§47. Fueling Efficiency of Gas Puffing on Large Helical Device

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The fueling efficiency of gas puffing is one of the important parameters to describe the particle balance of the fusion plasmas. The fueling efficiency has been investigated based on the particle balance model [1]. The particle balance of gas-fueled hydrogen plasma heated by the NB injection can be modeled by the equation below [1];

$$N_e' = \alpha(\Phi_{puff} + R_{div}\Gamma_{div} + R_{wall}\Gamma_{wall}) + \Phi_{NB} - \frac{N_e}{\tau_p}. \quad (1)$$

The response of N_e' to Φ_{puff} can be directly related to α;

$$\alpha \approx \frac{\partial N_e'}{\partial \Phi_{puff}}, \quad (2)$$

as long as the other parameters are insensitive to the change of Φ_{puff}.

Five discharges from the series of the density ramp-up experiment are selected to examine Eq. (2) and estimate α. These five discharges consist of the plasmas heated by different P_{NB}, with the natural/cancelled/extended magnetic island of m/n = 1/1. The particle balance has been analyzed in the latter phase of the density ramp up discharges (Phase II in Fig. 1). The increase rate of the plasma density is correlated to the particle flux gas puffing alone and not to the other parameters such as the recycling flux, at that phase.

The relation between Φ_{puff} and N_e' in the Phase II is shown in Fig. 2. The least square fit of N_e' with Φ_{puff} gives the linear equation below;

$$N_e' = (0.115 \pm 0.002) \times \Phi_{puff} - (11.5 \pm 0.5), \quad (3)$$

where the unit is 10^{19} /s. Comparing Eq. (3) with Eq. (1) (or, Eq. (2)), the fueling efficiency is obtained from the slope of Eq. (3); i.e. α = 0.115. The offset of Eq. (3) (= −11.5) corresponds to the sum of the other terms than $\alpha\,\Phi_{puff}$, in the right-hand-side of Eq. (1). As seen in Fig. 2, all of the five discharges have similar slopes as Eq. (3), although the offsets are different. This suggests that α is insensitive to the heating power or the existence of the magnetic island, within the experimental conditions studied here. As for the offsets, it seems to change according to the experimental condition. It is remained as the future problem to find out the control parameter that determines the offset.

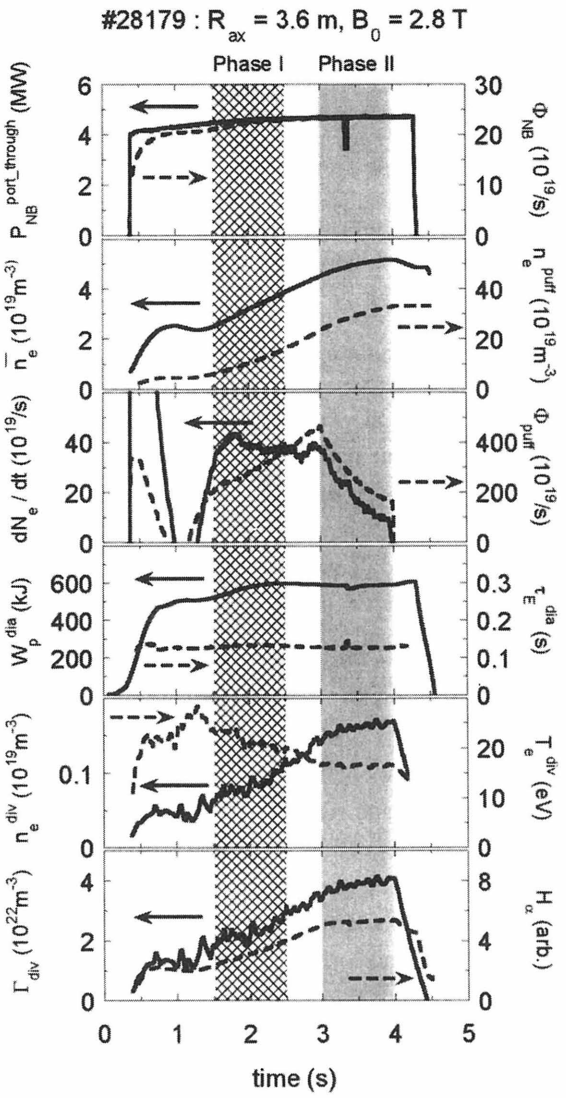

Fig. 1. Waveforms of typical parameters in the density ramp up discharge.

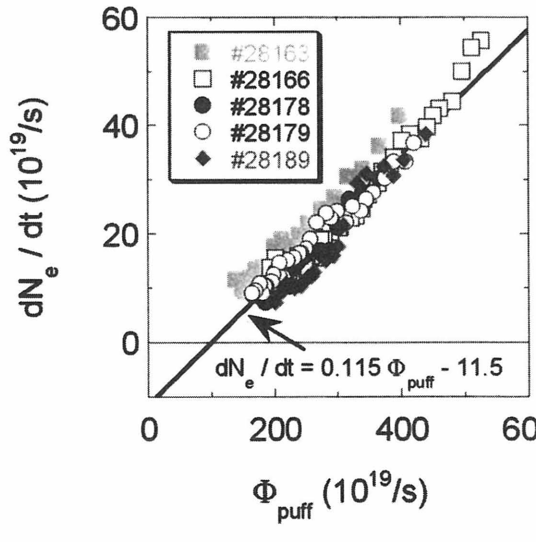

Fig. 2. Relation between Φ_{puff} and $N_e' = dN_e/dt$.

Reference

1) Miyazawa, J., et al., paper presented at PSI-15 (P3-48), submitted to J. Nucl. Mater.