Contribution ID: **363** Type: **Poster**

Exploring current loss mechanisms on the Z accelerator using PIC/DSMC methods

Wednesday 21 June 2017 13:30 (1h 30m)

Initial optimization of the Sandia National Laboratories Z accelerator has enabled the delivery of tens of MA's of current to various load types. However, plasma formation in the vacuum magnetically insulated transmission lines (MITLs) is seen as one of the limiting factors in improving machine performance. It is believed that severe heating of the electrode surfaces, due to a combination of Joule heating and ion-impact processes, can cause neutral desorption from the surface. This desorbed neutral layer, combined with field emission of electrons from the cathode, can lead to plasma formation which can break the magnetic insulation of the power flow architecture (i.e. current loss). Simulations of the highest electric field regions (e.g. convolute post-holes and radial transmission lines) are challenging due to geometric complexity, the transient behavior of the plasma, and the detailed chemistry involved in the plasma formation. Here, an electro- and magneto- static kinetic approach is employed to investigate the early-time underlying plasma formation that may contribute to subsequent current loss.

A one-dimensional model of the post-hole convolute (d = 1.22 cm) is constructed. Water desorption is assumed from both anode and cathode. A realistic time-varying voltage pulse is enforced as a boundary condition on the anode and a time-varying magnetic field is introduced consistent with that measured on the Z accelerator. Known electron-neutral collision cross sections for H2O, O, and H are included into the model to track the creation, flow, and loss of these neutrals and their associated ions. This kinetic approach allows for detailed analysis of the underlying physics that lead the plasma formation.

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

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Session Classification: Poster session III - Pulsed Power Physics and Technology, Components and HV Insulation

Track Classification: Pulsed Power Physics and Technology, Components and HV Insulation