Recent progress on non-inductive current drive and particle balance control towards steady-state operation on QUEST

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Non-inductive plasma current start-up is a crucial issue in development of spherical tokamaks (STs) and steady state operation (SSO) is a common issue in further development of cost-effective fusion power plants. The QUEST project aims to obtain SSO of STs with non-inductive current drive and well-controlled hydrogen recycling. QUEST has a capability to inject three kinds of RFs of 2.45GHz, 50kW CW, 8.2GHz, 400kW CW and 28GHz, 500kW 1sec, to drive non-inductive plasma current and has newly equipped a hot wall (up to 673K) inside of the vacuum vessel to control hydrogen recycling. Recent progress towards SSO on OUEST will be introduced.

Non-inductive plasma start-up without fundamental electron cyclotron resonance (1^{st} ECR) was successfully demonstrated in both 28GHz [1] and 8.2GHz [2]. Especially the plasma current was finally ramped up around 50-60kA and it had good reproducibility with 28 GHz RF. A comparison of their efficiency between with and w/o 1^{st} ECR was performed with the 8.2 GHz RF system and the efficiency to drive current and produce plasma w/o 1^{st} ECR is significantly inferior as compared with 1^{st} ECR heating and soft X-ray measurements in different energy ranges shows inefficient extendibility of electron energy at the ECR layer. Numerical calculations is well-explained by a poor capability to electron acceleration at higher harmonics ECR. An experimental survey of the efficiency on troidal field (B_T) gives us a further possibility to gain plasma current in higher B_T. It is expected to drive more than 60 kA with the 28 GHz RF in higher B_T.

Fuel hydrogen behavior in plasma-facing wall (PFW) has been investigated with measuring injecting and evacuating hydrogen molecules (H_2) in the plasma-producing vessel of QUEST. Approximately 80% of the wall-storing hydrogen atoms (H) is almost out-going within 300s after termination of the discharge, which indicates dynamic retention is dominant. A newly proposed particle balance equation to express hydrogen recycling on dynamic retention dominant wall is successfully confirmed in long duration discharges. The equation predicts to significantly control hydrogen recycling with the hot wall and the first experimental results will be presented.

[1] H.Idei, *et al.*, 25th Fusion Energy Conference (FEC 2014), Saint Petersburg, Russia 13 -18 October 2014

[2] H. Miura, K. Hanada, *et al.*, Plasma and Fusion Research, 10, 3402066.

[3] K.Hanada, *et al.*, Journal of Nuclear Materials, 463 (2015), 1084-1086.