§28. Heat Flux Measurement with Thermal Probe Method in Heliotron J Edge Plasma

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It is well known that there exist the sheath regions between plasmas and solid components which face to plasmas and that current through these sheath is determined by the sheath potential drop. According to sheath theory, momentum and heat flux through the sheath is also the function of the sheath potential drop. Recently Combined force-Mach- Langmuir probe and thermal probe[1)] were proposed to measure these flux and to obtain not only electron parameters but also ion information such as its temperature.

It is also very important to measure the heat flux itself in divertor plasma. In the design of fusion reactors like International Tokamak Experimental Reactor(ITER), vast heat flux(> 10[MW/m^2]) is expected to flow onto divertor target plate through this sheath boundary. In order to check proposed methods to reduce this heat load such as "detached plasma formation", direct measurement of heat flux is indispensable, since relation between heat flux and plasma parameter is very complicated. Moreover, ion temperature contribution could not be ignored as usual text books, since ion temperature is often larger than electron temperature in divertor plasma.

The Hybrid Directional Probe (HDP) used in Compact Helical System[2)] were moved to Heliotron-J device under Collaboration with National Institute for Fusion Science (NIFS). Figure 1 shows the HDP sideview. HDP is composed of 1 magnetic probe sensor(Pin 6) and 7 Langmuir probe tips(Pin 1-5, 7-8), 5 tips of which are equipped with type-K thermocouples(TC) and available also as thermal probes. In Fig.1, only even number pins are shown. These pins are made of oxygen-free-cupper and the diameter and length are 4.0 and 10[mm] respectively.

HDP has a driving system of three parameters $(R_p, \theta_p, \alpha_p)$ and positions of its pins and can be changed shot by shot. R_p is the HDP probe head shift along the major radius direction in mm unit. When R_p increases, HDP moves toward confined main plasma (left side of Fig. 1). θ_p is the swing angle in degree unit along the poloidal direction and α_p is the rotation angle in degree unit around the axis of cylindrical HDP head. Due to the mechanical limitation, only half rotation data are available. α_p can be scanned $-110 \sim 10$ and difference of initial position of Pin3 and Pin4 is 60.

Figure 2 shows heat flux profile around the HDP head[3)]. Holizontal axis is angle coordinate around HDP(α) and vertical axis is the heat received during whole discharge ($q\Delta t$). $R_p(=210)$ and $\theta_p(=0)$ are fixed and α_p is scanned. Pin3 (and Pin5) covers $\alpha = -120 \sim 0$[deg.] and Pin4 covers $\alpha = -60 \sim 60$[deg.]. For example, when α_p is set to be -50, Pin3 stays at $\alpha = -60$[deg.] and Pin4 detects heat flux at $\alpha = 0$[deg.]. Although data is limited and shows scattering, the maximum heat flux is found around $\alpha = -50$[deg.]. The most probable explanation for these profiles is the existence of plasma flow, which directs toward $\alpha = -50$[deg.] or $\alpha = 130$[deg.] direction.

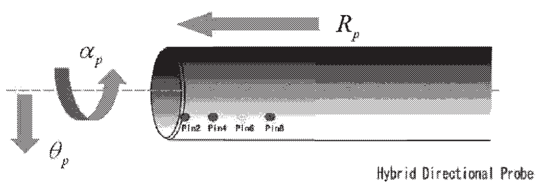

Fig. 1: Side view of the Hybrid Directional Probe (HDP) and its driving direction. Parameter R_p shows the movement along major radius. θ_p is the poloidal rotation and α_p it the rotation around probe head axis.

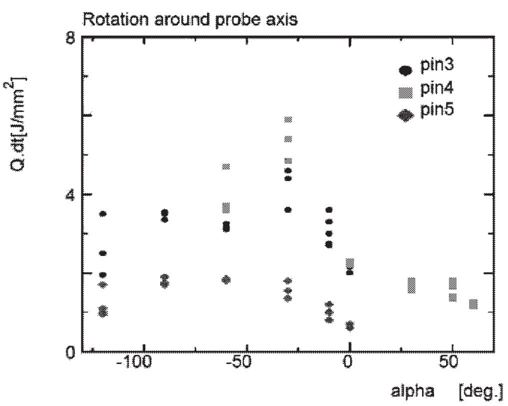

Fig. 2: Heat flux profile around HDP head. Holizontal axis is angle around HDP(α) and vertical axis is the heat received during whole discharge ($q\Delta t$). For rotation angle $\alpha_p = 0$, Pin3 (and Pin5) is at $\alpha = -10$[deg.] and Pin 4 is at $\alpha = 50$[deg.].

1) H.Matsuura et al.: Contrib. Plasma Phys. **46** (2006) 406.

2) K.Nagaoka et al.: Plasma Fusion Res. **2** (2007) S1092.

3) H.Matsuura et al.: NIFS-PROC **78** (2009) 439.