§ 34. Initial Result of Repetitive Pellet Fueling

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Our previous study with a conventional pipe-gun type pellet injector indicates that pellet fueling has transiently extended the operational region of the LHD plasmas to higher densities, which cannot be attained by gas puffing while maintaining the favorable dependence of the energy confinement on the density. If this advantage of the pellet fueling is demonstrated in steady state operation, pellet fueling offers significant advantage for future a fusion reactor. For the purpose of investigations of fueling issues towards the steady state operation of fusion plasmas, a repetitive pellet injector with compact cryo-coolers has been developed. This facility is capable of completely steady state pellet injection in principle with the repetition rate up to 11 Hz. Maximum pellet mass is 5×10^{20} atoms per pellet. The pellet velocity is adjustable in the range of 150-550 m/s. This injector has been installed to Large Helical Device (LHD) and repetitive pellet fueling experiments have been started.

The hydrogen pellets are injected into NBI heated hydrogen plasmas with the standard magnetic configuration (R_{axis}= 3.6 m, $B_t \approx$ 2.8 T) from an outboard side at the horizontal elongated cross-section. Typical NBI heating power is 4 MW for 5 s discharges at the energy of 130 - 150 keV. Effective pumping speed of the vacuum vessel is about 150 m^3/s and there is no active pumping at divertor.

Fig. 1 shows typical waveform of the repetitive pellet fueling discharge. 50 pellets were injected with repetitive rate of 10 Hz to an NBI heated plasma. Quasi steady-state operation of 2 s was achieved at plasma parameters of $\bar{n}_e$= 0.8×10^{20} m^{-3}, T_i= 1.3 keV, T_e= 1.0 keV with 4 MW NBI heating from 3.6 s to 5.6 s. In this quasi steady state phase, the line averaged electron density ($\bar{n}_e$) and the center temperatures ($T_i(0)$, $T_e(0)$) stay at constant value. However, edge parameters such as the neutral pressure (p_{np}), the hydrogen emission (H_α) and the divertor flux (Γ_{div}) continue to increase. These phenomena suggest an increase of recycling in quasi steady state phase. Plasma stored energy (W_p) declines in response to increase of recycling. Though it cannot tell that the neutral pressure rise is a cause or a result of the confinement deterioration, it is suggested that the neutral pressure have close connection to the global confinement.

Fig. 2 shows diagrams of the plasma stored energy, which normalized by NBI power, respect to electron density for high density discharges. As for gas puff fueling, a high density discharge around 1.0×10^{20} m^{-3} is also possible by using massive gas puff, but the obvious confinement deterioration is observed at the density of 0.35×10^{20} m^{-3} and above. In the case of the large pellet, favorable confinement is achieved at high density region, though this behavior is transient. In the case of repetitive pellet, though the confinement deterioration is observed at the density of 0.5×10^{20} m^{-3} and above, positive dependence on electron density is kept beyond 0.8×10^{20} m^{-3}.

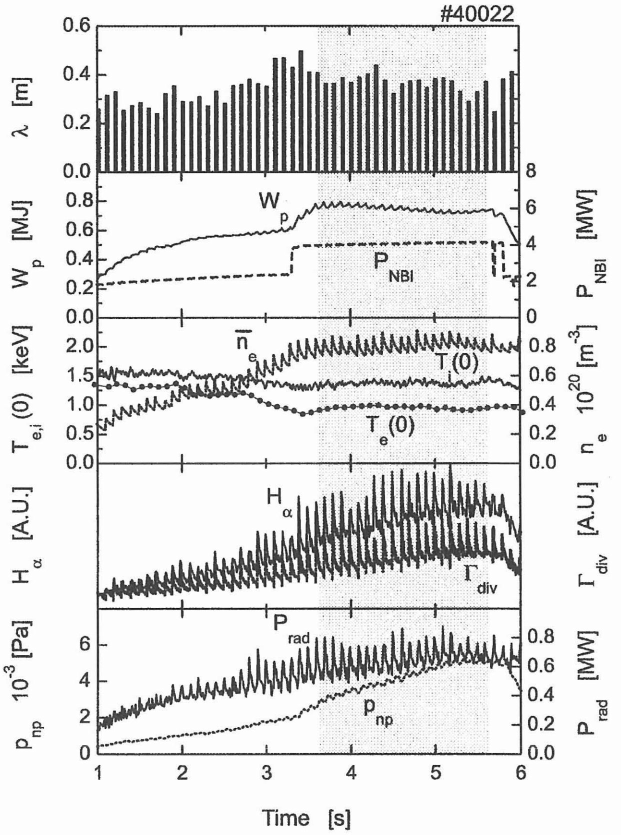

Fig. 1 The temporal evolution of the key parameters in repetitive pellet fueling discharge.

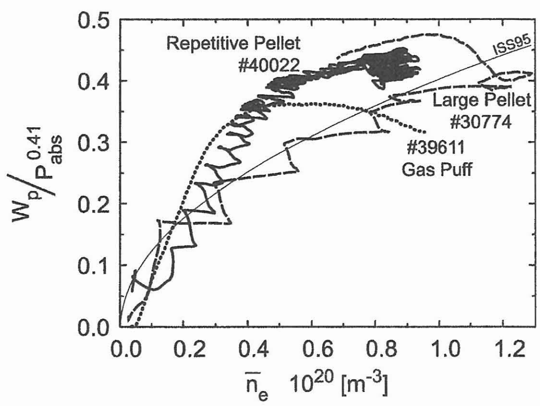

Fig. 2 The diagram of the normalized plasma stored energy respect to electron density.