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P2.104 PFC Heat Flux Enhancement from Magnetic Field Errors in the NSTX-U Recovery Project

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The Plasma Facing Components (PFCs) of the National Spherical Torus Experiment Upgrade (NSTX-U) protect the vacuum chamber wall from high plasma heat fluxes which are mostly carried by energetic particles that flow along magnetic field lines. The magnetic field lines will have very shallow impingement angles to the PFC surfaces (as small as 1o), a consequence of flux expansion at the divertor. The heat flux along a shallow field line can be more than 50 times greater than the nominal axisymmetric heat flux making the surface normal heat flux very sensitive to field errors arising from coil misalignments and distortions.

Low aspect ratio spherical tokamaks place the divertors at a radius closer to the centerline of the machine and thus are more affected by misalignments with the toroidal field. The inner coils of NSTX-U are very close to the plasma facing surfaces of the divertor and thus small coil position errors have a large effect on the incident angles of the plasma on the tiles.

Adding to this heat flux enhancement is the need to protect leading edges of individual tiles exposed by the gaps between tiles (needed for installation and thermal expansion) and protrusions toward the plasma introduced by tolerances. NSTX-U has chosen to taper (aka fishscale) the tiles in one direction toroidally to provide shadowing of adjacent tiles. This protects tile edges at the cost of further increasing the surface normal heat flux.

An analysis of the influence of each potential perturbation (i.e. displacements, rotations and distortions) of each PF and TF coil along with tile tolerances on surface heat flux enhancement was undertaken to provide a tool for evaluating their relative importance. The combined impact was assessed using Monte-Carlo analysis. This in turn was used to provide guidance for coils and PFCs fabrication and assembly tolerances.

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