§54. Feedback Control of the Plasma Shape and Divertor Configuration in QUEST

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The CCS (Cauchy Condition Surface) method is an exact numerical method which is based on the boundary integral equation. The Cauchy condition surface is defined as a hypothetical plasma surface, where both the Dirichlet (ϕ, poloidal flux function) and Neumann (B_t, poloidal magnetic field tangent to the CCS) conditions are unknown, as shown in Fig. 1(a). This surface is located inside the real plasma region. It is assumed that CCS encloses all the plasmas and there are no plasmas outside the CCS[1]. After reconstruction, only the flux surfaces outside of the plasma boundary are right including the boundary, which is similar to "image method" in calculation of static field due to a point charge in the presence of semi-infinite ideal conductor.

Fig. 2(a) shows the time evolution of eddy current profile by EDDYCAL[2]. The current is large in the inside of the vessel at the initial phase and is higher in the outside thereafter. It is noticed that the current is small in the top and bottom. The profile is almost uniform in each section and only the current magnitude will be calculated hereafter[3].

Fig. 3 shows waveforms of CS, plasma and vertical field currents in ohmic discharge assisted by ECRH (41 kW between 1.28 and 1.33 sec). The CS current was swung in single polarity: This time, after CS coil is excited in negative polarity by CT power supply, by decreasing the current, plasma current was started. At the same time, the plasma current is driven further by increasing PF26 coil current. Vertical field for horizontal equilibrium was applied by PF17 coil before the plasma initiation and added further by PF26 coil.

Fig. 1(b) shows magnetic surfaces ($t = 1.5$ sec) reconstructed by CCS method. In this reconstruction, 22 flux loops were used among 67 loops. Uniform eddy currents were assumed in 8 sections. In this figure, closed magnetic surface is found, though closed magnetic surface exists in the inner half region of the plasma space surrounded by fixed limiters and diverter plates as confirmed as a round plasma shape in TV camera image. The verical asymmetry suggests some asymmetry of magnetic fields or eddy currents.

Fig. 2(b) shows time evolution of the eddy current in each sections. The eddy current is high in the inside of the vacuum vessel in the initial plasma current ramp-up stage and becomes higher in the outside after the plasma current peak, since the time constant of the eddy current is longer in the outside. This tendency does not contradict the time evolution due to CS coil current decrease in Fig. 2(a).

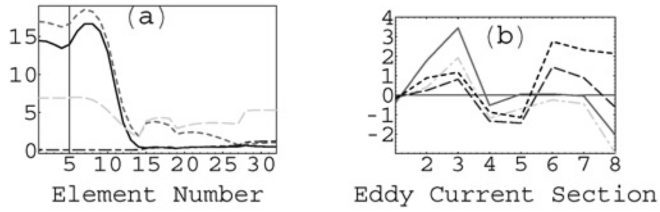

Fig. 2: (a) Eddy current density profile calculated by EDDYCAL. Solid, dotted, broken and dashed lines indicate the profiles at $t = 1, 10, 11$ and 25 ms after the decrease in CS coil current. Element number is counted from the inside along the vacuum vessel contour arc. The numbers 6, 14, 18 and 27 indicate the corners between the sections E1, E2, E4, E6 and E8 in Fig. 1(a). (b) Time evolution of eddy current in QUEST ohmic discharge. Solid, dashed, broken and dotted lines indicate the profiles at $t = 1.3, 1.305, 1.36$ and 1.4 sec in Fig. 1(a).

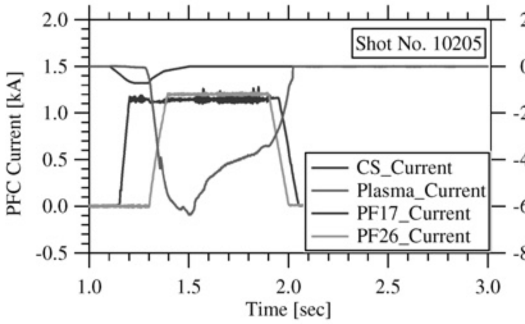

Fig. 3: Coil and plasma current waveform in QUEST ohmic discharge.

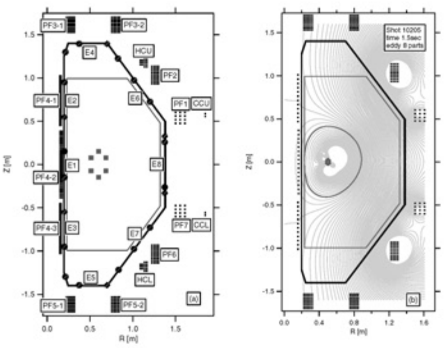

Fig. 1: Cross-section of QUEST. (a) Eddy current sections (E1 to E8) inside the vessel, flux loops (solid circle) on the inner surface of the vessel and CCS points (6 solid rectangle) in the interior of the vessel. (b) Magnetic surfaces reconstructed by CCS method in ohmic discharge.

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

2) A. Kameari, J. Comp. Phys., Vol.42, No.1, 1981, pp.124-140.

3) K. Nakamura, S. Matsufuji, Y. Jiang, X.L. Liu, O. Mitarai, et al., APFA, Aomori, 2009, P27p1.