Simultaneous Feedback Control of Plasma Rotation and Stored Energy on the DIII-D Tokamak

J.T.Scoville, J.R. Ferron, D.A. Humphreys, M.L. Walker

General Atomics, San Diego, CA, USA

One of the major modifications made to the DIII-D tokamak during the 2005 Long Torus Opening was the rotation of one of the four two-source neutral beam injection systems. Prior to this modification, all beams injected power with a component in the same direction as the usual plasma current (“co-injection”). Starting in early 2006, two of the seven beams inject with a component in the opposite direction (“counter-injection”). This new capability allows, for the first time, a partial decoupling of the injected energy and momentum during neutral beam heating experiments.

An immediate advantage of mixed co- and counter-injection beams is the capability to control the plasma rotation velocity. High beta plasmas can now be studied over a wide range of the plasma rotation velocity. The stabilizing effect of rotation on the resistive wall mode (RWM), for example, can be directly compared to the stabilization achieved by external feedback coils. This is an advantage over previous techniques to control plasma rotation, such as magnetic braking, which have had only limited success.

We describe development and implementation of a model-based control algorithm for simultaneous regulation of plasma rotation and beta. The model includes the two relevant plasma states (plasma rotation and stored energy), and describes the dynamic effects of the relevant actuators on those states. The actuators include the applied beam torque and beam power, which depend on the amount of co- and counter-injected beams. Implementation of the model-based control within the plasma control system (PCS) [1] requires real-time measurements of the plasma rotation, obtained from the charge exchange recombination (CER) diagnostic, and stored energy calculated by the real-time EFIT equilibrium reconstruction. Details of this model and its development, and a comparison with experiment are reported here. Implementation of a control algorithm based on this model within the PCS is described. We also discuss some initial results obtained during experiments in which the new beam control algorithm is used to simultaneously control plasma rotation and stored energy.

[1] B.G. Penaflor, et al, “Current Status of DIII-D Plasma Control System Computer Upgrades,” Fusion Eng. and Design **71** (2004) 47.