§58. Higher-precision Reconstruction and the Feedback Control of Divertor Plasma Shape in QUEST

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In the spherical tokamak QUEST (Bt = 0.25 T, R = 0.68 m, a = 0.40 m), as one of the methods to obtain a steady-state divertor plasma, a high-density divertor plasma is made by OH (ohmic heating) and the plasma current is planned to be sustained by EBW current drive.

OH divertor plasma of lower triangularity (Candy-shape) was produced with PF35-12 inner and outer divertor coils connected in series. And OH divertor plasma of higher triangularity (D-shape) was produced with PF35-1 inner divertor coil. The divertor plasma was designed by TASK/EQU code and the plasma boundary shape was reconstructed by CCS (Cauchy Condition Surface) method according to data from two kinds of magnetic sensors (flux loops and magnetic probes). The reproduced result showed a double-null divertor configuration (Fig. 1) and was compared with that by Windows E-FIT code (Fig. 2).

The CCS method is an exact numerical method which is based on the boundary integral equation. The CCS is defined as a hypothetical plasma surface, where both the Dirichlet (poloidal flux function) and Neumann (poloidal magnetic field tangent to the CCS) conditions are unknown. This surface is located inside the real plasma region. Though eddy current is also unknown, poloidal field coil current is known including connecting and returning windings of toroidal field coils. After reconstruction, only the flux surfaces outside of the plasma boundary are correct including the boundary[1].

In the present OH plasma with a lot of high-energy electrons, there may be an isotropic plasma pressure, which makes difficult a usual equilibrium analysis, but the CCS method can reconstruct the plasma shape precisely regardless of the anisotropy[2]. Since magnetic probes have been installed in addition to flux loops inside the vacuum chamber, CCS can be set on the measuring (magnetic sensor) surface. Vacuum vessel and the outer space are also outside of vacuum region. Boundary integral equation is applied also on the magnetic sensor surface. Eddy current and PFC (Poloidal Field Coil) do not have to be considered in this case. And in RF-driven plasma, the plasma current effect in the open magnetic surfaces outside of the closed magnetic surfaces could be considered by assuming hypothetical conductors or hypothetical PFC's in the open magnetic surfaces.

As for debugging and confirming of the CCS code in QUEST, we are going to carry out a bench mark test using magnetic data of JT-60U and reconstructed result by CCS code in JAEA.

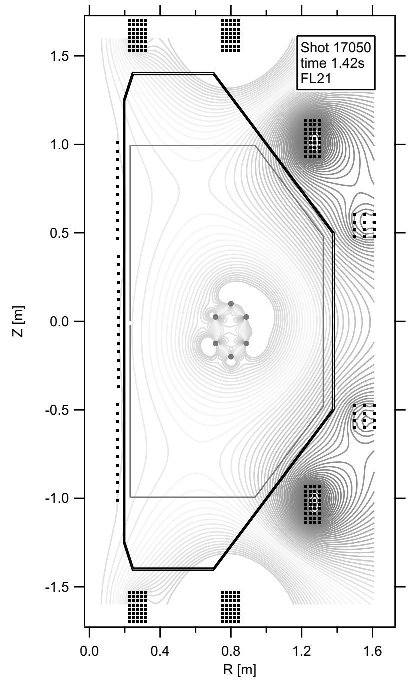

Fig. 1: OH divertor plasma of lower triangularity (Candy-shape) produced with PF35-12 and reconstructed by QUEST CCS.

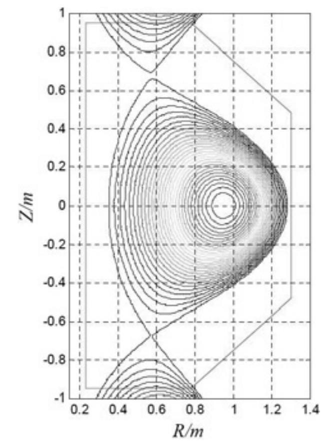

Fig. 2: OH divertor plasma of lower triangularity (Candy-shape) was produced with PF35-12 and reconstructed by Windows E-FIT.

1) K. Kurihara, Fusion Eng. Design, 51-52, 2000, pp.1049-1057.

2) K. Nakamura, Y. Jiang, X.L. Liu, O. Mitarai, K. Kurihara, Y. Kawamata, M. Sueoka, M. Hasegawa, K. Tokunaga, et al., Fusion Eng. Design, 86, 2011, pp.1080-1084.