§27. Development of the Monitoring System for Divertor Heat Flux Distribution

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Hybrid directional probe(HDP)[1], which was composed of thermal probes (TP) and directional Langmuir probes (DLP), was firstly used in Compact Helical system (CHS), then moved to Heliotron J under collaboration with NIFS. By using HDP, an anomalous transport of fast ions induced by bursting global Alfven eigenmode was experimentally investigated. Two unsteady heat conduction model for thermal probe tips were constructed and heat flux was also estimated from experimental data of type-K thermocouples (TC).[2] However this probe system was not optimized for Heliotron J experiment. So in the fiscal year of 2012, a new type of probe was constructed in order to expand the applicability of this DLP.[3] The probe head was modified to be removable and the connection of the probe head is now unified with other probe system in Heliotron J. The arrangement of probe pins was also modified to monitor plasma flow more easily. Figure 1 shows the reconstructed probe head.

Although thermocouple setting was designed to have fast response, probe tip temperature signal becomes small compared with the electromagnetic noise from helical coil current. Figure 2 shows the comparison of TC signal obtained with old HDP and new one. Temperature signal response with the new HDP is found to be much slower. TC signal for #31604 increased after plasma shot and reached the maximum about $t = 1$ sec, although TC signal for #51889 shows large noise and continues to increase even $t > 2$ sec. Moreover, electromagnetic noise around $t = 0.5$ sec. becomes serious problem for the new HDP, since it may induce TC signal shift.

By applying the delta-function heat pulse model to this experiment, it was found that effective distance between probe surface irradiated by plasma and the hot junction of a thermocouple becomes much longer than those in the old HDP head. This might be due to technical problem to fix the hot junction onto probe tip. Fortunately, time-integrated heat flux per one plasma shot is still possible to be estimated with this model and new HDP data. Figure 3 shows one example. Probe position was moved shot by shot and temperature increment indicated crosses show a scattering. This comes from that zero level of temperature increment did not recover before the next shot starts. Estimated heat flux, however, shows the reasonable profile shape and its value is almost the same as those measured with the old HDP for the similar plasma density and heating power.

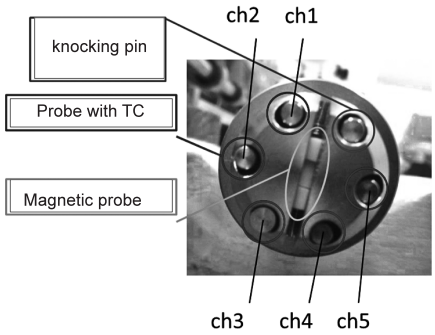

Fig. 1: Photo of reconstructed probe head.

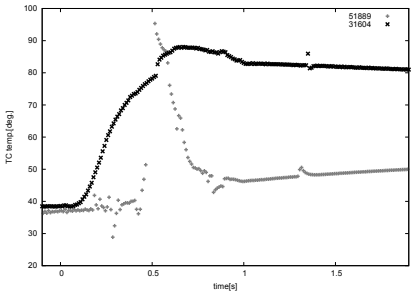

Fig. 2: Comparison of TC signal obtained with old HDP (#31604) and new one (#51889).

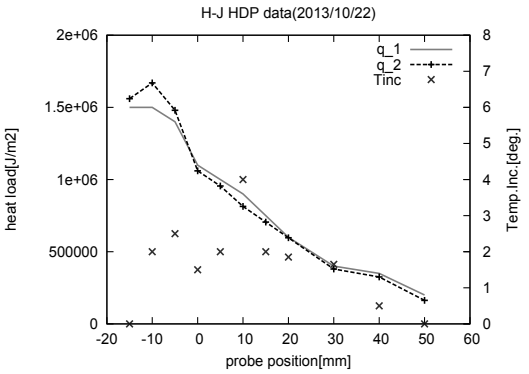

Fig. 3: Estimated one shot heat load profile obtained with the new HDP. Two fitting method was compared to reproduce TC signal evolution and to estimate heat flux integrated for one shot.

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

2) H.Matsuura *et al.*, Plasma Fusion Res. **5**, S1045 (2010).

3) K. Nagaoka *et al.*, Annual report NIFS Apr.2012-Mar.2013(2013)521.