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Core fueling of DEMO by direct line injection of high-speed pellets from the HFS

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Core fuelling of a DEMO tokamak fusion reactor is under investigation within the EUROfusion Work Package "Tritium, Fuelling and Vacuum"(WP-TFV). An extensive analysis of fuelling requirements and of related presently available fuelling technologies, indicate that pellet injection still represents, to date, the most realistic option. Modelling of both pellet penetration and fuel deposition profiles for different injection locations, for specific DEMO plasma reference scenarios and assuming the ITER reference pellet mass (6×1021 atoms), indicates that Low Field Side (LFS) injection is inadequate, while effective core fuelling can be achieved launching pellets from the High Field Side (HFS) at ⊠1 km/s. Vertical injection may be effective only provided that pellets are injected at relatively high speed from a radial position ⊠≤ ⊠8 m, which may depend, however, on the specific plasma scenario. An innovative approach, aimed at identifying suitable inboard "direct line" (or "free-flight") paths, to inject high-speed pellets from the HFS, has been recently proposed as a potential backup solution , and is presently undergoing preliminary investigation. The fuel deposition profiles that can be achieved by this approach are being explored using the HP12 simulation code. The results of some preliminary simulations will be presented, showing that there are probably geometrical possibilities for direct line injection that can provide good fueling performance, despite they do not aim at the plasma core (for fear of an excessive neutron flux across the direct line of sight of the injection path),. However, these trajectories are rather peripheral and thus quite sensitive to the plasma scenario, so that high injection speeds are required in this configuration in order to maintain the component of the pellet velocity perpendicular to the flux surfaces at a large enough value. The deposition profile obtained simulating the injection of 3 km/s pellets through a direct line injection path forming an angle of 68° with the equatorial mid-plane, is quite similar to that obtained injecting pellets at 1 km/s from the HFS, by means of curved guide tubes. The problem of neutron flux deserves however further investigation; if neutrons will turn out to not represent a serious issue, constraints on the injection angle could be relaxed, and further simulations could probably yield better fuel deposition profiles. The identification and integration of suitable tilted straight injection paths may be a rather difficult task, due to the many constraints and to interference with existing structures, including the breeding blanket (BB). In this perspective, the angle scatter of high-speed direct flight injection, and/or the suitability of straight guide tubes to reduce the scatter cone and the corresponding open cross section on BB penetration, are of main interest. An experimental program, aimed at solving these technological issues, has been recently started in collaboration with ORNL, using an existing ENEA/ORNL two-stage pneumatic D2 pellet injector. Preliminary activities related to this program will also be reported.

Eligible for student paper award?

No

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