Development of Real-Time Neoclassical Tearing Mode Control System with ECH/ECCD in KSTAR

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A real time Neo-classical Tearing Mode (NTM) control system using ECH/ECCD is under development to achieve a high performance and steady state plasma in KSTAR. Since the NTMs are inevitable in high beta plasma, it degrades the plasma performance and finally causes a serious disruption. In KSTAR, it is experimentally observed that the NTM is triggered by a big sawtooth crash in the low $\beta_N$ (about 0.8) plasma, and then the plasma beta is decreased. Since the auxiliary heating power increases in KSTAR, the NTMs will appear more frequently in the future. The NTMs can be effectively affected by the localized heating and current drive to produce the bootstrap current inside the NTM island. For the NTM suppression, the ECH/ECCD is one of the powerful and well-known tools because the power deposition can be highly localized and controllable by steerable antenna. KSTAR has a plan to develop a real time NTM control system by using ECH/ECCD. It will be implemented in the basis on KSTAR Plasma Control System (PCS) including active feedback control of ECH system. This work is mainly for a good alignment the ECH/ECCD deposition position with the NTM island location. Active feedback control of ECH includes feedback control of the deposition position of ECH power by the fast mirror movement, real-time ray-tracing calculation of EC beam, and real-time detection of the deposition location of EC power. The NTM island location tracing will be fulfilled by real-time detection of mode, position, and phase of NTMs by real-time equilibrium reconstruction data and diagnostics such as Mirnov coils, ECE, MSE, and so on.

In 2013, we had set up real-time ECH mirror movement during a single plasma discharge by upgrading the KSTAR PCS and the ECH launcher controller. The KSTAR 170 GHz ECH launcher, designed and fabricated in collaboration with PPPL and POSTECH, has a final steerable mirror in both poloidal and toroidal direction. Only poloidal direction of the steerable mirror was controlled by the PCS and then ECH power deposition position was changed along the resonance layer. The slow PLC launcher controller has been upgraded to FPGA-based system for reducing the response time. The test results of the launcher controller speed will be presented. The first NTM suppression experiment was performed with the PLC launcher controller with long response time. In this paper, we present experimental results of NTM suppression, NTM characteristics in present KSTAR, and upgrade plan of ECH and the real time NTM control system.