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P2.1025 Real-time wall conditioning through B powder injection in fusion devices

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The performance and operation of magnetic confinement fusion devices strongly depend on the characteristics of PFCs, which represent the principal source of impurities and, through deuterium recycling, can contribute substantially to plasma fueling. A commonly-used method to reduce and control these effects is to pre-condition the walls with low-Z materials, e.g. boron (B). Although well-established, boronization entails handling hazardous gases (e.g. B2D6, B10D14), which require interruptions of experimental operation, with possible evacuation of facilities. Moreover, gas-based boronization procedures are inapplicable to long-pulse devices, where coatings will significantly erode during a single plasma discharge.
Experiments carried out in the DIII-D and ASDEX-Upgrade (AUG) tokamaks, explored the possibility of generating boron coatings in "real-time", by injection of B and B enriched powders during tokamak operation. The experiments were enabled by a new device designed to inject calibrated amounts of a wide range of impurity powders.
Boron injection into DIII-D H-mode plasmas (graphite plasma-facing components, PFCs) correlated with increase of wall pumping and impurity concentrations during the initial plasma current ramp2. Wall conditioning improvement similar to boronization was observed in AUG (tungsten PFCs) following injection of pure B and boron nitride (BN) powder into Hmode plasmas. The improvements included reduction of O and W influx from limiters. In both devices, the B injection appeared to be central to achieving low collisionality plasmas3. The combined AUG-DIII-D dataset suggests that B powder injection could be used to supplement the standard boronization and extend its beneficial effects by regenerating the coatings during tokamak operation. Simulations with the UEDGE code, including powder transport and ablation through scrape-off layer via the DUSTT4 code, are used to reconstruct B fluxes to the wall. Preliminary results indicate that small particles ~ 1m will ablate in the far scrape-off layer, while large particles ~ 100m will penetrate near the separatrix. This leads to the prospect of an optimized real-time boronization using a range of particle sizes to thoroughly cover the PFCs.
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