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Plans for long-pulse operation in JT-60SA

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JT-60SA is a large fully superconducting new tokamak device built jointly by Europe and Japan [1]. The tokamak was fully assembled in March 2020, and the integrated commissioning of the tokamak is on-going. The mission of JT-60SA is to contribute to the early realization of fusion energy by addressing key physics issues for ITER and DEMO. Especially, development of fully non-inductive steady-state high β_N operations above the no-wall ideal MHD stability limits, for long time exceeding the current diffusion time is an important target of JT-60SA.
The machine enhancement of JT-60SA takes a staged approach. There are three major phases in JT-60SA: the initial research phase, the integrated research phase, and the extended research phase. In the initial research phase, power of 33 MW (P_{NNB}/ P_{PNB}/ P_{EC}=10/ 20/ 3 MW) and plasma current up to 5.5 MA are available. High power and high plasma current operation will be demonstrated. As an inertial cooled lower divertor with CFC tiles will be used in this phase, the pulse length with high heating power experiment will be limited to about 5 seconds. In the integrated research phase, power of EC will be upgraded to 7 MW and the divertor will be upgraded by an actively cooled divertor. Those enhancement will enable us to try steady-state long pulse operation at a divertor heat load of 10 MW/m^2. We also have a plan to replace the carbon divertor by the tungsten-coated divertor to develop long pulse operations compatible with the metal wall environment. In the extended research phase, further enhancement of heating and current drive is envisioned.
Significant modelling activities have been conducted to predict the plasma performance in the long-pulse operation. A strong predict first activity has been carried out with integrated modelling codes such as TOPICS and CRONOS. It is shown that the expected values for β_N, H98y2 and fBS, as described from 0-D studies in the JT-60SA Research Plan [2], can be attained in long-pulse operation. To prepare for hybrid scenarios, the safety factor profile control using off-axis ECCD during Ip ramp-up phase is studied and it is found that q > 1 can be maintained if 2.2 MW of ECCD is applied at ρ ~ 0.3. To realize a high β_N long pulse operation with high radiation fraction, multi-impurity seeding scenario is studied and it is found that high radiation in the divertor region without increased radiation in the core region can be envisioned with a mixed Ar and Ne seeding.

[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

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