Tracer-Encapsulated Solid Pellet (TESPEL)

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1. Purpose

A Tracer-Encapsulated Solid Pellet (TESPEL) is a double-layered impurity pellet, which basically consists of polystyrene polymer (-$CH(C_6H_5)CH_2$-) as an outer shell and tracer particles as a core. TESPEL can be utilized for various physics-oriented experiments, e.g. impurity injection for the perturbative impurity transport, induction of a cold pulse propagation, and so on.

2. Name of analysis (Kaiseki) data / module of MyView2

2.1. Retrieve

Diagnostic Name = "TESPEL"

2.2. Kaiseki-data server

Diagnostic Name = "TESPEL_abl"

2.3. Module of MyView2

Currently, not available.

3. General descriptions

3.1. TESPEL

- Outer diameter: 400 ~ 900 μm
- Tracer material: It can be utilized as a tracer as long as it is solid. 43 kinds of elements (from Li (Z=3) to Lu (Z=71)) have been used as a tracer of the TESPEL in the magnetically-confined high-temperature plasmas.
- Typical tracer size: 100 ~ 200 μmϕ
  ➔ Resulting typical deposition width of the tracer: 2 ~ 3 cm

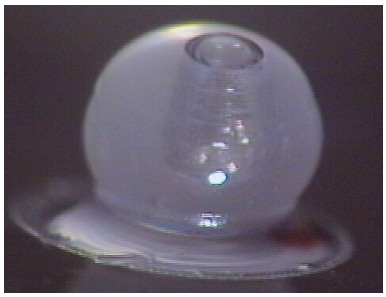

Fig.1 Photo of TESPEL

3.2. Injector (#1(TESPEL4) from 3O-BC01-01(being prepared), #2(TESPEL2) from 3O-BC-06-02)

Uniqueness of the TESPEL Injector #1: Double straight injection lines (see Fig. 2)

- This injector (TESPEL4) has double straight injection lines, which are located on the equatorial plane of the LHD vacuum vessel.

- TESPEL4 is currently being prepared, and it will be available from 22nd LHD campaign.

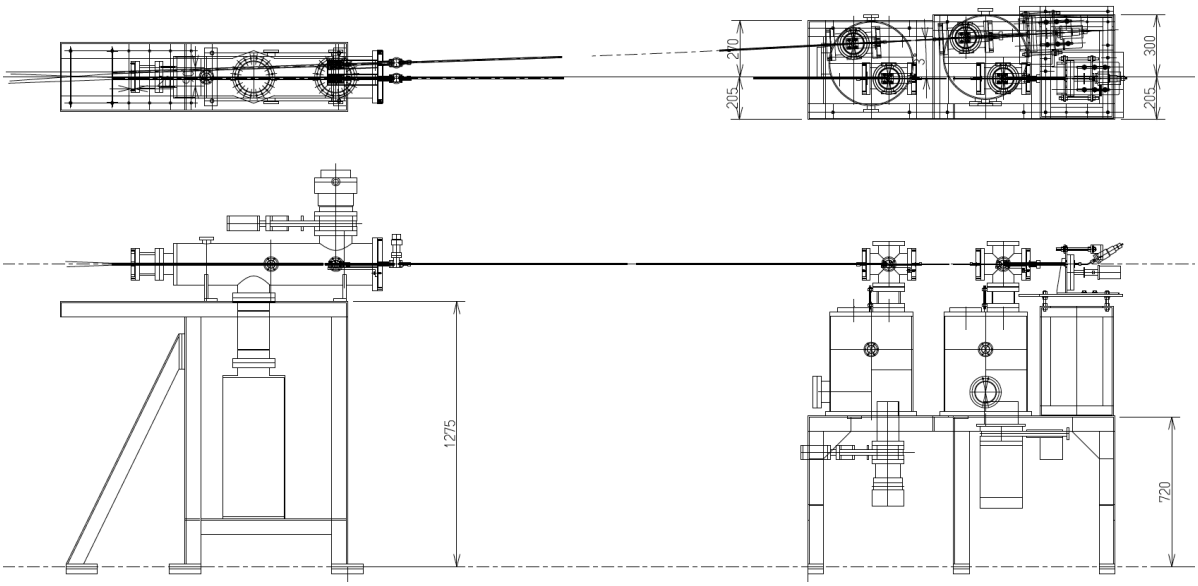

Fig. 2 A vertical projection view of the TESPEL4. Both injection lines are located on the equatorial plane of the LHD vacuum vessel.

Uniqueness of the TESPEL Injector #2: Single oblique injection line (see Fig. 3)

- This injector (TESPEL2) has curved guide tubes to achieve an oblique injection of the TESPEL into the LHD plasma. In TESPEL2, one injection line is available.
- The deposition location can be varied by changing the position of the final guide tube, which is located inside the vacuum vessel of LHD.

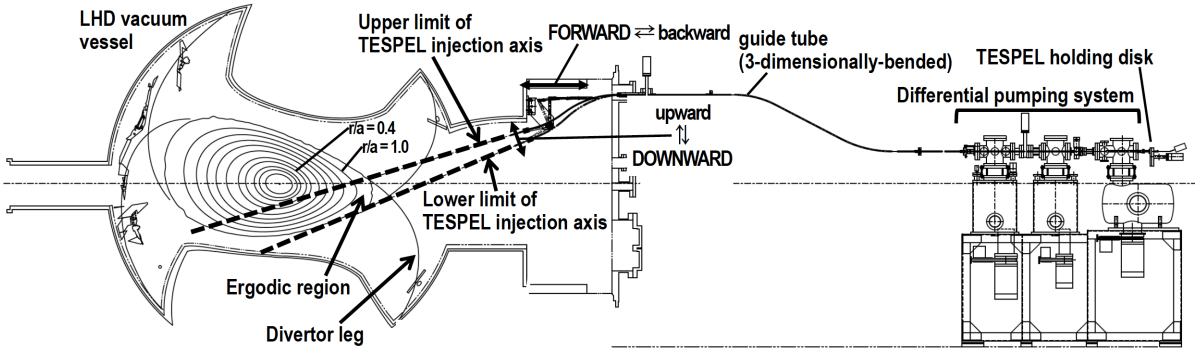

Fig. 3 A vertical projection view of the TESPEL2 with cross-section of the plasma and vacuum vessel of the LHD. The remote-controlled drive mechanism can move the final guide tube of the TESPEL2 upward and downward. Consequently, the expected location of the tracer deposition with the TESPEL2 is ranged from the location at $r_{\mathrm{eff}}/a_{99} \sim 0.4$ (in the case with $R_{\mathrm{ax}} = 3.75$ m) to that outside the last closed flux surface of the LHD plasma, i.e., inside the edge ergodic region.

Common features of the TESPEL injectors

- Necessary time interval to inject another TESPEL from the same disk: About 1 min.
- By using the TESPEL4, the time interval to inject the second TESPEL will be greatly decreased, but a minimum interval between two TESPEL injections remains to be clarified (the minimum interval will be investigated in the 22nd campaign).

- Available number of the TESPEL per disk: 59 or 89 pieces
  - If you need a larger number of TESPEL, please consult with the person in charge beforehand.

3.3. Observation system for the TESPEL ablation cloud (3O-AL01-02, 3O-AL01-03, 3O-BC01-03, 3O-BC01-04)

Photo-multiplier tubes (PMTs) and fast camera are used to measure the behavior of the TESPEL ablation.

3.3.1. PMT diagnostics

The PMTs are basically filtered (e.g., Hα, C I) according to the materials in the TESPEL.

- Typical temporal resolution: 1 μs

3.3.2. Stereoscopic Fast camera diagnostics

An ultra-fast frame CMOS-camera (model FASTCAM SA-X2 by Photron Inc., Japan), which is equipped with a 12-bit CMOS sensor, is used to observe a high temporal evolution of the TESPEL ablation cloud.

- The optical filtering on the fast camera will be done as the situation demands.
- Typical frame rate of the camera: 20,000 – 40,000 frames/s for 1024 x 672 – 640 x 488 pixels.
- A pair of stereo images is taken from different viewports, which are focused on a single focal plane of the CMOS sensor of the ultra-fast frame camera by using a bifurcated imaging fiber bundle.
- The resulting spatial accuracy in the vertical direction of the stereoscopic measurement: at least about +/- 1 cm.

4. Requirement in use

If you need the TESPEL even without the tracer in your experiment, please contact the person in charge (Dr. Naoki Tamura, tamura.naoki@nifs.ac.jp) in advance (at least one month before the start of the LHD experimental campaign), because the TESPEL is a handmade pellet and the TESPEL can be injected only by his operation.

5. Description of analysis (Kaiseki) data / module of MyView2

We are in the process of rearranging the setup of DAQ modules. If you need to know the setup of DAQ modules, please contact the person in charge (Dr. Naoki Tamura, tamura.naoki@nifs.ac.jp).

References

[1] S. Sudo, J. Plasma Fusion Res. **69** 1349 (1993).

[2] S. Sudo and N. Tamura, Rev. Sci. Instrum. **83** 023503 (2013).
[3] N. Tamura *et al*., Rev. Sci. Instrum. **79** 10F541 (2008).
[4] N. Tamura *et al*., Plasma Fusion Res. **10** 1402056 (2015).
[5] N. Tamura *et al*., Rev. Sci. Instrum. **87** 11D615 (2016).