Second Technical Meeting on Plasma Disruptions and their Mitigation

Contribution ID: **24** Type: **Contributed Poster**

MHD modeling and optimization of a passive helical coil for mitigation of runaway electrons

Tuesday, 19 July 2022 13:00 (20 minutes)

A helical coil designed to passively generate non-axisymmetric fields during a plasma disruption has been shown, via electromagnetic analysis, linear MHD modeling, and relativistic drift orbit tracing, to be effective at deconfining runaway electrons (REs) on a time scale significantly faster than the plasma current quench. Magnetic equilibria from DIII-D RE experiments are used to calculate the toroidal electric field generated during the current quench phase of a disruption, which in turn drives current in a proposed n=1, m=1 in-vessel helical coil, without the need for any external power supplies or disruption detection diagnostics. Simulations of the plasma evolution using the TokSys GS Evolve code predict the inductive coupling of coil currents up to 12% of the pre-disruption plasma current into the helical coil. The coil geometry is systematically varied to maximize both the non-resonant and resonant components of the 3D magnetic perturbation, resulting in an optimized coil location on the vessel center-post and generating fields as strong as δB/B˜10^{-2} at the plasma edge and a vacuum island overlap width of up to $0.7\psi_N$. The REORBIT module of the MARS-F code is used to model the full non-axisymmetric magnetic field for toroidal modes up to n=6 and trace RE orbits to determine the effect on RE deconfinement, with up to 70% of the RE orbits lost after 0.2 ms. A two-stage evolution of the RE orbit loss fraction is observed to be caused by resonant trapping between multiple magnetic island chains. Scaling estimates are shown to be favorable for the operation of a passive RE deconfinement coil on a larger ITER-scale device, with only marginal decreases in relative coil current and magnetic perturbation amplitudes. Electromagnetic and thermal stresses on the coil are calculated to be within acceptable limits for both a DIII-D coil as well as a larger ITER-scale coil: worst-case J×B stresses are less than 40% of the stainless steel yield strength, and the total temperature rise caused by joule heating throughout the current quench is less than 50°C. Electromagnetic modeling of the 3D eddy currents in the vacuum vessel wall suggests that while a conductive wall may slow the coil current rise time by up to a factor of two, the maximum current is not affected. These findings motivate future experimental study of the helical coil concept in DIII-D or other tokamaks.

Work supported by General Atomics Internal funds and US DoE Office of Science under Contract DE-SC0016452 and DE-FC02-04ER54698.

Speaker's title

Mr

Speaker's email address

weisbergd@fusion.gat.com

Speaker's Affiliation

General Atomics, San Diego

Member State or IGO

United States of America

Primary authors: WEISBERG, David (General Atomics); PAZ-SOLDAN, Carlos (Columbia University); LIU, Yueqiang (General Atomics, PO Box 85608, San Diego, CA 92186-5608, USA); BATTEY, Alexander (Columbia University); MURPHY, Christopher (General Atomics); CROWE, Christopher (General Atomics); WELANDER, Anders (General Atomics); DUNN, Collin (Georgia Institute of Technology)

Presenter: WEISBERG, David (General Atomics)

Session Classification: Posters

Track Classification: Mitigation