Switching Arc Spectroscopy

Analysis and modeling of switching arcs using spectroscopy methods

High voltage circuit breakers are essential safety elements in power grids. Self-blast circuit breakers represent the state of the art. Here the pressure build-up in a heating volume, necessary for arc quenching, is attained by the ablation of nozzle material due to arc radiation. One focus of circuit breaker development is the substitution of the strong greenhouse gas sulfur hexafluoride by carbon dioxide. The time interval of the current zero crossing and the period immediately after current interruption are of high importance for the interruption performance of the circuit breaker. In these time intervals several physical effects occur, such as flow reversal in the heating channel, translation from an ablation-controlled to an axially blown arc, the extinction of the arc and a continued evaporation of nozzle material after current zero due to the preceding thermal stress. The understanding of these effects is to date limited and cannot be quantitatively determined by existing models. Therefore a deeper understanding of these effects, their transient behavior and their effects on the dielectric recovery of the gap between the contacts after current zero, as well as the complete modeling by circuit breaker simulations are the main intention of this work. The working approach comprises the experimental investigation of a circuit breaker model with peak currents in the range of some kilo amperes. In contrast to previous investigations the focus of these investigations is on the stepwise analysis of the physical properties and processes during the interruption process from the high-current-phase up to some milliseconds after current zero. Three complementary groups of methods are used. Capacitive sensors are used for measuring the spatially resolved distribution of the arc resistance over the complete time range.

Spectroscopy Investigations

The radiation of the electrical arc is analyzed by optical emission spectroscopy for a spatially resolved determination of plasma temperature and relevant particle densities. Both methods have been successfully applied to the high current phase in previous investigations. Nevertheless, it has to be determined to which extent and up to which point of time before the arc extinction, the radiation emission of the arc leads to reliable results. Therefore, the absorption spectroscopy is additionally applied to the circuit breaker model, in order to determine the density of the cooling gas after current zero, such as resulting from the nozzle evaporation.

Simulation and Modelling

The third method is the simulation of the gap between the contacts together with the modeling of the dielectric strength. Detailed conclusions are drawn from the experimental investigations with respect to the physical properties of the plasma along with the cooling of the flowing gases. Thus, the simulations are validated and models including nozzle evaporation of the complete investigated time range, leading to a self-contained model of the interruption process, are derived.

Project information

Deutsche Forschungsgemeinschaft

Partner

- Deutsche Forschungsgemeinschaft (DFG)

Facts

- Reference number: SCHN 728/16-1