IFERC Newsletter

IFERC-N-2023-18, 4 Dec. 2023
International Fusion Energy Research Centre, Rokkasho, Aomori 039-3212, Japan

Status of DEMO Design Activity

Highlights on Plasma scenario development

The joint EU/JA activity of Task 1, Plasma scenario development, focused on two main topics in 2023:

- Topic I: Optimum H&CD Mix
- Topic II: Runaway Electrons (REs) and First Wall (FW) protection

As for Topic I, pulsed plasma operation scenario has been analyzed in the current Ramp-Up (RU) and flat-top phases using EC only for H&CD in JA DEMO as shown in Fig.-1. Kinetic and magnetic control simulations in the current RU phase will be performed by using the TOPICS and MECS codes in 2024.

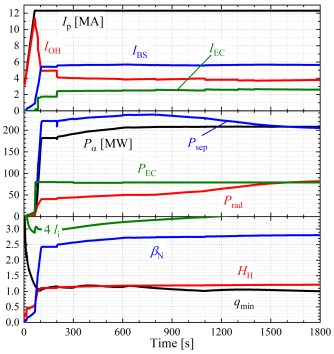

Fig.-1: Pulsed plasma operation scenario using EC only for H&CD in JA DEMO

On the EU side, the optimization of plasma composition (with He) to reduce heat flux at the divertor during ramp-up is implemented with the ASTRA code as shown in Fig.-2, and the activity on ASTRA/Simulink "flight simulator" for kinetic/magnetic RU/RD simulations started.

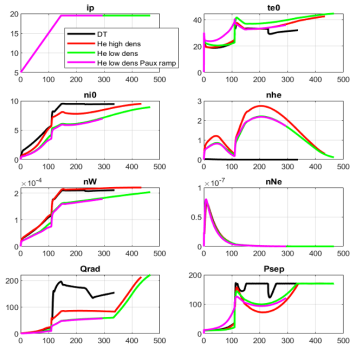

Fig.-2: Time evolution of relevant physics quantities during RU for different plasma isotope compositions.

Concerning Topic II, underlying long-term questions are how the RE power is deposited, and the sacrificial limiters are effective against REs. Relevant to these long-term questions, a two-year (FY 2021-2022) joint work for developing the workflow has been completed. The work plan is composed of 1) "code adaption" to implement RE model to INDEX code and to compare Vertical Displacement Event (VDE) simulations between JA and EU (to FY 2021), 2) "Scenario of RE wall impact" to analyze VDE with RE beam and to identify low-n MHD unstable scenario of RE beam (in FY 2021), 3) "Orbit loss analysis" to analyze RE orbit with MHD modes and to evaluate energy deposition pattern (in FY 2022) and 4) "Assessment of machine protection" to apply workflow for sacrificial limiter design and to develop disruption mitigation scenario (in FY 2023-2024).

VDE simulations coupled with the RE generation model have been successfully implemented for both the JA DEMO and EU DEMO configurations by using the INDEX code. To evaluate the RE wetted area and the impact angle against the first wall, the RE orbit following with/without MHD perturbation in VDE has been performed by using test particles with a single kinetic energy and a single pitch angle, and an analytical model to the external kink mode (m=3,n=1) as an MHD perturbation. It was found that most REs strike the upper limiters, and more REs strike the first wall with stronger MHD instability in the case of REs with 10 MeV. On the other hand, in the case of 100MeV REs, even without MHD perturbation, a fraction of REs strikes the first wall on a short timescale (<μs) due to the large orbit width (Fig.-3). The MHD perturbation further enhances the RE flux to the wall. The developed workflow can be useful for providing the information on the RE fluxes required by an energy deposition analysis code, such as FLUKA. This will be carried out on EU side.

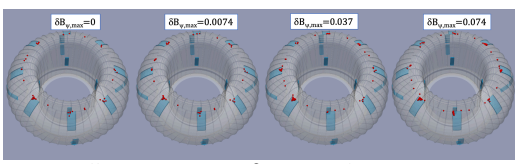

Fig.-3: Collision points of REs with E=100MeV in EU DEMO with four different perturbation strengths

(DEMO Design Task-1 TROs)