Contribution ID: **42** Type: **Poster**

Implementation of 3-D effects of the ITER plasma-facing components in a 2-D real-time model-based approach for wall heat flux control on ITER

Friday, 26 October 2018 08:30 (4 hours)

A real-time (RT) first wall (FW) heat load control system will be required at a very early stage of ITER plasma operations. The long pulse nature of the device imposes active cooling of all plasma-facing components (PFCs) and thus strict control of surface power flux density at all times. Plasma current ramp-up in limiter configuration on the beryllium FW panels (FWP) is foreseen for all ITER discharges, with a preference for the inner wall surfaces. Limiter phase heat flux densities on the shaped FWP in the vicinity of plasma contact are expected to approach the maximum design values and hence the deposited heat flux must be monitored and carefully controlled. Development of a physics-based and control oriented model, based on real time (RT) equilibrium reconstruction for implementation into the ITER Plasma Control System has thus already begun. The model-based approach in the simplest case, describes the heat flux deposited on PFCs as a poloidal flux function with two parameters to be specified by the modeler: the power exhausted across the plasma boundary, P_{SOL} and scrape-off layer (SOL) width, λ_q. A modular, flexible and expandable Matlab/Simulink architecture for the 2-D model based approach has been successfully developed, implemented, and verified with DINA scenario data on the Plasma Control System Simulation Platform (PCSSP). An additional module containing weighting factors has also been implemented in the 2-D RT model based approach to include the true 3-D geometry of the FWP. This is an essential modification if a more realistic value for the true maximum heat flux is to be correctly predicted. Integration of the 3-D effect into the algorithm is performed by offline determination of the heat load distribution on the full 3-D poloidal sector using a new utility, SMITER, developed at the ITER Organization, in which the SMARDDA field line tracing code has been embedded in a GUI interface permitting import and appropriate meshing of full CAD descriptions of the FW geometry. For each equilibrium, weighting factors associated with the position in the poloidal plane and magnitudes of the peak heat flux are extracted for implementation into the 2-D model based approach. The improved RT model is also being experimentally tested and validated on the TCV tokamak using infra-red measurements of the central column surface power flux density.

Country or International Organization

ITER

Paper Number

EX/P7-24

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Session Classification: P7 Posters