§54. Experimental Study of the Various Plasma Current Start-up Methods in QUEST

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

1. QUEST Ohmic experiments

In general as a spherical tolamak has a large plasma cross-section, a large plasma current can be flown. This is a favorable aspect in an ST to achieve ignition than a conventional high aspect ratio tokamak. However as the flux of the Ohmic transformer is limited due to the narrow space near the central post, it is difficult to ramp up a plasma current. To overcome this problem, it was proposed by one of author that the vertical field coil inherently equipped in a ST can ramp up the large plasma current. Therefore it is important to demonstrate the large plasma current by such effect in QUEST together with the small CS flux.

Since the first Ohmic plasma generation up to 13 kA achieved in the last fiscal year, it was intended to increase the plasma current Ohmically. However, it was difficult to increase the plasma current furthermore. This might be due to the fact that when the CS coil current ramp-down is smaller the plasma current is larger as shown in Fig. 1. This is contradicted to the common sense in a tokamak operation.

In this fiscal year, this reason was clarified and trial to increase the plasma current has been done using modified CS power circuit capable of having any waveform shape.

2. The second cycle experiments: (10~12. 2009)

As the reason of the experimental contradiction on the CS current found in the last campaign has been clarified experimentally as shown in Fig. 2. The vertical field measured inside the vacuum chamber has an opposite direction to the equilibrium vertical field (Fig. 2-(b)), which is induced by the vacuum chamber current. Therefore, the equilibrium vertical field becomes small during the plasma current ramp-up phase when the CS ramp-down rate is large. The "EDDYCAL" computer code also confirms this effect.

Before modification of CS power circuit, it was tried to use the initial phase of the slow change in the CS coil current, which can remove the large opposite vertical field. Using this technique we could demonstrate that the plasma current ramp-up to 48 kA can be obtained by the slow CS current ramp-down as shown in Fig. 3. Thus we have demonstrated we should modify the CS power circuit to increase and control its waveform.

3. The third cycle experiments: (1~2. 2010)

To increase in the plasma current by the double swing operation of CS current, we planned to use the additional CS circuit with the central B coils connecting to the PF17 coil power supply circuit. The numerical calculation shows that the plasma current of ~100 kA could be induced. We have tried once this discharge. However, as the plasma position measurement was not correct due to the CS current polarity change, diagnostic systems has been compensated and adjusted for the next experimental campaign.

The plasma current up to 60 kA has been obtained by CS coil single swing operation and together by PF26 vertical field (#6109). The constant PF17 coil current was applied for the breakdown adjustment. After CS current decays to

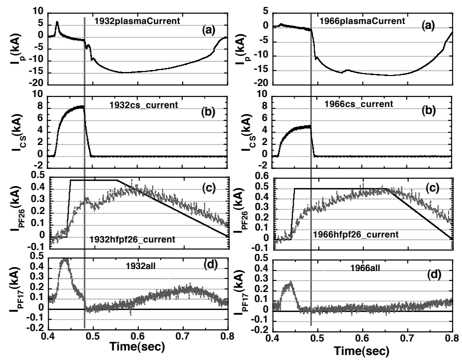

Fig. 1. Plasma current evolution in QUEST at B_t=0.14 T with the one turn cancellation coil. Left column shows I_{CS}=8 kA (#1932) and right one I_{CS}=5 kA (#1966). (a) Plasma current, (b) CS current, (c) PF26 vertical shaping coil current (N_{PF26}=72 turns) and set value, (d) PF17 vertical field coil current.

zero, the plasma current is ramped up clearly, the vertical field can produce the plasma current but with inner movement.

This work is performed with the support and under the auspices of the NIFS Collaborative Research Program NIFS09KUTR042.

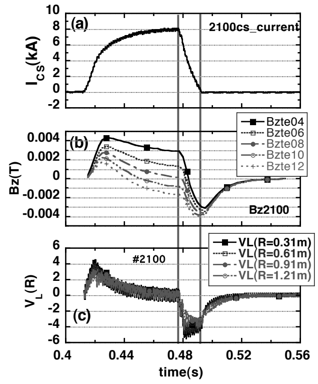

Fig.2. Measured vertical field inside the vacuum chamber for I_{CS}=8 kA. (#2100)

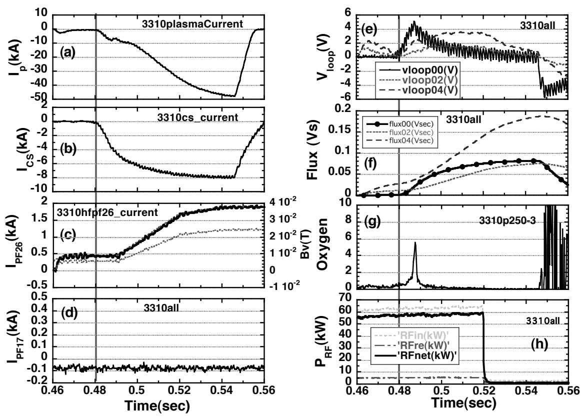

Fig. 3 The plasma current evolution for the slower OH coil current ramp-down. (a) Plasma current (b) CS current, (3) PF26 vertical shaping coil current and vertical field, (d) PF17 vertical field coil current, (e) loop voltage measured at three locations, (f) measured fluxes at three locations, (g) oxygen impurity line, and (h) 8.2 GHz RF power. (#3310)