Comparison of hydrogen and deuterium plasmas in ECH start-up experiment in the TST-2 Spherical Tokamak

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In spherical tokamaks (STs), non-inductive start-up method is studied aiming fusion reactors without center solenoid [1-3]. Wave heating is one of the methods. In the TST-2 spherical tokamak, non-inductive plasma start-up and sustainment experiments were performed by injecting waves at 21 MHz (RF) and 2.45 GHz (EC). When we inject EC power alone, the plasma current shows a gradual slow increase (Fig. 1). After a certain period, the plasma current increases abruptly (so called a current jump) and an ST configuration with closed flux surfaces is formed (Fig. 1). Since a current jump seems to occur around a certain plasma current value, the initial increasing rate should be fast enough to induce a current jump within a finite discharge duration [2]. The initial current increasing rate depends on a filling gas pressure. In addition, appropriate additional gas puff is necessary to sustain the discharge. Therefore, it is important to confirm the effect of wall recycling, wall conditioning and the difference of working gas. In this paper, we report the wall conditioning effect and the difference between hydrogen puff and deuterium puff. It was found that the Ohmic discharge wall cleaning is useful to make reproducible discharges. Furthermore, while the initial current increasing rate and the current waveform in ST phase do not depend on the kind of gas, the waveform around the current jump is different, and deuterium seems to be preferable to promote earlier ST formation.

In addition to the good reproducibility, the Ohmic discharge cleaning is efficient to reduce carbon and oxygen line emissions in ECH start-up plasmas. By switching gas species and observing H_β and D_β simultaneously, we can isolate the components ejected from the wall. After confirming the reproducibility of hydrogen ECH start-up discharges, we switched the fuelling gas from hydrogen to deuterium. In this case, D_β time traces show a gradual decrease after the initial plasma generation, while H_β shows a gradual increase. At the initial phase, D_β is dominant. Thus, the initial discharge evolution is determined by deuterium, and effect of hydrogen released from the wall becomes important at later phase. Figure 1 shows the comparison of reproducible hydrogen (red) and deuterium (black) discharge waveforms. The operational conditions including filling pressure are the same. It is remarkable that the initial waveforms ($t < 30$ ms) and the last half waveforms ($t > 60$ ms) are similar, but the period around the current jumps (30 ms $< t < 60$ ms) are different. In this period, ECH reflection power is high (Fig. 1(b)). These results suggest that appropriate density profile and/or ECH deposition profile is required to induce the current jump.

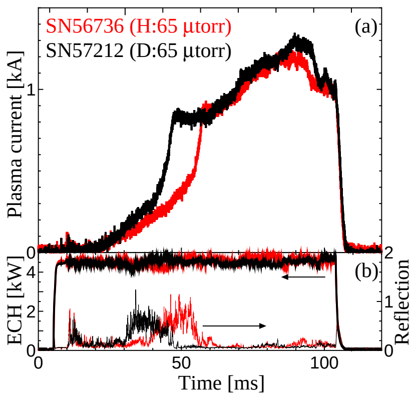

Fig. 1 Comparison of ECH start-up hydrogen and deuterium plasmas.

[1] T. Maekawa et al., Nucl. Fusion. 45, (2005), 1439
[2] J. Sugiyama, et al., Plasma Fusion Res. 3, (2008) 026.
[3] O. Watanabe et al., Plasma Fusion Res. 3, (2008) 049.