IFERC Newsletter

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Status of DEMO Design Activity

Highlights on divertor and power exhaust studies for DEMO

Three tasks have been conducted for BA DDA Task-2 activity: (1) EU DEMO divertor simulations by SONIC and SOLPS-ITER, (2) He and particle exhaust studies, and (2) a common definition of engineering design criteria, assumptions and material data for EU and JA divertors

In Task 2-1, SONIC (JA code) simulations for EU DEMO divertor have been carried out as shown in Fig. 1(left). Parameter scans of the radiation power fraction (f_{rad}^{div}) and gas puff rate were performed with the same χ (0.2 m^2/s) as EU used. The peak heat load (q_{target}) reduces from 12 to 6.7 MWm^{-2} with increasing f_{rad}^{div} from 0.7 to 0.8（Fig.1 right）; This is because detached plasma region is extended (7 cm) and the peak q_{target} appears in the detached region. The peak q_{target} is 2 times larger than that of SOLPS result , while peak q_{target} appeared similarly in the detached region. Investigation of the plasma dissipation models in the detachment is future work.

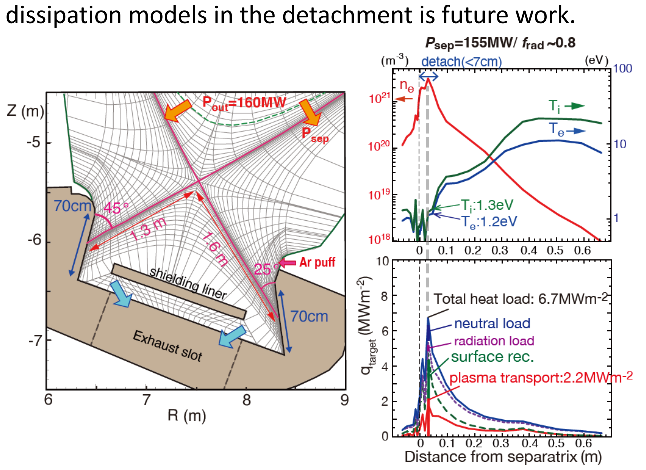

Fig-1: EU DEMO divertor simulation with SONIC

EU has considered reduced exhaust model for core-edge modelling or scoping studies (core plasma transport solver based on ASTRA). One critical issue is the calibration of a simplified SOL model used currently (0D based on the Lengyel formulation, part of PROCESS system code), which was calibrated against ASDEX-Upgrade experiments. One approach for the scaling is to use the existing factors like n_eR. But this neglects other factors like plasma geometry and divertor shape. Dissipation factors of the power-balance in the DEMO divertor were obtained from the SOLPS-ITER DEMO simulations and improved, and are now taken into the PLASMOD simulations.

In Task 2-3, two coolant conditions were proposed for the divertor target and the other components (liner/dome, reflectors and cassette) both in EU and JA divertor designs, but each condition was different. Design bases for the coolant were summarized.

For the EU DEMO divertor shown in Fig-2, the choice of target coolant inlet-temperature (130-140 °C, 5 MPa) is determined by the need of a low transient heat flux for cases as a re-attached divertor plasma, with maximum heat flux of ~70 MWm^{-2} . With strike-point sweeping, the heat load could be reduced to values below melting level of W-surface (~40 MWm^{-2}). Critical Heat Flux margin of the coolant and surface temperatures of the W-monobloak (MB) and CuCrZr pipe are the paramount criteria. The operation temperature range of the target coolant is determined by other factors. The inlet temperature for the cassette body coolant (180℃ to minimize EUROFER97 embrittlement) was determined by considering high temperature parts (such as supports of reflector plates) submitted to nuclear heat.

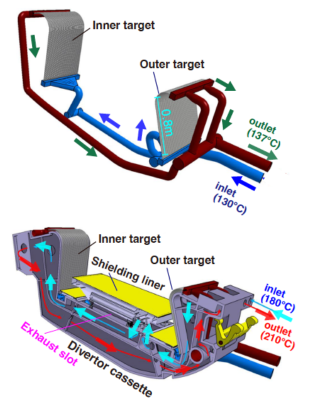

Fig-2: EU DEMO divertor

JA DEMO divertor design anticipates degradation of the mechanical properties at high temperature, and replacement of the divertor targets after 1-2 year operations, i.e. more frequent than Breeding Blanket replacement. The inner and outer target units with W-MB and CuCrZr pipe broadly cover the high heat load region (0.8 m) near the both strike-point. The arrangement of the coolant route for both targets is revised from series to parallel. The parallel distribution concept is also a baseline of the EU DEMO divertor. Relatively high temperature coolant (200°C) is provided in order to minimize the irradiation embrittlement.

(DEMO Design Task-2 TROs)