23Pp18

圧空パイプガン方式によるペレット速度と燃料付与の特性と制御性
Characterization and controllability of hydrogen-pellet speed and fuel deposition by a pneumatic pipe gun

戴暁玥[a]，山田弘司[a,b]，磯部有吾[b]，坂本隆一[b,c]
DAI Xiaoyue[a], YAMADA Hiroshi[a], ISOBE Yugo[a], SAKAMOTO Ryuichi[b]

[a]東大工，[b]東大新領域，[c]核融合研
[a] F. Eng. Univ. Tokyo, [b]GSFS Univ. Tokyo, [c]NIFS

Characteristics of penetration depth and speed of solid hydrogen-pellet are discussed with the results from LHD. The solid hydrogen pellet injection is a promising method for fueling to maintain the plasma confined by the magnetic field. This method is expected to be highly efficient direct fueling for future large-scale fusion reactors since pellets are penetrated into a core region beyond a hot scrape-off layer. Fuel particles are deposited in the core region through the ablation of pellets and the following drift motion of high-density plasmoid. Therefore, the integrated understanding of physical properties such as pellet speed and mass, target plasma parameters and magnetic field is a prerequisite for the establishment of control of fueling position and improvement of efficiency. The aim of this study is the comprehensive characterization of fuel deposition by pellet injection.

The neutral gas shielding (NGS) model [1] has been used as a basic theoretical prediction model for pellet ablation. According to this theory, the pellet penetration length can be expressed by Eq (1)

$$\lambda/a = 0.079 T_{e0}^{-5/9} N_{e0}^{-1/9} m_p^{5/27} V_p^{1/3} \quad (1)$$

where λ/a, T_{e0}, N_{e0}, m_p, and V_p are the penetration length normalized by plasma minor radius, electron temperature, electron density, pellet mass and pellet speed.

The comparison of the experimentally observed penetration length and the prediction by the NGS model in LHD is shown in Fig.1. The penetration length is evaluated by the duration of H_β emission from pellets and the pellet speed estimated by the time of flight. A distinguished difference in the performance of NBI and ECH plasmas has been found. The penetration length in the case of NBI is shorter (shallower) than ECH. This may be due to the influence of fast ions originated by NBI on ablation. The dependence of penetration length on operational parameters such as NBI heating power and magnetic field strength, which is not included in the NGS model, is discussed with the results from regression analysis.

For a future experiment, the controllability of pellet speed has been assessed. According to the ideal gas-gun theory (IGT) [2], the pellet speed can be controlled by the pressure and the species of propellant gas, and the

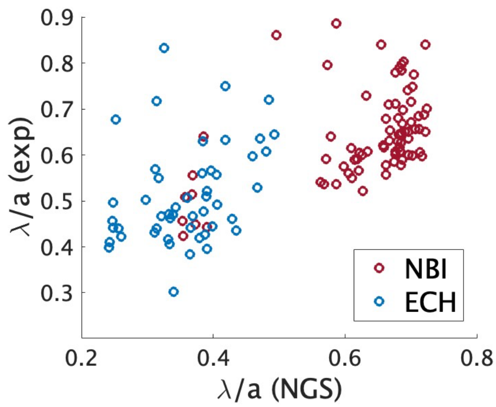

Fig.1 Comparison of penetration length in the experiment and prediction from the NGS model (Eq.(1)).

pellet material. Figure 2 shows V_p predicted from IGT in curves and observations in the experiment (circles) as a function of the propellant gas pressure. A significant difference between cases of H_2 and He has not been identified unlike IGT, which suggests a difference in effective acting pressure between diatomic molecule gas and a noble gas. The experimental speed for H_2 acceleration only remained at 60% of the NGS predictions while the cases of He and Ne reached 75% and 80%, respectively.

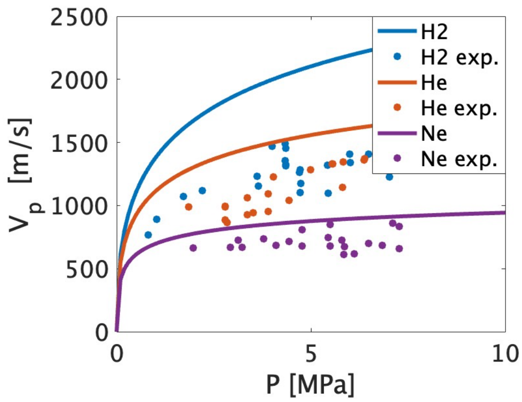

Fig.2 Pellet speed as a function of propellant gas pressure by IGT (curves) and experimental observations (circles) for different gases of H_2 pellet under different propellant gases.

[1] L. R. Baylor et al., Nucl. Fusion **37**, 445 (1997).
[2] L. D. Landau and E. M. Lifshitz, Fluid mechanics (Pergamon Press, 1987).