PROGRESS TOWARD AN ADVANCED TOKAMAK AT DIII–D*

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Operation of the tokamak in an advanced operating regime requires active stabilization of plasma instabilities, effective management of the plasma edge, and the ability to control internal pressure and current profiles. Recent additions of an active instability control system, an expanded divertor pumping system, improved energy handling of the plasma facing components, upgraded plasma shape control system, higher power and longer pulse heating and current drive systems, and upgraded diagnostic systems have permitted the DIII–D program to address many of the issues critical to advanced tokamak operation.

One of the primary instabilities limiting the performance of the plasma in advanced tokamak operating regimes is the resistive wall mode (RWM). A system designed to actively control the RWM has been installed on DIII–D. The system consists of a set of six sensor coils and three corresponding pairs of independently powered external excitation coils. The signals are processed by real-time software in the DIII–D plasma control system and initial results indicate that control of these modes extends the energetic phase of the discharge. Future plans include the installation of an expanded external coil set and internal sensors.

Control of the plasma profiles is key to the achievement of enhanced tokamak performance. RF heating and current drive have evolved as essential tools for profile control. Four 1 MW class 110 GHz gyrotrons have been commissioned and six tubes are expected to be operational by early Fall. The three newest tubes are capable of operating for 10 s pulses when coupled with a diamond output window. A new steerable launcher permits scanning of the ECH power both poloidally and toroidally, and thus allows direct comparison of co-and counter current drive as well as heating and mode stabilization experiments. The recent addition of an inside, top, and outside launch pellet injection system also provides a valuable tool for density profile control.

The achievement of enhanced performance in a configuration that is capable of handling high, steady-state heat flux is one of the key objectives of the DIII–D divertor research program. A third, upper inner cryopump and divertor baffle region has been added that will allow investigation of the effect of pumping both divertor strikepoints on impurity control and will also provide improved density control in our high performance double-null discharges. As part of the divertor installation, the heat handling ability of the target region graphite armor tiles has been significantly improved by the improved edge-to-edge alignment of the tiles, replacement of faceted tiles with contoured tiles, reduction of gaps between tiles, and the use of high conductivity graphite in certain key locations. An axisymmetric, D_2 and impurity gas injection system and an extensive set of new diagnostics has also been added to aid in these divertor experiments.

A critical element for these experiments is the advancement of our plasma control system with the goal of providing integrated, real-time control of plasma shape, current and pressure profiles. Recent advances include the test of a model-based multi-input-multi-output controller developed using closed loop simulation tools coupled with a real-time equilibrium reconstruction. To provide the computing speed required for the intergrated control, a system upgrade is in progress using high speed Alpha processors running a real time Linux kernel.

*Worksupported by U.S. Department of Energy under Contract No. DE-AC03-99ER54463.