§50. Experiments of Current Start-up by RF on QUEST

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Plasma current start-up is an indispensable process to produce tokamak configurations. It was obtained by electron cyclotron heating (ECH) without ohmic heating (OH) and a low aspect tokamak configuration could be successfully maintained for 37 s on QUEST.

1. Introduction

Spherical tokamak (ST) is a candidate for cost-effective fusion reactor and the improvement of the plasma performance of ST has been tried in many institutes. It is important to obtain the academic basics to support high beta and steady state operation approaches. The QUEST (Q-shu University Experiment with Steady State Spherical Tokamak) project focuses on the steady state operation of the spherical tokamak (ST) which has the capability to attain high β rather than conventional tokamaks. A final target of the project is the steady state operation of ST with relatively high β under controlled plasma wall interaction (PWI).

2. Plasma start-up experiments by the only RF

The plasma current of 15kA could be achieved and it maintained for 1 s, significantly more than magnetic diffusion time of the vacuum vessel (approximately 10ms) as shown in Fig. 1. As no loop voltage was supplied from PF coils during the maintenance on I_p of approximately 15kA, the plasma current could be maintained by a fully non-inductive current drive. An result of magnetic surface reconstructed by EFIT shows q_a~30, β_p~0.1, A=1.45, where q_a, β_p, and A mean safety factor at last closed flux surface, poloidal beta, and aspect ratio, respectively. The calculated aspect ratio is sufficiently low for a condition of spherical tokamaks. These results represent that a spherical tokamak configuration can be maintained by full non-inductive current drive, and the possibility to steady-state operation of spherical tokamaks could be demonstrated.

Fueling was only done for the plasma production just before the discharge and no more fueling was done during the discharge. The plasma current was significantly reduced with a rise of H_α signal which can be worked on a good-monitor of out-gassing from the wall. Usually, several hot spots appeared mainly on the outer wall and they are surely one of the strong sources of out-gassing. At present time, the longest discharge achieved on QUEST is shown in Fig.2. Out-gassing has been prevented from maintaining the plasma at any cases [2].

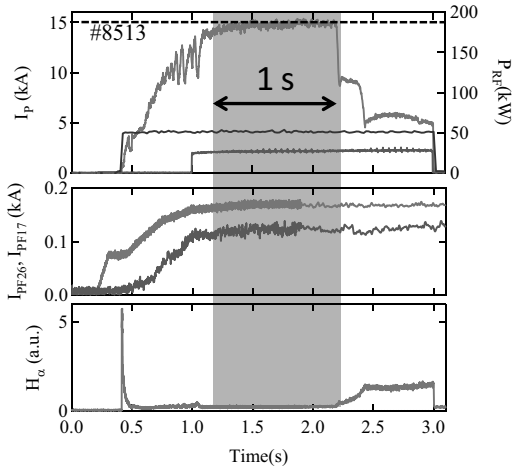

Fig. 1 Typical waveforms of plasma current, I_P, injected microwave power, P_{RF} (two systems were running in this shot) in top figure, currents of PF1/7 and PF2/6 in middle one, and H_α signal in bottom one on non-inductive current drive experiment are shown [1]. Sampling rate of PF1/7, PF2/6 coil currents for data acquisition was changed around 1.8 sec.

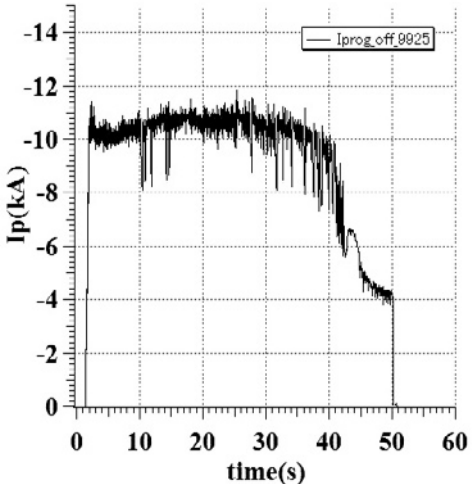

Fig. 2 The longest discharge achieved on QUEST is shown. The plasma current of more than 10kA could be sustained fro 37 s, and strong out-gassing as shown in a rise of H_α signal prevent from maintaining the plasma finally [2].

[1] K.Hanada *et al.*, Plasma science and technology, to be published.
[2] K.Hanada *et al.*, Proc. of 6th IAEA-TM on steady state operation of tokamaks, Vienna, Dec. 6-8, 2010, (2010).