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

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1. Introduction

In general a spherical tokamak can flow a larger plasma current with respect to the magnetic field due to a fat configuration compared to the high aspect ratio tokamak. This is favorable to achieve ignition. However as the flux of the Ohmic transformer is limited, it is difficult to ramp up large plasma current. To overcome this problem, it was proposed by one of author that the equilibrium vertical field coil can ramp up the large plasma current together with a heating power in a ST. Therefore it is important to demonstrate such effect in QUEST after establishing the plasma current by the small CS flux.

In this fiscal year, the plasma current up to 120 kA and divertor operations have been demonstrated using the CS flux and vertical field without the heating power application.

2. Single swing operation

After modification of CS power supply circuit, the CS coil current waveform was adjusted to the current ramp-up time of 0.1 s. Ohmic experiments have been performed during the discharge cleaning phase prior to RF experiments. Figure 1 shows the discharge waveform of the 90 kA flat top plasma current. Finally 100 kA has been obtained.

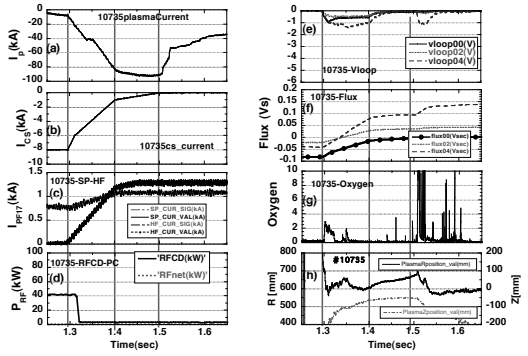

Fig.1. The plasma current evolution in ohmic discharge with for I_{CS}=8 kA. (a) Plasma current (b) CS current, (c) PF26 vertical shaping coil current and PF17 vertical field coil current, (d) 8.2 GHz RF power, (e) loop voltage measured at three locations, (f) measured fluxes at three locations, (g) oxygen impurity line, and (h) horizontal and vertical plasma positions. (#10735) Operated by Hasegawa.

3. Pseudo-double swing operation

To increase the plasma current further, we have used additional B coils wound at the central part of CS. The coil turn number is almost one third of CS. After decay of the main CS current, B-coil current is induced reversely. We call this the pseudo-double swing operation of CS current. As shown in Fig. 2, the peak current of 120 kA has been achieved. However the flat top current is not obtained due to lack of optimization time.

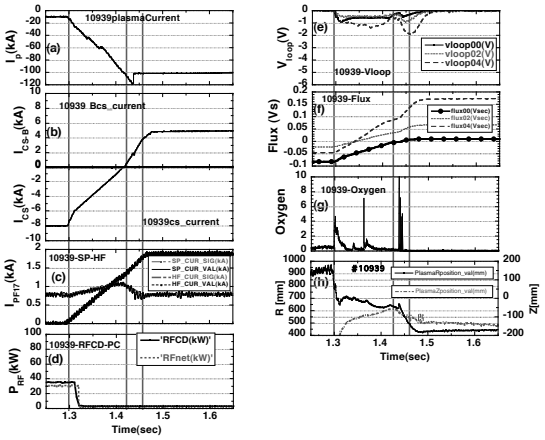

Fig.2. The plasma current evolution in pseudo-double swing operation with for I_{CS}=8 kA (#10939). (a)–(h) are the same as in Fig. 1.

4. Divertor operation

In QUEST two types of divertor operations are possible. For the first trial we have used the outer and inner divertor coil series connection. The plasma equilibrium has been calculated before experiments, and coil currents were set as predicted. As the outer divertor coil has a reverse induction effect on the plasma current because of the same direction of the divertor coil current and plasma current. To reduce such effect it is better to operate with the small time change in the divertor coil current. Therefore, in the initial breakdown phase, the divertor coil is activated together with the vertical field with PF17 coil to reduce the stray field. Also the outer divertor coil current reduces the vertical field, the actual vertical field for equilibrium is reduced. Therefore the resultant plasma current is as small as 40 kA. As shown in Fig. 3, the plasma current up to 40 kA has been obtained by CS coil single swing operation and

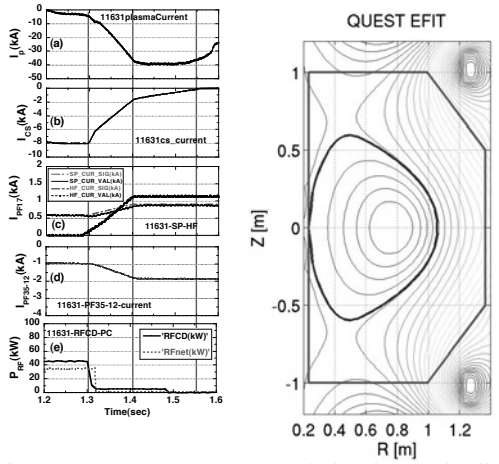

Fig. 3. The plasma current evolution in ohmic divertor operation. (a)–(e) are the same as in Fig. 1, except for (d) PF35-12 divertor coil current. Right figure: EFIT plasma cross section at 1.49s.

together by PF26 vertical field and divertor coil current.

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