§77. Continued Study for the Installation of a Tracer-Encapsulated Solid Pellet (TESPEL) Injector on QUEST to Measure Various Physical Quantities

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The final goal of the Q-shu University Experiments with Steady-State Spherical Tokamak (QUEST) project is to achieve a steady-state plasma with a high beta value (< 10 %) under controlled plasma-wall interactions. In the QUEST experiments, damage to the vacuum vessel wall of QUEST by high-energy ions, which could be existed outside a last-closed flux surface (LCFS), becomes a problem. Therefore, it is an urgent issue in QUEST to evaluate absolute amount of such high-energy ions that exists around the LCFS. In this regard, we proposed to use the injection of a Tracer-Encapsulated Solid Pellet (TESPEL)[1] as probes to evaluate the absolute amount of the high-energy particles outside the LCFS. When the TESPEL is injected during such experiments, the ablation process of the TESPEL will be accelerated by collisions with the high-energy particles. Thus, the absolute amount of the high-energy particles can be evaluated from the comparison between calculated and experimentally obtained temporal evolutions of the TESPEL ablation. In addition, when given the TESPEL injection through the different poloidal locations, the spatial distribution of the high-energy particles can be also estimated, even roughly. The purpose of this study is to design the injector of the TESPEL for the QUEST.

A basic policy of the installation of the TESPEL injector[2] on the QUEST is as follows: The TESPEL injection system, which consists of a fast electromagnetic gas puff valve and a TESPEL holding disk, will be provided by NIFS. The differential pumping system, which is essential for preventing the high-pressure gas for the acceleration from penetrating into the vacuum vessel of the QUEST, will cannibalize existing vacuum vessels of hydrogen pellet injectors, which had been developed in Kyushu University. Transfer guide tubes in the system from the TESPEL holding disk to the vacuum vessel of the QUEST will be newly developed. In the fiscal 2015, we made the TESPEL injection system with a 200 mm length barrel. This system uses the TESPEL holding disk, which is formerly utilized for the Compact Helical System (CHS). Thus this disk can be controlled manually. The barrel length of this system is half that of the system currently used for the LHD. However, the obtained velocity, several hundred m/s, of the TESPEL by using this system is almost the same as by using the system for the LHD. Therefore, the TESPEL injector on the QUEST could be more compact by using this holding disk. Figure 1 shows a conceptual drawing of the TESPEL injector for the QUEST around the first guide tube. The existing vacuum vessels will be connected by the first guide tube. In order to block definitely the gas flow from the first guide tube, the gate valve will be installed right after the second expansion chamber. As shown in Fig. 1, the first expansion chamber is connected directly to turbo-molecular pump. In practice, a surge tank will be added between the expansion chamber and the pump.

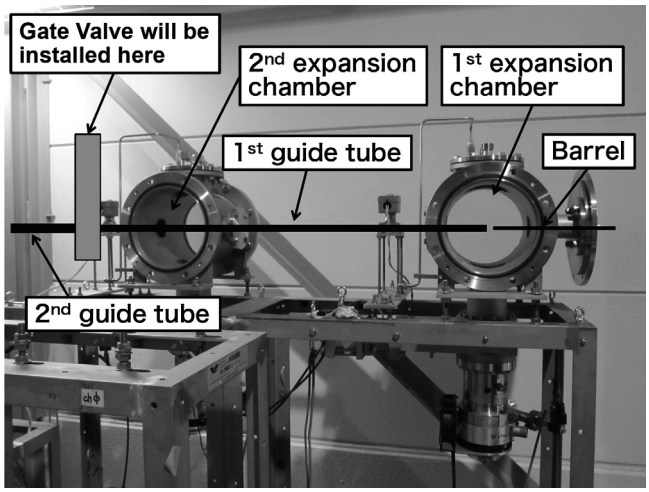

Fig. 1. Conceptual drawing of the TESPEL injector for the QUEST around a first guide tube.

Concerning a cost estimation of the installation of the TESPEL injector for the QUEST, the necessary cost for that is estimated totally as approximately 5,500,000 JPY, which is included overhaul costs of three turbo-molecular pumps. This is found to be three times less than that for the whole system to be newly developed. Now it is at the stage of financing arrangements, followed by this result. This work is supported by the NIFS Collaboration Research Program (NIFS14KUTR101).

1) Sudo, S.: J. Plasma Fusion Res. **69** (1993) 1349.
2) Sudo, S. and Tamura, N.: Rev. Sci. Instrum. **83** (2012) 023503.