§31. Plasma Heat Transport through LHD Divertor Leg

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In the helical plasma experiments such as LHD, interaction between plasma and neutral particle is an important factor for the control of heat and particle fluxes to the divertor. Experimental information is, however, still insufficient, since their profile is intrinsically three-dimensional. Moreover, little information on ion temperature and plasma potential makes it impossible to deduce plasma heat flux. A new analyzing model was proposed to deduce time-dependent plasma heat flux from thermocouple (TC) data of the hybrid directional Langmuir probe (HDLP).[1)] It has successfully demonstrated to measure heat flux change due to detach plasma formation, and same model is also applied to analyze neutral beam shine-through power from fast response calorimeter data embedded in armar plates.

In this study, we applied this model to evaluate the time evolution of plasma heat flux on 10I divertor tiles. Divertor plates (typically $390 \times 540 \times 850$ mm) consist of isotropic carbon tiles, and cooled by water. Thermocouples are embedded in all toroidal sections of the divertor plates, in horizontally and vertically elongated poloidal cross-sections to measure temperature rises. Figure 1 shows the five plate temperature data measured at 10I divertor. The thermocouples are located at the center of the divertor plates, and at a 5 mm depth from the surface. So the time response of thermocouple signal is relatively slow and it is hard to detect temperature change in usual short discharge of about 3 second. During long-pulse discharge such as # 123722, magnet axis R_{ax} swing operation has been proposed and conducted to disperse the heat load on the divertor plates and to prevent from uncontrollable increases in electron density, radiation collapse resulting from outgassing, or impurity release from the divertor plates.[2)] In fact, temperature increase of all channels is delayed by R_{ax} swing. But heat flux reduction has not estimated with the proper modeling yet.

In our model, time dependent heat flux is approximated as the sum of step-function like heat pulses with different timing and pulse height. Figure 2 show the analysis results of channel 3 thermocouple data in Fig. 1. Since our model is one-dimensional heat conduction and heat sink is not ideal to cool down to pre-discharge temperature level after discharge stop, accuracy of estimated heat flux still needs model improvement. Figure 3 shows comparison of five divertor plate heat flux. From magnetic field line calculation, this heat flux change comes from the change of divertor leg thickness, not from the leg position.

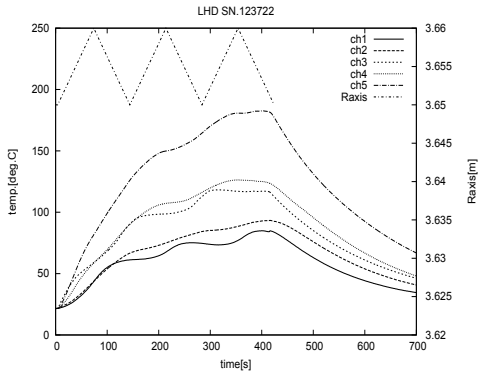

Fig. 1: Monitored temperature for five divertor plate of 10I section during magnetic axis swing.

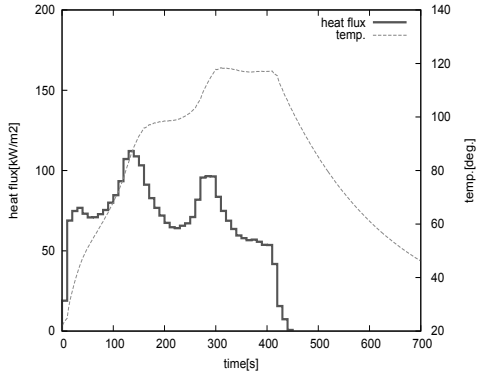

Fig. 2: Reconstructed divertor plate temperature and plasma heat flux. (#123722, channel 3)

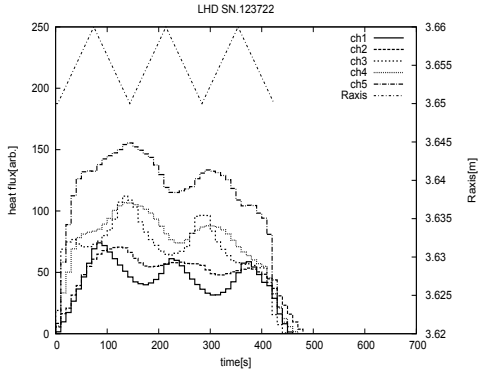

Fig. 3: Heat flux evolution during magnetic axis swing. The effect of magnetic field angle is not compensated and channel 5 value is larger than other channels.

1) H.Matsuura *et al.*, Contrib. Plasma Phys. 54, 285 (2014).

2) Ogawa *et al.*, PFR 2, 043 (2007).