Heat flux measurement in Heliotron J with the hybrid directional probe

H. Matsuura, K. Nakano, H. Okada[a], K. Nagaoka[b], T. Mutoh[b], S. Kobayashi[a], T. Mizuuchi[a], F. Sano[a] and S. Kitajima[c]

Osaka Prefecture University, 1-1 Gakuen-chi, Sakai Naka-ku 599-8531,Japan
[a]Kyoto University, Gokasho, Uji 611-0011, Japan
[b]National Institute for Fusion Science,322-6 Oroshi-cho, Toki 509-5292, Japan
[c]Tohoku University, 6-6-01-2 Aoba, Sendai Aoba-ku 980-8579, Japan

matsu@me.osakafu-u.ac.jp

In the design of fusion reactors like International Tokamak Experimental Reactor(ITER), vast heat flux($> 10[\mathrm{MW/m^2}]$) is expected to flow onto divertor target plates through the 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. Conventionally, simple formula $q = \gamma T_e I_{is}$ has been used to estimate plasma heat flux q. But, even if electron temperature T_e and ion saturation current I_{is} can be measured, sheath heat transmission factor γ can not be assigned exactly, since γ depends not only upon plasma parameter such as space potential upon probe tip surface process such as energy reflection. Especially, since ion temperature is larger than electron temperature in divertor plasma [1], ion temperature contribution could not be ignored as usual text books.

Hybrid directional probe(HDP), which was composed of thermal probes and directional Langmuir probes, was firstly used in Compact Helical system [2], then moved to Heliotron J[3] under collaboration with NIFS. Two unsteady heat conduction model are constructed and heat flux is estimate from experimental data of type-K thermo couples in thermal probes [4]. Usually discharge pulse length of Heliotron J is shorter than thermal diffusion time in a probe tip. So Delta-function type heat pulse model can be available. Obtained heat flux value, although it is time averaged, shows positive correlation with plasma heating power, more exactly with plasma internal energy. Angular distribution of the heat flux around the probe axis shows the similar profile shape as previous reported probe current distribution. More detail results will be shown at conference.

On the other hand, in the low field experiment under collaboration with Tohoku University, discharge pulse length becomes comparable with thermal diffusion time and finite length heat pulse model must be applied. Since present thermal probes are not applicable to monitor plasma behavior change, design and construction study on new type of thermal probe is also now on going.

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[3] F.Sano et al., Nucl. Fusion **45** (2005) 1557.
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