Experimental and numerical study of arc commutation and restrikes in Low-Voltage Circuit Breaker (LVCB)

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An experimental setup and a numerical model to investigate the breaking process in LVCB are presented. The influence of current level, contact opening speed, geometry of the chamber or the materials used for the electrodes are studied using current, voltage, pressure measurements and high-speed imaging. The experimental results are also used to develop a Computational Fluid Model (CFD) based on the commercial Fluent software. When validated, this model is used for a better explanation of experimental observations and can be used for predictions on new configurations that have not been tested. Yet, description of phenomena such as restrike or commutation implies the ignition of a new arc root on the electrode and therefore necessitates taking into account sheath physics and departure from thermal equilibrium. The work done toward such a predictive model of arc behaviour in LVCB will be revealed.

1. Introduction

LVCBs, and in particular Miniature Circuit Breakers (MCB), are classical apparatuses of electrical protection commonly found in houses or offices. When an electrical fault is detected, the LVCB opens its contacts, creating an arc. The arc then commutates on rails and moves toward the splitters plates where it loses its energy and extinguishes due to a current limitation [1]. In the meantime, an arc may appear in the contacts area because the gap is smaller and the gas still hot. This phenomenon, called back-commutation or restrike, causes delay in arc extinction and reduces the efficiency of the LVCB.

Understanding and predicting arc commutation is both a scientific and industrial challenge as a reliable simulation would reduce the need for prototype to be tested in a long and costly empirical development.

2. Experimental setup

To reproduce the current fault we use a capacitor bench that is discharged through and inductor to produce a 50Hz current sine wave up to 10kA. This current supply can be used to test either industrial LVCBs or our test apparatus presented in Fig.1. This setup is composed of a simplified arc chamber and a mechanism to achieve contact opening at a speed chosen between 2 and 8m/s with repeatability and synchronisation. Dedicated post-treatment tools have been developed in order to analyse the experimental data and conduct statistical analyses since breaking arc are rather chaotic.

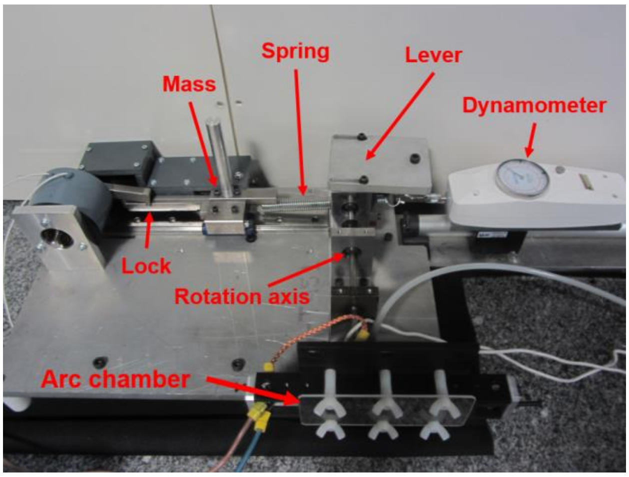

Fig.1: Experimental setup

3. Numerical model

A magneto-hydrodynamic model has been developed to describe the moving arc [2]. Several methods can be used and improvements have to be made in order to simulate commutation and to calculate the electrode fall voltage [3, 4]. Comparison between the behaviour of experimental and simulated arcs will be presented.

4. References

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