Comparative study of a conventional, Quasi-snowflake and Liquid Lithium divertor for the DTT (Divertor Test Tokamak) tokamak

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The possibility to adopt advanced magnetic configurations or a Liquid metal divertor in order to mitigate the power exhaust issue envisaged on the divertor plates of a fusion power reactor is currently under investigation in the fusion community. In this context, a new tokamak test facility, DTT (Divertor Test Tokamak), has been proposed and, thanks to the high flexibility, this device is able to deal with a wide range of divertor magnetic configurations[1].

In this work we present a preliminary comparative study of a conventional single null (SN) and a Quasi-snowflake (QSF, as defined in [2]) configuration for the DTT tokamak by means of the 2D edge code EDGE2D-EIRENE. In the simulations we have considered a closed divertor, a full W wall and a high level of power crossing the separatrix that corresponds to a scenario without impurity seeding. The transport coefficient has been set constant and such that, in attached conditions, we get an outer midplane decay length of 3 mm. In order to assess the behavior of the different solutions, a density scan has been performed both in case of SN and QSF configurations. This latter configuration is featured by the presence of a second null point that modifies the divertor magnetic topology and yields to an increase of the flux expansions[2]. In the conventional scenario high power loads are foreseen by the code in all the density scan, with peak values higher than 20 MW/m². This is observed also in case of partially detached conditions where the strike point electron temperature falls below 5 eV and there is a clear indication of the roll-over of the density and of the saturation current. However, this condition is reached for upstream density higher than the one foreseen even in the high density scenario. On the contrary, in case of a QSF configuration, manageable value of the power load are obtained also for the medium density scenario. Furthermore, the code predicts detachment conditions for lower value of the upstream density. This behavior is probably related to the benefit deriving from the geometrical feature of the QSF in terms of increase in the flux expansion.

Finally, a preliminary EDGE2D-EIRENE study with a liquid Lithium divertor has been performed and compared with the conventional scenario. As a first approximation, the Li divertor is simply modeled by imposing a constant temperature of the target plates and considering the presence of the Li impurity inside the SOL plasma. A low level of the impurity radiation by Li is observed very close to the target since the constraint on the temperature corresponds to a regime dominated by the sputtering of Li. As a consequence slight differences are observed in terms of power load on the target. However, a more complete description should consider different temperature of the Li target in order to access regimes dominated by the Li evaporation from the wall. In this case we could expect a high level of radiation and thus a decrease in the power loads onto the plate.

[1] DTT, Divertor Tokamak Test facility project proposal, ENEA, 2015