IFERC Newsletter

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International Fusion Energy Research Centre, Rokkasho, Aomori 039-3212, Japan

Status of DEMO Design Activity

Highlights on divertor and power exhaust studies for DEMO

Task-2 has three sub-tasks; Task 2-1: EU-DEMO divertor simulations by SONIC and SOLPS-ITER, Task 2-2: He and particle exhaust studies for JA DEMO and EU DEMO, and Task 2-3: Common definition of engineering design criteria, assumptions and material data for EU and JA Divertor.

Regarding Task 2-1, JA continued SONIC simulations for EU DEMO divertor by applying similar plasma parameters as EU SOLPS-ITER used as shown in Fig-1: parameter scans of radiation power fraction (f_{rad}^{div} = P_{rad}^{div}/P_{sep}) and SOL density (n_e^{sep}) gas puff rate (100-150-200 Pam^{3}s^{-1}; 4.8-9.6 Ds^{-1}) were carried out for a given f_{rad}^{div} (~0.7 and 0.8) series. Previous Ar seeding simulation results were renewed to self-consistent calculations with Ar seeding and He exhaust. The divertor detachment and peak heat load (q_{target}) were basically similar between with and without He exhaust calculation. For the smaller f_{rad}^{div} ~0.7 series (gas puff scan), the plasma detachment (i.e. T_e^{div}~T_i^{div} = 1-2 eV) was produced near the strike-point of the outer target. For the larger f_{rad}^{div} ~ 0.8 series, the detached region was extended on the target and the peak q_{target} appeared at the detached region as shown in Fig-2. Dissipation of momentum and ion flux such as volume-recombination and charge exchange will be examined.

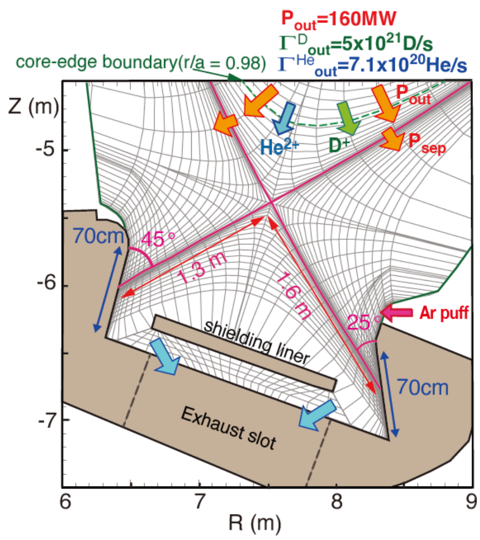

Fig-1: EU DEMO divertor simulations by SONIC (configuration and calculation mesh)

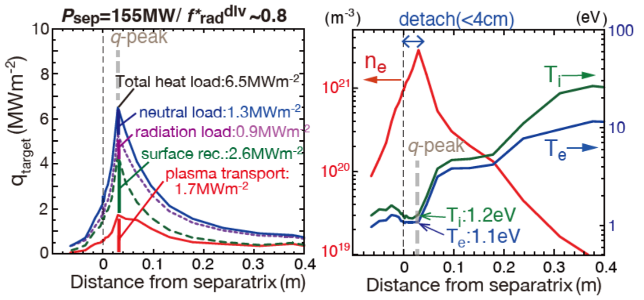

Fig-2: DEMO divertor simulations by SONIC (outer target heat load and plasma detachment)

EU has revised the workplan to assess the operational window of the EU-DEMO divertor conditions (2021 magnetic equilibrium). The possibility to use an Advanced Fluid-Neutral model (AFN) will speed up numerical convergence tremendously, and the possibility to exploit a full 2D grid extension up to the first wall will allow a refined assessment of PWI in EU-DEMO (e.g. erosion by fast CX neutrals).

Concerning Task 2-2, compared to exhaust He/ion flux ratio of $\Gamma_{out}^{He}/\Gamma_{out}^{D}$ = 0.14 at the core-edge boundary (r/a=0.98), He concentration c_{He} = n_{He}/n_e was small both in inner and outer midplane edge (c_{He} ~1.5% and <0.6%, respectively), which was also smaller than SOLPS-ITER result. Further investigation of He transport processes in the SOL and divertor is needed.

As for Task 2-3, in 2022, coolant circuit design of the W-monoblock supports and Cassette Body (CB) for JA-DEMO divertor was developed by introducing Computational Fluid Dynamics simulation. Current baseline design concept of the EU DEMO divertor was re-visited and the fundamental design features were re-evaluated in terms of high-level stakeholder requirements such as reduction of radwaste, maintainability, reliability, and cost saving, etc. It was decided to investigate an alternative design concept which should cope with the high-level requirements. It is characterized by design features: easily detachable vertical targets with an ITER-like target attachment unit and Pressuerized Water Reactor cooling condition for CB.

Joint review paper of DEMO divertor designs was published: https://doi.org/10.1016/j.nme.2023.101446.

(DEMO Design Task-2 TROs)