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Analysis of Neutral Particle Distribution in the Closed Divertor Module in the Linear Plasma Device NAGDIS-II

直線型装置NAGDIS-IIに設置された閉ダイバータモジュール内の中性粒子分布

Morihiko Urakawa, Noriyasu Ohno, Yosuke Nakashima*, Mamoru Shoji**

裏川杜彦，大野哲靖，中嶋洋輔*，庄司主**

Graduate school of Engineering, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, Aichi 464-8603, Japan

**Plasma Research Center, Tsukuba University, Tsukuba, Ibaraki 305-8577, Japan*

***National Institute of Fusion Science, Toki, Gifu 509-5292, Japan*

名古屋大学大学院工学研究科，〒464-8603 愛知県名古屋市千種区不老町

*筑波大学プラズマ研究センター，〒305-8577 茨城県つくば市天王台1-1-1

**核融合科学研究所，〒509-5292 岐阜県土岐市下石町322-6

Plasma detachment is considered to be effective method to reduce particle and heat loads on the divertor plate. Experiments on plasma detachment by using a simple closed divertor module were performed in the linear plasma device NAGDIS-II. We have calculated the distribution of neutral gas density and temperature in the simple closed divertor module by DEGAS code. The simulation result shows that plasma temperature and recycling process strongly affect the distribution of neutral gas in the small confinement space.

1. Introduction

In magnetically confined fusion device, plasma detachment by plasma-gas interaction is considered as an effective method to reduce plasma heat and particle loads on divertor plates. Closed divertor concept aims at the reduction of plasma heat and particle loads associated with plasma detachment. There are two methods to increase neutral gas pressure in the closed divertor region, additional gas puffing and enhancement of the recycling process. In the high recycling regime, distribution of recycled neutral gas density and temperature are important to determine the plasma detachment.

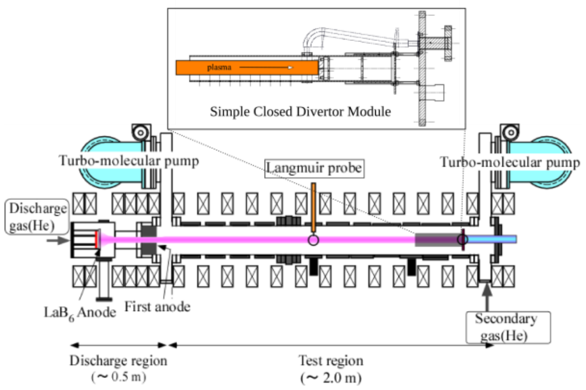

Fig.1. Simple closed divertor module setup in NAGDIS-II

An experiment was done in the linear divertor plasma simulator NAGDIS-II to control the neutral gas pressure in the simple closed divertor module by varying the electron density [1]. The experiment also aimed at achieving plasma detachment in the cylinder module, consequently.

Fig. 2(a) shows that neutral gas pressure in the cylinder module is increased with electron density. Coordinate Z starts from the bottom face of the cylinder, toward to the end objective. Fig. 2(b) shows electron temperature profiles as a parameter of electron density. It is found that electron temperature does not decrease with the electron density. Plasma detachment requires that electron temperature should be less than 1 eV. Therefore, no plasma detachment was observed in this experiment.

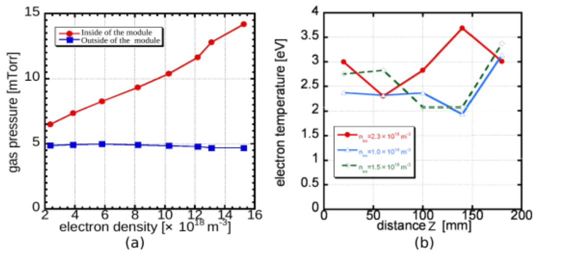

Fig. 2. Results of simple closed divertor module experiments, (a) neutral gas pressure with varying electron density and (b) electron temperature in the module.

In order to explain the experimental results, the distribution of neutral gas temperature in the module is thought to be one of the key parameters, because higher neutral gas temperature prevents cooling of ions as well as electrons.

In this study, we used neutral particle transport code "DEGAS" [3, 4] to calculate the distribution of the neutral gas density and temperature in the cylinder module.

2. Simulation Setup

We assume a cylinder module with a diameter of 2.4 cm and length of 53 cm. From the center of the bottom face to that of the top face, there is a Z axis from 0 to 53 cm. Bottom of the cylinder is an exit, and the rest of the wall is set to Fe material. There is assumed to be a steady state He plasma with an electron temperature of 2.5, 5, 10 eV and an ion temperature of 3 eV. Plasma density is set to be 10^{12} cm^{-3} ($n_i = n_e$). Background neutral particles are injected from the bottom face and their initial energy is 300 K (Maxwell's distribution). The neutral particles generated by the surface recombination start from the top face and their initial energy is determined by Bohm velocity, calculated from the electron temperature. We also add a recycling option due to ionization process. If the option is enabled, when a neutral particle is ionized, a produced ion moves straightforward to the top face (Z = 53 cm) of the cylinder module. Then the ion is neutralized on the face and released as a new neutral particle. However, the parameter of the plasma is not changed throughout this process.

3. Simulation Result

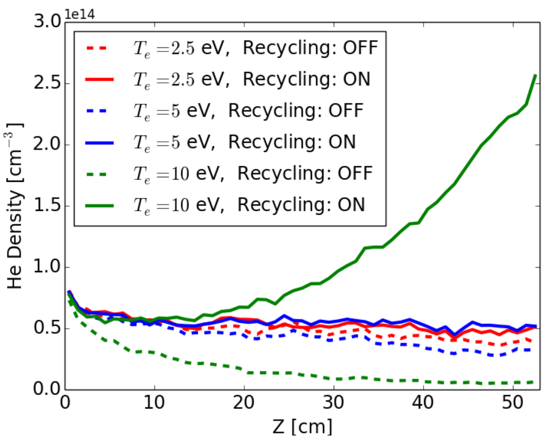

Fig. 3. Density of the background He gas.

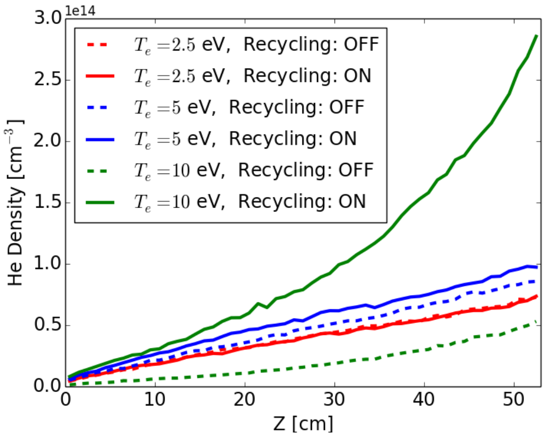

Fig. 4. Density of He gas generated by the surface recombination on the top face (Z = 53 cm)

Figure 3 shows the result of the distribution of the He neutral gas density. In this case, neutral particles (background He gas) with an initial temperature of 300 K are injected from Z = 0 cm, and neutral particles generated at the top face are not taken into account. On the other hand, in Fig. 4, neutral particles generated due to the surface recombination are only considered.

Both of Figs. 3 and 4, it is found that He neutral density profile is determined by electron temperature. When the recycling option is enabled, He neutral density increases toward the end of the module. The recycling process associated with ionization process in the module leads to enhancement of neutral gas pressure, which is observed in the experiment.

References

[1] N. Ohno, *et al*., Annual Report of NIFS April 2011 – March 2012 p.483

[2] D. Heifetz, *et al.*, J. Comput. Phys. **46** (1982) 309-327.

[3] Y. Nakashima *et al*., J. Nucl. Mater. **196-198** (1992) 493.

[4] M. Shoji *et al.*, J. Nucl. Mater. **313-316** (2003) 614.