§60. Optimization Experiments of the Ohmic Plasma Current Start-up in QUEST

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1. Introduction

In a spherical tokamak (ST) a larger plasma current can be flown with the larger safety factor due to larger plasma size compared to a high aspect ratio tokamak. This is favorable to achieve ignition. However as the flux of the central solenoid (CS) is limited, it is difficult to ramp up large plasma current. In addition, the divertor coil current has the same direction of the plasma current, its induction reduces the plasma current. Therefore, careful operation is necessary in a ST with the small CS flux and divertors.

In this annual report, we report that the CS flux to obtain the plasma current of ~30 kA is experimentally compared in the inner divertor and limiter operations with the same major radius, keeping the plasma external inductance identical. We can compare the characteristics of the inner and outer divertor operation (conducted in the last fiscal year) by this experiment.

2. Inner divertor operation with 30 kA range

Figure 1 shows the OH discharge waveform with inner divertor operation for the plasma current of 32 kA. Near the current peak, the central plasma position is around 0.8 m, the CS current is changed from -8 to -1.8~-1.6 kA, with the difference of ΔI_{CS}=6.2~6.4 kA. The initial divertor coil current was increased from -5 to -9 kA to reduce the reverse induction. By setting I_{PF17}=0.6kA, I_{PF25}=0.95 kA, the divertor configuration has been obtained by EFIT code as shown in Fig. 2.

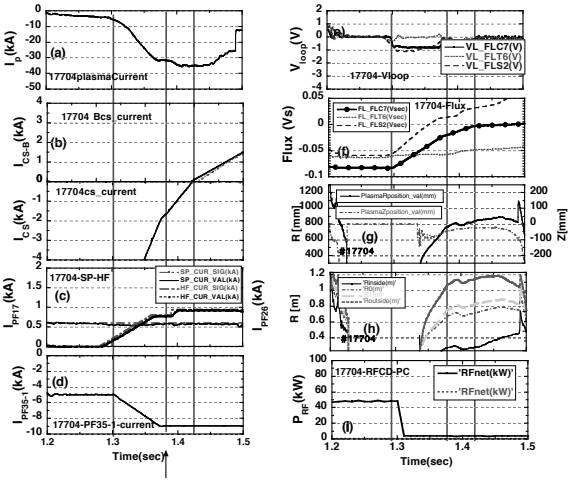

Fig. 1. The plasma current evolution in ohmic discharge with the PF35-1 inner divertor operation. (#17704) (a) Plasma current (b) CS current with B-coil current, (c)PF26 vertical shaping coil current and PF17 vertical field coil current, (d) PF35-1 inner divertor coil current, (e) loop voltage measured at three locations, (f) measured fluxes at three locations, (g) horizontal and vertical positions of the plasma center, (h) the plasma edge positions, and (i) 8.2 GHz RF power.

3. Limiter discharge with 30 kA

For comparison, the limiter discharge with the identical major radius were produced as shown in Fig. 3 by adjusting CS, and vertical field. The plasma current of 32 kA was induced by the difference of the CS coil current was ΔI_{CS}=5.8 kA.

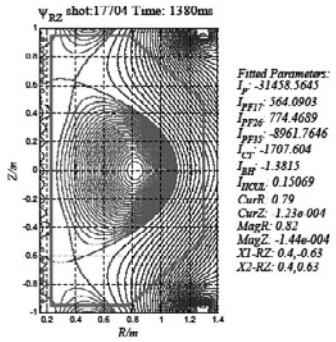

Fig. 2. EFIT equilibrium for the inner divertor operation at t=1.38 s. (#17704).

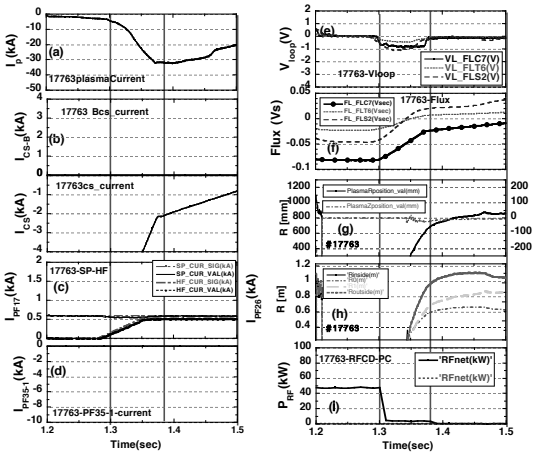

Fig. 3. . The plasma current evolution in ohmic limiter operation. (#17763) (a) -(i) are the same as in Fig. 1.

Combining the last year's data,

40kA outer divertor: ΔI_{CS}=6.0~6.8kA,
40kA limiter: ΔI_{CS}=5.5~5.7kA
32kA inner divertor: ΔI_{CS}=6.2~6.4kA,
32kA limiter: ΔI_{CS}=5.8kA

Based on stringent case of 40kA limiter of ΔI_{CS}=5.7kA for conversion, 40kA inner divertor should be ΔI_{CS}=5.8~6.0kA, which is slightly smaller than the flux in outer divertor operation.

Thus, the outer divertor operation needs more CS flux to achieve the same plasma current. This might be due to the fact that the reverse induction effect from the inner divertor coil is weaker. This result may imply that snowflake divertor (corresponding to an inner divertor) is better suitable to induce the lager plasma current than super-X divertor (corresponding to an outer divertor).

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