§36. Study of Pellet Injection for Efficient Core Plasma Fuelling in Heliotron J

Motojima, G., Sakamoto, R.,
Nagasaki, K., Mizuuchi, T., Okada, H., Ohyabu, N.,
Nakamura, Y. (Kyoto Univ.),
Yamada, H., Sano, F. (Kyoto Univ.)

The design study of the pellet injection system required in Heliotron J has been conducted. In this study, a prototype of the injection barrel has been manufactured towards the pellet injection test.

One of the advantages of the pellet injection compared with other fuelling methods is that particles are deposited into the core plasma efficiently. Although gas puffing and super molecular beam injection are already used for the high density experiments in Heliotron J, the pellet injection is expected to be a higher efficient refuelling system. Also, Heliotron J has a robust NBI system compatible with the pellet injection. There is a potential of high performance and high density plasmas using the pellet injection. In this study, pellet size, speed, acceleration method and injector size required in Heliotron J have been investigated. The detail is reviewed as follows:

1. A pellet ablation code (ABLATE [1]) based on the neutral gas shielding model reveals that the pellet size of 0.8 mm ϕ $\times$0.8 mml (cylindrical shape) and the pellet speed of 300 m/s-500 m/s are required in order not to perturb the core plasma by too much penetration in Heliotron J.

2. By using ideal gun theory [2], pellets could be injected with the speed mentioned above by an in-situ technique and pneumatic acceleration when the barrel length is optimally minimized as less than 10 mm.

3. In the pellet injection system which utilizes pneumatic acceleration, the differential pumping system is required to prevent the propellant gas (e.g. He) from flowing into the plasma vacuum vessel. As for the hardware, the size of the pellet injection system is mainly occupied by the differential pumping system. The volume of the two-stage differential pumping stages is investigated in order to approximate the size of the pellet injection system, with the result that we propose the use of the differential pumping system used in punch mechanism-based low speed pellet injector utilized in LHD [3], whose pumping capacity is also similar or more than the estimation.

Based on the design study above, the in-situ technique and pneumatic acceleration is decided to be applied to the pellet injector in Heliotron J. The prototype of the injection barrel has been built for the small size of the pellet. Figure 1 shows the design of the barrel. The stainless tube with the inside diameter of 0.8 mm was firstly attempted for manufacturing the barrel. However, it was difficult to obtain the strength enough to maintain itself. Also, there was a technical problem of the soldering between the thin cupper and the minute stainless steel. Therefore, the barrel is manufactured by the hot isostatic pressing material of cupper and stainless steel. Moreover, in order to propagate the propellant gas efficiently, the taper structure is applied. Figure 2 shows the photograph of the prototype. In future, the injection test will be conducted using this prototype barrel.

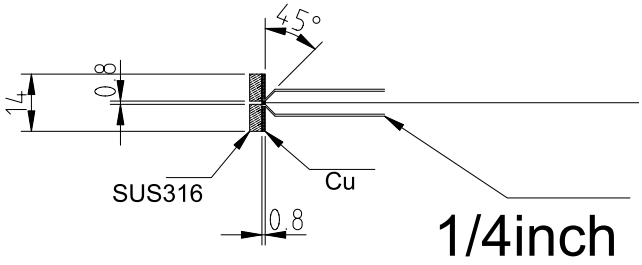

Fig. 1. Design drawing of the barrel for smaller size pellet

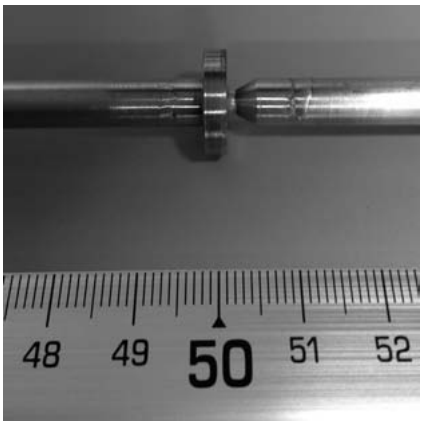

Fig. 2. Photograph of the prototype barrel.

1) Y. Nakamura et al., Nucl. Fusion 26, 907 (1986).
2) L.D. Landau, E.M. Lifshitz, Fluid mechanics (Pergamon Pres, 1987).
3) J.S. Mishra et al., Rev. Sci. Instrum. 82 (2011) 023505.