Plasma physics and control studies in JT-60SA for ITER scenario development and risk mitigation

M. Yoshida[1] and the JT-60SA Team[2]

[1] *National Institutes for Quantum and Radiological Science and Technology, Naka, Japan*

[2] *EUROfusion, F4E, QST and 27 EU and Japanese Institutes*

JT-60SA is a large fully superconducting new tokamak device being built jointly by Europe and Japan [1]. The tokamak is being fully assembled and close to start plasma operation in September 2020. The first tasks will be plasma breakdown and optimization of equilibrium control up to a plasma current of ~2.5 MA using toroidal and poloidal superconducting coils. For these controls, we have simulated operation scenarios of the first plasma phase with advanced computational codes and control logics, such as pre-magnetic optimization scheme, plasma equilibrium control with isoflux scheme, control gain optimization method, and strategies for accessing stable operational regimes. EC wall cleaning operations are also explored with flexible EC and horizontal field. These simulations and results in JT-60SA first plasma campaign will contribute to highly valued subjects in ITER first plasma (ECWC, plasma start-up, vertical position control, etc.) and subsequent operations.

After the tokamak commissioning, physics-oriented experiments will start in 2023 using the validated control systems, enhanced diagnostics, particle fueling, and power of 26.5 MW (P_{NNB}/ P_{PNB}/ P_{EC}=10/ 13.5/ 3 MW) at higher current up to 5.5 MA. The Research Unit on JT-60SA has focused the program on scenario development and risk mitigation in ITER as well as on investigating DEMO relevant regimes, as described in the JT-60SA Research Plan [2]. Recent main progress for the above-mentioned purposes are summarized as follows.

Scenario development: Plasma breakdown and equilibrium controls, EC wall cleaning and EC-assisted breakdown, Heat load handling with multiple impurity seeding, and Edge and divertor modelling in ITER-like scenarios with advanced codes, Impacts of fast ions and plasma shape on microturbulence, Gyrokinetic theory based neural-network transport modeling, Globally optimized steady-state transport solver coupled with turbulence models. The simulations show the compatibility of high pressure and radiative divertor in ITER relevant regimes. For mild beta like ITER standard scenario, turbulent ion transport reduces with increasing the plasma elongation even in the core. The new transport solver and model have enabled us to predict plasma profiles in JT-60SA as well as ITER in a stable and faster way.

ITER risk mitigation: Magnetic perturbation effect on both transient and stationary heat load, Simulation study of vertical displacement event, Plasma response to MGI, Pedestal and ELM stability and control. Required RMP coil current to reduce ELM energy loss is estimated in ITER-like scenario. Plasma response to MGI, which will be located very close to the plasma in JT-60SA is simulated to study the disruption physics.

The aim of this paper is to present the main results of the above-mentioned studies and to identify the JT-60SA contributions for ITER on plasma physics and first ITER campaigns.

[1] P. Barabaschi et al., Nucl. Fusion **59** (2019) 112005.

[2] JT-60SA Research Plan - Version 4.0, Sept. 2018, http://www.jt60sa.org/pdfs/JT-60SA_Res_Plan.pdf