§22. High Efficiency Gas Divertor Control by Molecular Activated Recombination Process

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The control of the detached plasma is thought to be a key issue in order to reduce the heat flux at divertor plates. In a detached plasma, the recombination process associated with molecular reactions, such as the molecular activated recombination (MAR) involving a vibrationally excited hydrogen molecule, has been emphasized in theoretical investigation and modeling. Especially, the negative ion plays an important role in the mutual neutralization of MAR, providing a new method of controlling detached plasma[1].

We have developed a new way to control detachment plasma based on the negative ions formation of hydrogen atom in the linear divertor plasma simulator, TPDSHEET–IV (Test Plasma produced by Directed current for SHEET plasma) as shown in Fig.1. The hydrogen plasma was generated with the hydrogen gas flow of 70 sccm at the discharge current of 50 A. The neutral gas pressure P_{Div} in the divertor test region was able to be changed from 0.1 to 20 mtorr by feeding a secondary gas. A cylindrical probe made of tungsten (ϕ 0.4 x 2 cm) and the laser sheets(4.0cm × 1.0cm) was used to measure the spatial profile of the negative ion of the hydrogen atom H^- by a laser photo-detachment method. The maximum power of fundamental (1064 nm) radiation of the laser was 120 mJ at 50Hz. The negative ion density was determined from the photodetached electron current. The heat flux onto the target plate W was

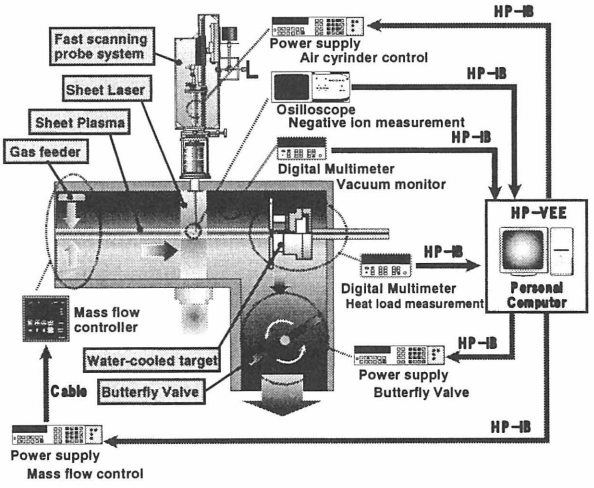

Fig.1 Schematic diagram of control system.

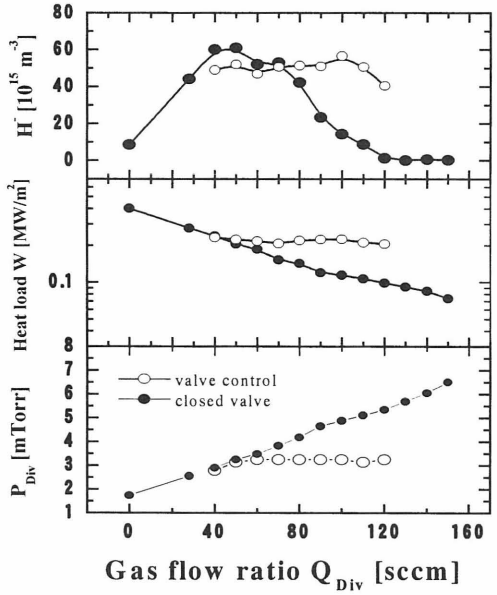

Fig.2 Typical characteristics of P_{Div}, W and H^- on the gas flow ratio Q_{Div}.

measured with the calorimetric method.

The concept of control of detached plasma by negative ion can be shown in as following step; a)to measure the experimental data related to the basic parameters (gas pressure P_{Div}, heat load W) in order to determine a threshold values of upper limit, b)to control a rotated valve so quickly as to keep the maximum value of the negative ion density, c)to carry out a real time feedback control the constant in order to maintain the steadily detached plasma in the neighborhood of the target plate

Figure 2 shows the typical characteristics of the neutral gas pressure P_{Div}, heat load W and the negative ion density H^- on the gas flow ratio of the secondary hydrogen gas Q_{Div}. The solid circle is no for feedback control of the neutral gas pressure at closed valve and the open circle is for the feedback control of the neutral gas pressure by rotated valve. Without the neutral gas pressure by rotated valve, the density of H^- in the circumference of the plasma increased rapidly and the heat load onto the target plate is reduced with increasing the secondary hydrogen gas puffing. The detached plasma is maintained steadily in the neighborhood of the target plate by the control of rotated valve so quickly as to keep the maximum value of the negative ion density and the constant neutral gas pressure, while the radiative and three-body recombination processes were disappeared. The new system has permitted the establishment of both a reduction of heat flux and the minimum amount of gas flow ratio in detached plasma.

Reference

1)A.Tonegawa, et al, 28th EPS conference on Controlled Fusion and Plasma Physics.,Vol.24(2001)2145.