc roots motion are presented alongside with a tool to determine the position of the arc using its light emission. The experiment consists in a simplified low-voltage circuit breaker (LVCB) chamber where voltage, current, pressure measurements and high-speed imaging are performed. 3-D computational fluid dynamic model based on the Fluent software is developed for the simulation of the arc in the same configuration as the experiment. Comparison between tests and modelling are presented.

1. Introduction

Electrical arc motion is a significant issue for several industrial applications such as breaking arcs, plasma torches, welding or in-flight lightning strike.

In LVCB the arc must be moved quickly from the opening contact to the extinction chamber. This improvement is mainly made by long empirical developments. Hence the industry is calling for predictive models. Here two numerical methods to simulate the arc movement are presented and compared to experimental results.

2. Experimental setup

LVCB have a complex design. For an easier study a rectangular arc chamber with two parallel iron electrodes is used. One of the lateral walls is transparent to allow high-speed imaging. The discharge can be ignited by contact opening or by a fuse wire. In order to get rid of the opening speed parameters the fuse wire ignition is used. The breaking current is a 50Hz sine wave up to 10kA.

3. Numerical model

A magneto-hydrodynamic model is developed to describe the plasma [1] and two different methods are used to calculate the arc motion:

In the first method named "Global Current Resolution Method" (GCRM), current density and heat transfer between the plasma and the metallic electrodes are solved neglecting the sheath mechanisms. This is an easy method to implement but it requires advanced calculation algorithms due to a strong difference of electrical conductivity between the two mediums. Therefore, calculation time is high.

In the second method, named "Mean Electrical Conductivity Method" (MECM), classical boundary conditions for anode and cathode roots [2] are used and applied where the electrical neighbouring conductivity of the plasma is the highest. Two arc roots can be specified on the same electrode.

4. Preliminary results & perspectives

A comparison between numerical and experimental results for the arc movement is presented Fig. 1. The good agreement validates the two methods used.

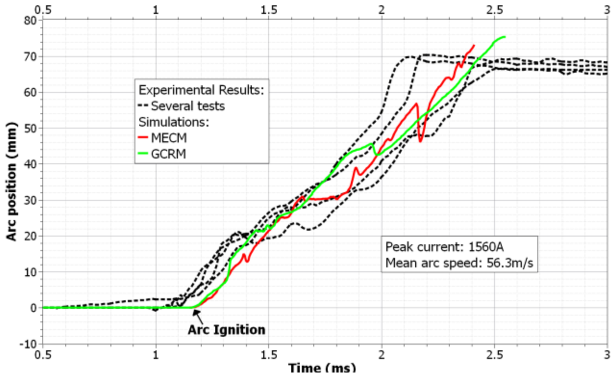

Fig.1: Experimental and simulated arc motion

With such tools we are able to investigate the parameters influencing the arc movement. To improve our model, description of the anodic [3] and cathodic [4] sheaths could be developed in order to allow a better description of arc commutation and calculation of the arc voltage.

5. References

[1] A. Gleizes, J-J. Gonzalez, P. Freton, J. Phys. D: Appl. Phys. **38** (2005) R153-183

[2] P. Freton, J-J. Gonzalez, A. Gleizes, J. Phys. D : Appl. Phys. **33** (2000) pp. 2442-2452

[3] F.Lago, J-J. Gonzalez, P. Freton, A. Gleizes, J. Phys. D: Appl. Phys. **37** (2004) 883-897

[4] M.S. Benilov, J. Phys. D : Appl. Phys. **41** (2008) 144001