§15. Prevention of Reversed Flow in Gas Divertor with High Vacuum Chamber

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i) Introduction

A reduction in a reversed flow of gas in a gas divertor toward a main plasma is required to achieve both a low thermal load on a divertor plate and high magnetic confinement in the main plasma.1) It is the purpose of this paper to evaluate experimentally the effect of the high vacuum (HV) chamber set in front of an inlet of the gas divertor on the prevention of the reversed gas flow.

ii) Experimental setup

Fig. 1 shows the TPD-II (Test Plasma generated by Direct Current) at the National Institute of Fusion Science. The helium plasma produced in a plasma source goes out through an experimental and the HV chambers, and contact finally with the Ne gas in the gas divertor chamber. The diameter of the orifice 2 was 10 mm comparable to the effective He plasma diameter. The Ne gas tended to flow into the experimental chamber at neutral gas pressure P_E, of ~0.1 Pa. The neutral gas pressure in the HV chamber, P_{HV}, was varied from ~0.1 Pa to ~8 Pa. The reversed Ne gas flow was detected with a quadrupole mass spectrometer (Q-mass) at the experimental chamber. The variation of reversed Ne gas flow was determined with both the pressure difference between P_{HV} and P_E and the plasma density n_p.

iii) Experimental Results

The amount of the reversed Ne gas flow, Q, is plotted on Fig.2 in the range of the pressure difference between P_{HV} and P_E, ΔP ($=P_{HV}-P_E$), for various n_p. The slope of Q against ΔP decreases with increasing n_p. Such a slope under no plasma may be related to conductance, C_0, for the orifice 2 in Fig. 1, defined by

$$Q_0 = C_0 \Delta P, \tag{1}$$

where Q_0 is the amount of reversed Ne gas flow under no plasma. The dependence of a ratio given by C/C_0 on n_p is shown in Fig.3. Here, C represents the conductance under the plasma existence. The ratio of C/C_0 decreases with increasing n_p. It can be considered that the reversed Ne particles are scattered by collisions with the He plasma; thus,

$$\frac{dQ(z)}{dz} = -n_p \sigma Q(z), \tag{2}$$

where Q(z) and σ are the amount of reversed Ne flow at axial position z from the orifice 3 and the cross section of the scattering of Ne particles. Substituting a distance from the orifice 3 to the orifice 2, L(=0.32m), to z, we obtain

$$Q = C_0 \Delta P e^{-\sigma L n_p} = C \Delta P, \tag{3}$$

where C is $C_0 \exp(-L\, \sigma\, n_p)$. The value of σ estimated by taking the slope obtained from Fig. 3 and the distance L is approximately $6\times10^{-20}\,m^2$, which is comparable to the value of $10^{-19}\,m^2$ for the cross section of elastic collision between Ne and He ions. The amount of reversed Ne gas flowing into the experimental chamber will be predicted by using eq.(3).

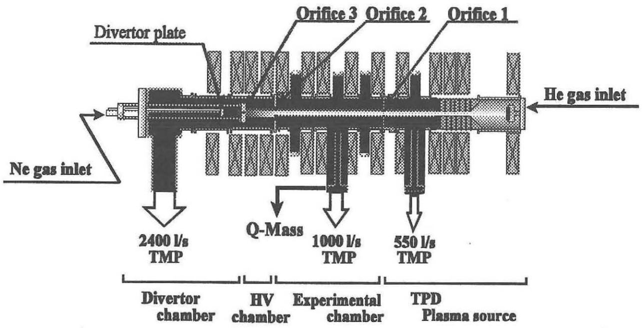

Fig. 1. Schematic diagram of the Test Plasma produced by Direct current II (TPD-II) in the National Institute for Fusion Science. Diameters for the orifices 2, and 3 are 10 mm and 2 mm, respectively.

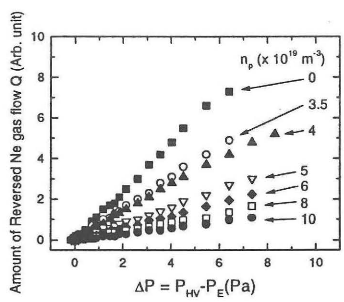

Fig 2. Amount of the reversed neon gas flow, Q, as a function of the pressure difference between P_{HV} and P_E, ΔP ($=P_{HV}-P_E$) for various plasma density n_p (numbers in the frame).

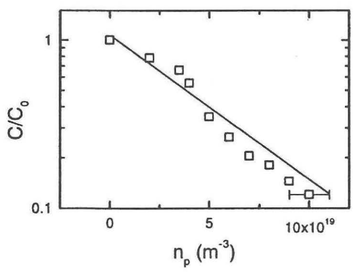

Fig. 3. Dependence of a ratio given by C/C_0 on the plasma density n_p. The values of C and C_0 are slopes obtained from Q vs. ΔP in Fig.2 under the plasma and no plasma, respectively.

1) Matsubara, A., et al. : J. Nucl. Sci. Tech., Vol. 37, No.6, (2000) 555.