Contribution ID: **83** Type: **Invited (Plenary Session)**

Power exhaust studies in the Divertor Tokamak Test facility

Thursday 7 November 2019 10:30 (20 minutes)

Dealing with power exhaust is one of the most difficulty tasks in foreseen fusion reactor based on magnetic confinement. It is commonly recognized that the standard Single Null Divertor (SND) configuration can face some difficulties in providing a scalable solution based on H-mode tokamak operation compatible with present solid divertor target technological solutions. To provide a safer solution two approaches are being considered: the adoption of alternative divertor magnetic configurations (ADCs) could favour plasma detached operations, thus mitigating the heat load on targets; liquid metallic targets are also studied for their ability to survive to high heat load while providing also a self-mitigation of incoming heat flux.
The Divertor Test Tokamak (DTT) facility [1] is being designed to specifically explore and qualify most of the ADCs (and liquid metal targets) with divertor conditions as close as possible to those foreseen in DEMO fusion reactor in terms of power crossing the separatrix, Psep/R, and heat flux decay length, q. All of the present more promising alternative divertor configurations are realizable in DTT: the flux flaring towards the target (X divertor), the increasing of the outer target radius (Super-X) and the movement of a secondary x-point inside the vessel (X-point target) as well as the entire range of Snowflake (SFD+/SFD-) configurations [2] and the presently reconsidered double null (DND) one. This divertor configurations flexibility is supplemented by a similar flexibility in operation scenarios which for example allows scanning triangularity from the DEMO positive value to negative one or moving from H-mode to the I-mode to test possible ELMs free high confinement regimes.
To analyse the possible beneficial effects ADCs configuration in DTT and starting to optimize plasma scenario and divertor geometry, 2D edge fluid-kinetic simulations has been done on previously described divertor configurations. The analysis has shown in pure deuterium the extension of the detached operation towards higher Psol power with all the ADCs, with respect to the SND, with the best results achieved at all targets for the SFD-. Modelling has also shown that the ADCs advantages extend to the case of (Ne/Ar) impurity seeding, whereby detached operations can be reached with a lower Zeff or dilution at the separatrix compared to the SND.

References

[1] R.Albanese and H. Reimerdes, Fusion Engineering and Design 122 (2017) 285–287 https://doi.org/10.1016/j.fusengdes.2016.12.025
[2] R. Ambrosino, et al., Fusion Engineering and Design 122 (2017) 322–332, https://doi.org/10.1016/j.fusengdes.2017.01.055

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Session Classification: Divertors in Next Step Devices

Track Classification: Divertors for DEMO and Reactors