Control of current profile and instability by radio frequency wave injection in JT-60U and its applicability in JT-60SA

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Control of current profile and instability is important to obtain and sustain a high-beta plasma. Radiofrequency (RF) wave can play an important role for this purpose due to its ability to localized deposition. In JT-60U, a 2 GHz lower hybrid (LH) wave injection system and a 110 GHz electron cyclotron (EC) wave systems are equipped, and a real-time RF injection system in conjunction with real-time plasma diagnostics has been also developed.

Current profile control has been demonstrated by using a real-time system, in which the value of the minimum safety factor is measured in real time with the motional Stark effect (MSE) diagnostic, and optimized LH wave power is injected according to the following relation: $dP_{\mathrm{LH}}/dt = -\alpha(q_{\mathrm{min}} - q_{\mathrm{min,ref}})$. Here, P_{LH}, α, q_{min}, $q_{\mathrm{min,ref}}$ are LH wave power, proportional gain (>0), minimum value of the safety factor and the target value of q_{min}, respectively. In this campaign, real-time current profile control in high-beta plasmas was performed. In experiments, LH wave power was successfully controlled so that the value of q_{min} follows the target value, and as a result q_{min} was sustained at ~1.7. The value of q_{min} decreased after the notching of the LH wave, showing that the LH wave was effective. Change in current profile measured with the MSE diagnostic shows that current density at ρ~0.3-0.5 was locally increased by the LH wave injection (ρ is the normalized minor radius) [1].

Stabilization of a neoclassical tearing mode (NTM) using EC wave has been continuously performed. In particular, stabilization effect on an m/n=2/1 NTM for misaligned ECCD has been investigated [2]. Here, m and n are the poloidal and toroidal mode numbers, respectively. From detailed scan of ECCD location, the stabilization effect is found to appear for misalignment of ECCD location less than about half of the full island width. Also, the amplitude of a 2/1 NTM increased when the misalignment was comparable to the full island width (~0.1 in ρ). This shows the importance of precise injection for avoidance of a mode locking as well as the improvement of the plasma performance. Simulation of 2/1 NTM stabilization using the TOPICS code combined with the modified Rutherford equation has been also performed. The coefficients in the modified Rutherford equation were determined by comparing the island evolution in the above experiments and those in TOPICS simulations. As a result, the simulation is found to well reproduce the stabilization and destabilization with the same set of the coefficients [2].

ECRF system is planned to be installed in JT-60SA for NTM control as well as plasma startup and localized electron heating [3]. Since NTMs are considered to appear also in JT-60SA, simulation of NTM evolution using the TOPICS code has been performed with the inclusion of experimental results in JT-60U. Details of the TOPICS simulation will be presented in this paper.

[1] T. Suzuki *et al*., *Fusion Energy 2006* (Proc. 21st IAEA Fusion Energy Conf. Chengdu, China), EX/6-4.
[2] A. Isayama *et al*., *Fusion Energy 2006* (Proc. 21st IAEA Fusion Energy Conf. Chengdu, China, EX/4-1Ra.
[3] T. Fujita *et al*., *Fusion Energy 2006* (Proc. 21st IAEA Fusion Energy Conf. Chengdu, China, FT/P7-4.