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Study of Single Null divertor in DTT with Nitrogen, Neon and Argon seeding

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The EUROfusion roadmap [1] has recognized the exhaust of large heat loads as one of the most critical issue to solve for the generation of electrical power with a Demonstration Fusion Power Plant (DEMO) by 2050. This condition is particularly challenging in the material facing the plasma in the divertor, where detached conditions must be guaranteed for safe operations of the machine. According to the limit imposed by the current technologies, the maximum tolerable peak heat flux is 10 MW/m2 and the temperature should be below 5 eV to avoid tungsten sputtering [2]. Considering the typical conditions of DEMO, this means that almost 90% of the power entering the SOL and diverted towards the divertor targets should to be radiated by inserting external impurity, as in high radiating scenarios in present experimental machines [3].
In order to bridge the gaps between present machines and the plasma conditions in DEMO, the Divertor Tokamak Test Facility (DTT) is in construction in Italy. The main goal of DTT is to test alternative divertor solutions - as Advanced Divertor Configurations (ADC) and liquid metal divertor –in DEMO relevant regimes [4]. The possibility to adopt these solutions will be assessed in terms of compatibility with core performances and of technological feasibility considering both materials and engineering aspects.
In this work we present the power exhaust analysis of the divertor for the conventional Single Null magnetic configuration in DTT. The study is performed by means of the 2D edge codes SOLPS-ITER [5] and SOLEDGE2D-EIRENE [6]. We refer to the medium density scenario characterized by a separatrix density of ne,sep = 5 x 1019 m-3 and an external input power level of Padd = 45 MW since it is the baseline scenario used to compare all the other alternative divertor solutions. The injection of nitrogen, neon and argon have been considered. In order to define the effect of the different impurities on the plasma performances and to study DTT operational scenarios, a scan in the impurity puffing rate has been performed. Here, we present a discussion on the possible operational windows in terms of tolerable heat loads, achievement of the detachment regime and radiating power fraction as a function of the different N, Ne and Ar puffing levels. Finally, the influence on the plasma performances on the choice of the impurity species is assessed by considering impurity concentrations in the three cases.

[1] European Research Roadmap to the Realisation of Fusion Energy, November 2018, https://www.euro-fusion.org/fileadmin/user_upload/EUROfusion/Documents/2018_Research_roadmap_long_version_01.pdf
[2] G. van Rooij et al., J. Nucl. Mater. 438 (2013) S42.
[3] Bernert M., (2017) Nuclear Materials and Energy 12 111–118 ISSN 2352-1791
[4] DTT Divertor Tokamak Test facility Interim Design Report, April 2019
[5] S.Wiesen, et al., (2015) Journal of Nuclear Materials, 463, 480-484
[6] Bufferand, H., et al., (2015) Nuclear Fusion, 55, 053025

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