Poloidal field configuration effect to electron cyclotron wall cleaning in KSTAR

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ECWC is an essential method for wall cleaning between plasma shots in superconducting devices. In KSTAR, ECWC has been actively utilized to address impurity issues caused by SPI (MGI) or disruptions, and research on this has also been conducted [1].

The effect of the poloidal magnetic field structure on ECWC performance has been studied. In KSTAR, it has been experimentally demonstrated that the performance of ECH plasma during ECWC improves when a vertical field is applied instead of a radial field [2]. Additionally, in the pre-ionization startup experiment using the TPC structure, it was found that introducing a slight curvature to the vertical field resulted in the formation of a high ionization rate pre-ionization plasma [3]. The current ECWC scenario utilizes the IM of this TPC startup scenario.

However, by further optimizing the magnetic field configuration, the confinement of the ECH plasma can be improved, which in turn can enhance the wall cleaning effect. While previous studies have investigated various parameters such as helium pressure and ECH injection conditions for wall cleaning, the influence of the background poloidal magnetic field configuration has not been evaluated. Therefore, in this study, we experimentally examined the formation of ECH plasma and the resulting wall cleaning effect by varying two factors of the poloidal magnetic field configuration: magnetic field curvature and strength.

The curvature of the poloidal magnetic field was controlled by changing the combination of coils used, while the magnetic field strength was adjusted by varying the current supplied to the coils. The coils employed in this study were PF5, PF6, and IRC. For each curvature condition, the electron density level of the formed ECH plasma was experimentally measured. The results are shown in Figure 1 (a). As the magnetic field curvature was increased in the direction of stronger toroidal magnetic field, the maximum electron density achieved also increased. Interestingly, according to conventional theory, plasma confinement in the absence of plasma current is expected to depend on the magnetic connection length, suggesting that higher density should be achieved under weaker magnetic field conditions. However, the experimental results indicate that there exists an optimal magnetic field strength for maximizing plasma density, which appears to lie in the range of approximately 50–100 G.

Accordingly, differences were observed in the amount of gas removed from the wall by the ECH plasma under each condition. This reflects how effectively the formed ECH plasma can remove impurities from the wall. The gas removal performance, as indicated by the pressure rise measured by the pressure gauge, was found to exhibit a pattern similar to that of the electron density levels. The results are shown in Figure 1(b). It was confirmed that the maximum amount of gas removal occurred when the curvature was applied in the direction of higher toroidal magnetic field using the PF5 coil, and the magnetic field strength was set to approximately 75–100 G.

These results suggest that maximizing the impurity removal performance using ECWC can contribute to improving the overall impurity conditions in tokamak plasma experiments.

References
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[3] J. Lee et al., NF 126003 (2017)

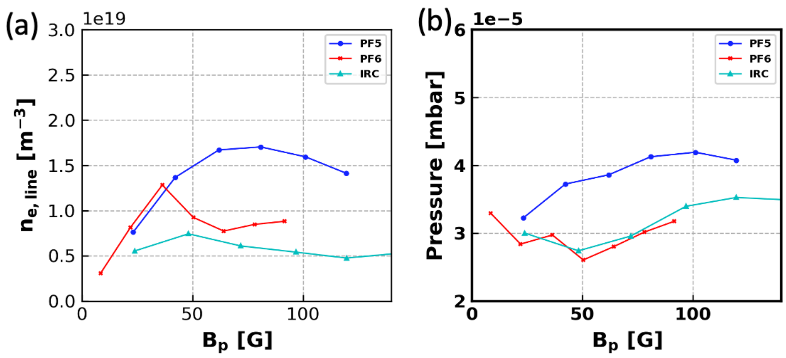

Figure 1. (a) Electron density of ECH plasmas and (b) deuterium removal performance at the wall under varying strength and curvature of the background poloidal magnetic field.