§44. Study of the Operation Scenarios in QUEST

Mitarai, O. (Tokai Univ., Kumamoto Campus),
Nakamura, K., QUEST Group (Kyushu Univ.)

In a spherical tokamak (ST) device it is generally difficult to make plasma current even with the central solenoid (CS). Because (1) the toroidal field is smaller, leading to the shorter field connection length, (2) stray fields from the toroidal coils and feeder parts are relatively large due to the larger coil current, (3) CS has a small volt-second, (4) the continuous vacuum chamber makes the large vacuum chamber current, changing the field configuration, and (5) a large plasma volume in a ST leads to a smaller RF power density for a given power. However, as the large power of ECRH systems are equipped in QUEST, it helps breakdown of the plasma. In addition we installed the canceling coil (CC) to make a null point for easy plasma current start-up and control.

In the QUEST equipped with CC, a variety of operation scenarios can be conceived. For example, (1) Ohmic heating experiment, (2) Ohmic start-up and subsequent RF current sustainment, and (3) CS-less start-up experiments, and merging current start-up experiments.

The canceling coil (CC) to make a null point in the electron cyclotron resonant regime has been constructed and installed in QUEST (R=0.68m, a=0.4m, B_t=0.25 T) as shown in Fig. 1. First reason of installing CC is the current ripple in the present PF26 power source. As CS and CC coils are connected in series, no such ripple problems exist. The second reason is that the present PF26 coil power source has not enough voltage with a fast response to make a null point and subsequent equilibrium vertical field. The position of CC with 4 turns is just outside the PF17 coils, where the space is available. By changing the turn number of CC the null point can be adjusted.

The plasma current of 3 kA was obtained in the second shot (#1448) after adjusting the gas puffing. The plasma current was increased to ~8 kA at the 5th shot and ~10 kA with 0.25s was obtained at 9th shot. These waveforms are shown in Fig. 2.

After optimization, the plasma current of 15 kA with about 0.3 s duration time has been obtained as shown in Fig. 3. As the vertical field coil current was applied initially (Fig.3-(c)), ~77 Gauss was produced at the breakdown phase. Therefore, no null point was created. The loop voltage is ~4 volts in the initial phase (Fig. 3-(c)), the RF power of 55 kW with 8.2 GHz was applied during the breakdown phase and at B_t=0.15 T (R=0.64 m). After Ohmic transformer current is zero, the plasma current is maintained and even ramped up. This is due to the vertical field induction effect.

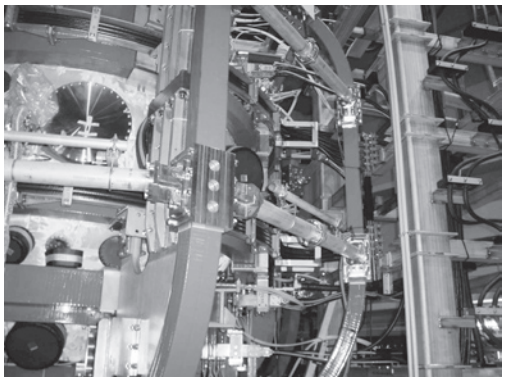

Fig. 1. The picture of the installed canceling coil in QUEST.

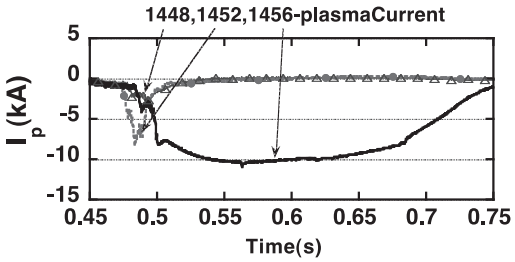

Fig2. Plasma current evolutions at second shot (#1448), 5th shots (#1452), and 10th shot (#1456) in the first day experiments of the Ohmic discharge in QUEST.

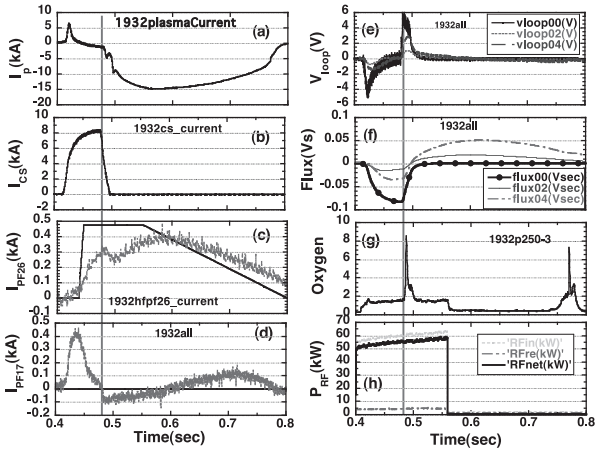

Fig. 3. Plasma current evolution in QUEST at B_t=0.15 T with the one turn cancellation coil. (a) Plasma current (b) CS current, (3) PF26 vertical shaping coil current and set value, (d)PF17 vertical field coil current, (e) loop voltage measure at the three locations, (f) Measured fluxes at the three locations, (g) Oxygen impurity line, and (8) 8.2 GHz RF power. (#1932)

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