Simulation of ITER Operational and Startup Scenarios in the DIII-D Tokamak*

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Operational scenarios designed for use in ITER to achieve its physics and technology goals have been explored in a shape close to that proposed for ITER. The scenarios studied include the baseline ELMing H mode, steady-state, and hybrid scenarios. Discharges with parameters matching the baseline (\(q_{95}=3, \beta_N=1.8\)) and steady-state (\(q_{95}=5, \beta_N=2.8\)) scenarios have been obtained. The performance is slightly below that needed in ITER for \(Q=10\) and \(Q=5\), respectively. In the baseline scenario, the presence of an \(n=2\) tearing mode degrades confinement slightly. Performance at the \(Q=10\) level can be recovered by a 10% increase in \(\beta_N\), but higher performance is limited by the appearance of an \(n=1\) tearing mode. In the steady-state scenario, higher \(\beta_N\) can be obtained for shorter duration, but \(\beta\) is limited by fast-growing MHD. In addition, all scenarios come into current equilibrium with \(\ell_i\) below the range used to design the poloidal field coil set.

The original startup scenario for ITER starts from a small outboard limited plasma. The cross-section expands to keep the limiter \(q\) constant as the current increases, with diverted plasma from 7.5 MA. Scaled to DIII-D, this scenario resulted in rapid current penetration (as planned), but \(\ell_i\) during the limiter phase exceeded the design window for ITER. Sawteeth appeared already during the limiter phase, making access to advanced scenarios that require \(q > 1\) difficult. These and other issues led to a proposed alternative ITER startup scenario with larger plasma from breakdown and divertor formation as early as 3.5 MA. With this new startup, it was possible to reach current flattop without sawteeth in DIII-D for reduced current discharges as in the steady-state scenario for ITER. Hybrid scenario performance approaching that needed for \(Q=10\) in ITER has been accessed in DIII-D with this startup, with small sawteeth appearing only at the end of the current rise. Feedback control of \(\ell_i\) was developed in the divertor phase of the current rise, using the current ramp rate as the means of changing \(\ell_i\). Work on the operational and startup scenarios have been carried out separately up to now; complete ITER simulation discharges will be carried out in the future.

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