DIII–D ADVANCED TOKAMAK RESEARCH OVERVIEW*

Vincent Chan for the DIII–D Team

General Atomics, P.O. Box 85608, San Diego, California 92186-5608

In the past year, significant progress has been made on DIII–D in demonstrating long-pulse advanced tokamak (AT) operation. Discharges with high normalized performance (β_N ~3.5, H_{89}~2.5, $H_{89}\,\beta_N < 10$) have been sustained for up to 2 s ($\leq 16\ \tau_E$, the energy confinement time) with an ELMing H-mode edge. This result represents a significant increase in the performance of long-pulse discharges previously reported.[1] Analysis has shown that about 75% of the current in these discharges is supplied non-inductively of which greater than 50% of the total current is calculated to be bootstrap current. The remaining inductive current is localized around the minor radius ρ=0.5 in agreement with the transport modeling. The plasma pressure is well above the calculated no-wall limit and $\beta_N > 4\ \ell_i$ for the entire high performance phase which suggests that MHD stability was not limited by ideal kink or ballooning modes. We will present evidence that the high performance duration was limited by resistive wall modes (RWM), rather than neoclassical tearing modes. Two strategies are being evaluated to extend the duration of the high performance operation. It is possible that the *q*-profile, which evolved slowly, is responsible for destabilizing the RWM. Off-axis ECCD can be used to replace the inductive current and sustain the *q*-profile in a stable regime. Towards this end, ECCD have been studied on DIII–D. For co-current drive, the observed current appeared to be higher than theoretical prediction. Finite collisionality effect is being considered to explain the discrepancy and agreement between theory and experiment is expected to improve at higher temperature. Density control is needed to increase the electron temperature for efficient current drive, and preliminary experiments with the cryopump have reduced the density by ~ 20%. Another approach to stabilize the RWM is sustenance of a large plasma toroidal rotation. On DIII–D, plasma rotation can be increased by varying the number and the energy of the neutral beam sources. Preliminary results show that increased angular momentum injection may be responsible for an increase in the duration of the high performance phase by nearly a factor of two. Further stability of RWM can be obtained by active feedback and experiments to test the idea is underway. Experiments have also been performed to explore the use of impurity puffing, shaping, and pellets to control edge instabilities which might terminate AT modes at higher β. The experimental results from DIII–D are encouraging for the prospect of achieving steady-state operation of AT regimes.

---

*Work supported by the U.S. Department of Energy under Contract No. DE-AC03-99ER54464.

[1] V.S. Chan, "DIII–D Tokamak Concept Improvement Research," Proc. 16th Int. Conf. on Plasma Phys. and Control. Nucl. Fusion Research, 1996, (International Atomic Energy Agency, Vienna), Vol. I p. 95.