Short Circuit Arc Behaviour in Miniature Circuit Breakers

Electro-Mechanical Research Group

Dr J.W. McBride
Electro-Mechanical Research Group
School of Engineering Science
University of Southampton
Southampton SO17 1BJ. UK.
Telephone: +44 (0) 2380 592895
Fax: +44 (0) 2380 593053
E-mail: jwm@soton.ac.uk

Introduction

A high speed Arc Imaging System (AIS) has been developed that records the movement of the electric arc. The AIS is a modular data acquisition system that records the light intensity distribution in arc chambers using a fibre optic array. The AIS data can be used to replay the arc motion as a series of computer generated arc contour images, Fig. 1. A key feature of the research was the development of a software technique to identify the movement of the two arc roots; this technique is known as “arc root trajectory plotting”, Fig. 2.

Miniature Circuit Breakers

MCBs are small electro-mechanical devices, Fig.3, widely used in domestic and light industrial electrical installations to protect circuits against overcurrent faults of up to 25kA. When a short circuit fault occurs, an electric arc ignites between the contacts. The design of MCBs exploits the non-ohmic current / voltage characteristic of the electric arc to minimise the fault energy during a short circuit, Fig. 4. The conductors in the MCB are arranged so that after the arc contact time (t_i) a strong self-blast magnetic field drives the arc off the contacts, along arc runners (t_r) into the arc stack. In the arc stack, the arc splits into a number of short arcs, achieving a high arc voltage. This drives the fault current down (t_s) reducing the peak fault current and let through energy. However, the behaviour of the short circuit arc is erratic and cannot be accurately predicted over the range of conditions experienced in an MCB. Prolonged arc contact times lead to severe contact erosion and reduce the current limiting performance of the MCB.

The Research

The Arc Imaging System has been applied to short circuit arc behaviour in a Flexible Test Apparatus (FTA) Fig. 5, designed to simulate the current limiting operation of an MCB. The arc root trajectory plots have been used to study the individual arc root contact times. The roles of the cathode and anode roots during the arc contact time have been explored for a range of MCB configurations. The current density distribution and magnetic flux density in the arc root regions have also been modelled in 3D using a Finite Element Model, Fig 6.

The AIS and FTA are currently being used to study arc mobility on a range of contact materials. A further apparatus, BREAK 3 Fig. 7, is also being used to research the erosion and weld properties of the materials.

For further information, please contact Dr. J. McBride Email jwm@soton.ac.uk

Figure 1: Arc Contour Images recorded on the AIS

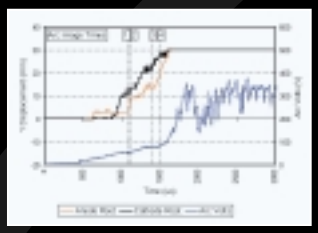

Figure 2 - Arc root trajectory plot

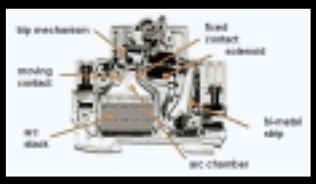

Figure 3: A Miniature Circuit Breaker

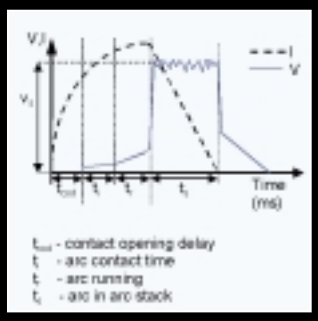

Figure 4: Idealised arc voltage and current characteristic

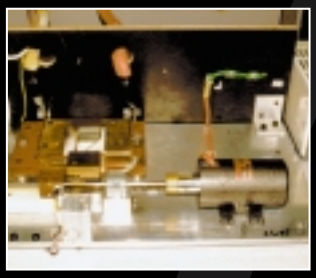

Figure 5: The Flexible Test Apparatus

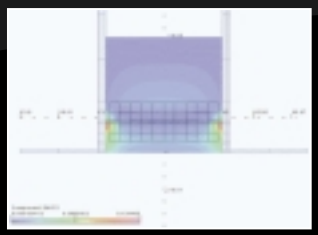

Figure 6: Magnetic flux density from 3D Finite Element Analysis Model

Figure 7: The BREAK3 Apparatus

Figure 8: Arcing in an Miniature Circuit Breaker

University of Southampton