Moderate beta baseline scenario in preparation to D-T operations at JET

V. K. Zotta[1], L. Garzotti[2], F. J. Casson[2], D. Frigione[3], R. Gatto[1], F. Koechl[2], E. Lerche[2], P. Lomas[2], C. Mazzotta[4], G. Pucella[4], F. Rimini[2], M. Sertoli[2], D. Van Eester[5] and JET Contributors*

[1] *Sapienza University of Rome, Rome, Italy*
[2] *CCFE, Culham Science Centre, Abingdon, UK*
[3] *University of Tor Vergata, Rome, Italy*
[4] *ENEA C. R. Frascati, Frascati, Italy*
[5] *Laboratory for Plasma Physics, LPP-ERK/KMS, Bruxelles BE*

In preparation to the JET Deuterium-Tritium (D-T) experimental campaign DTE2 a wide activity of modelling has been planned in order to extrapolate the relevant experimental scenarios with the objective of maximizing the possibility to achieve the experimental goals [1]. The H-mode can be reached in two different scenarios: the baseline where the confinement is achieved at high plasma current and moderate beta, and the hybrid, where the beta is higher while the current is lower and driven to shape the safety factor profile. The best performing baseline discharges are characterized by a normalized beta $\beta_N \approx 2.2$ and might be not extrapolable at plasma currents higher than 3.8 MA due to the lack of additional heating power. Therefore, a moderate β scenario ($\beta_N \approx 1.8$) has been chosen as reference for the extrapolations. In this paper, using JETTO with QuaLiKiZ [2, 3] as transport model, the simulations are performed in a fully predictive way. In particular, the experimental measurements are imposed as initial conditions at the beginning of the simulations, at the separatrix the T_e and T_i are both imposed at 100 eV, then the plasma quantities (e.g. T_e, T_i, n_e and the toroidal momentum) are computed self-consistently. QuaLiKiZ is a physics-based transport model, which takes into account the isotope effects on confinement in the core, while the sensitivity to the pedestal confinement pedestal is assessed by prescribing a range of thermal diffusivities in this region. A first group of simulations has been performed starting from the reference pulse and assuming different impurity mixes. In particular, Ni, Be and a combination of Be and Ni estimated from spectroscopy have been used as dominant impurities. The impurity transport has been modelled with the SANCO impurity transport code. As expected, the performance (in terms of neutron rate) decreases with increasing dilution. The best agreement with the experiments is obtained using a combination of Be and Ni and measured parameters are reproduced by the simulations within the experimental uncertainties. A second group of simulations is composed by the extrapolations in D-D plasma mixture at higher current by scaling the experimental plasma parameters in order to keep constant the safety factor q and the Greenwald fraction f_G. These simulations are performed at a constant additional heating power of 40 MW, higher with respect to the reference pulse. In these conditions it is expected a D-D plasma ready for the D-T operations (neutron yield of 5 10^{16} neutrons/s) [4]. A third group of simulations contains the extrapolations, in D-T plasma mixture, of each studied scenario, in terms of impurities and thermal diffusivities at the edge transport barrier. A sensitivity study has been done on the pedestal stability and on different impurity mix. In conclusion, some extrapolated scenarios show that it is possible to achieve a stable flat-top operating condition in D-T give producing 15 MW of fusion power. It should be noted that a saturation in the fusion performance is observed for $I_p > 4$ MA. This is attributed to the increased density at constant additional power (due to the extrapolation being performed at constant f_G) and, consequently lower T_i.

* See the author list of E. Joffrin et al.2019 Nucl. Fusion **59**, 112021.

References

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