World Academy of Science, Engineering and Technology
International Journal of Electrical and Information Engineering
Vol:17, No:11, 2023

Arc Interruption Design for DC High Current/Low SC Fuses via Simulation

Authors : Ali Kadivar, Kaveh Niayesh

Abstract : This report summarizes a simulation-based approach to estimate the current interruption behavior of a fuse element utilized in a DC network protecting battery banks under different stresses. Due to internal resistance of the battries, the short circuit current in very close to the nominal current, and it makes the fuse designation tricky. The base configuration considered in this report consists of five fuse units in parallel. The simulations are performed using a multi-physics software package, COMSOL® 5.6, and the necessary material parameters have been calculated using two other software packages.The first phase of the simulation starts with the heating of the fuse elements resulted from the current flow through the fusing element. In this phase, the heat transfer between the metallic strip and the adjacent materials results in melting and evaporation of the filler and housing before the aluminum strip is evaporated and the current flow in the evaporated strip is cut-off, or an arc is eventually initiated. The initiated arc starts to expand, so the entire metallic strip is ablated, and a long arc of around 20 mm is created within the first 3 milliseconds after arc initiation (v_elongation = 6.6 m/s. The final stage of the simulation is related to the arc simulation and its interaction with the external circuitry. Because of the strong ablation of the filler material and venting of the arc caused by the melting and evaporation of the filler and housing before an arc initiates, the arc is assumed to burn in almost pure ablated material. To be able to precisely model this arc, one more step related to the derivation of the transport coefficients of the plasma in ablated urethane was necessary. The results indicate that an arc current interruption, in this case, will not be achieved within the first tens of milliseconds. In a further study, considering two series elements, the arc was interrupted within few milliseconds. A very important aspect in this context is the potential impact of many broken strips parallel to the one where the arc occurs. The generated arcing voltage is also applied to the other broken strips connected in parallel with arcing path. As the gap between the other strips is very small, a large voltage of a few hundred volts generated during the current interruption may eventually lead to a breakdown of another gap. As two arcs in parallel are not stable, one of the arcs will extinguish, and the total current will be carried by one single arc again. This process may be repeated several times if the generated voltage is very large. The ultimate result would be that the current interruption may be delayed.

Keywords : DC network, high current / low SC fuses, FEM simulation, paralle fuses
Conference Title : ICHVE 2023 : International Conference on High Voltage Engineering
Conference Location : London, United Kingdom
Conference Dates : November 27-28, 2023