NSTX Disruption Simulations of Detailed Divertor and Passive Plate models by Vector Potential transfer from OPERA Global Analysis Results

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ABSTRACT

The National Spherical Torus (NSTX) project is planning upgrades to the toroidal field, plasma current and pulse length. This involves the replacement of the center-stack, including the inner legs of the TF, OH, and inner PF coils. A second neutral beam will also be added. The increased performance of the upgrade requires qualification of the remaining components including the vessel, passive plates, and divertor for higher disruption loads.

The vessel, passive plates, and divertor components are complex mechanical and electromagnetic structures. Global disruption simulations are of necessity, coarse in the regions of these complex structures in order to adequately model plasma motions and current changes in all of the passive conducting structures. For NSTX, a relatively simple OPERA transient electromagnetic axisymmetric model of the plasma and machine is used to obtain currents and loads. This analysis provides only toroidal currents. However the vessel, divertor and passive plate structures are complicated non-axisymmetric designs that result in eddy currents that cross toroidal field lines and develop significant loads not captured in the axisymmetric analysis. A procedure has been developed which maps the vector potential solution from the axisymmetric simulation to the detailed vessel/passive plate/divertor models. These are derived from the 3D Pro Engineer CAD models and include details of copper plate cuts, support brackets and representations of individual bolts. The detailed models are first analyzed in a transient electromagnetic analysis in ANSYS with the vector potential, from the axisymmetric analysis imposed as a boundary condition. Imposition of the vector potential solution eliminates the need to model air around the complex geometies, but is only appropriate for the fully penetrated resistive solution. Halo currents are added in the electromagnetic model as Amp nodal "forces" at specified entry and exit regions. The vector potential distribution for a 1/r toroidal field is added to obtain the correct background field for Lorentz force calculations. Forces are then applied to structural models in both static and dynamic analyses. To partially address the rigor of the procedure, toroidal current inventories in the ANSYS detailed transient EM analysis are compared with the toroidal currents in the OPERA axisymmetric analysis. Stress results are presented, and the possibility of more general application of this procedure is discussed.