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Design of the divertor and power exhaust scenarios development for the Divertor Tokamak Test facility

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The new high field superconducting divertor tokamak test facility (DTT) [1] presently under construction is devoted to specifically study power exhaust solutions in regimes as close as possible to those foreseen in DEMO fusion reactor in terms of power crossing the separatrix, P_{sep}/R, and heat flux decay length, λ_q. The first DTT divertor will use the ITER-like technology based on full tungsten monoblocks bonded on CuCrZr cooling tubes. The divertor has being designed to test and compare a wide set of different power exhaust solutions, in particular the standard SND configuration and with high priority some of the most promising ADCs, like the X divertor (XD) and the "hybrid Super-X/long leg SN"but not excluding the possibility to test also the SnowFlake (SF) one. Additionally, the negative triangularity (NT) operation is considered important to explore as a solution to avoid ELMs and to easier power exhaust management.

Considering the wide requirements in term of divertor configurations acceptance the definition and optimization of the divertor shape has been done by an extensive power exhaust modelling with the 2D edge code SOLDGE2D because it allows to manage all above mentioned divertor configurations without any constraint in divertor (and wall) shape. Some specific analyses have been also done with the 2D edge code SOLPS-ITER code, like in studying the effect of the divertor dome in presence of drifts. Divertor optimization has been done at the maximum additional power presently foreseen for DTT (45 MW), the toroidal field (6 T) and plasma current achievable for the various configurations (5.5 MA in SND, 4.5 MA in XD) and a density corresponding to a Greenwald fraction of about 0.5 in the SND case. Transport profiles have been validated in present experiments and tuned to provide a λ_q in agreement with available scaling laws, they have been kept constant in modelling all H-mode configurations. Considering the technological limits imposed on divertor shape by W monoblocks, it has been found that the best performances (lowest impurity content to achieve detachment by impurity seeding) between all configurations can be obtained with a wide divertor using the dome as third target and pumping slots for neutral compression.

Starting from the preliminary requirements, this presentation describes the compatibility of the various magnetic configurations with the technological constraints; the modelling activity to define the divertor shape and the different operating scenarios.

References

[1] DTT - Divertor Test Tokamak - Interim design report, R. Martone, et al., (editors), ENEA - Frascati (2019). https://www.dtt-project.enea.it/downloads/DTT_IDR_2019_WEB.pdf.

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