Unsteady evaluation method of heat flux on plasma-irradiated targets from long-discharge plasmas and accurate consideration of cooling effects

Tatsushi Yano[1], Hiroto Matsuura[1], Bui Xuan Nhat Son [2]
[1]Osaka Metropolitan University, [2] Dalat Nuclear Research Institute
e-mail (speaker): sp24928a@st.omu.ac.jp

The temperature of the target subjected to plasma irradiation is important. For example, few considerations have properly incorporated the effect of heat in the inactivation of microorganisms by plasma irradiation. [1] Reference [1] assumes the effect of heat as a constant heat flux over time, but there have been few reports on the change in heat flux during irradiation. On the other hand, in the field of fusion plasma, time variation of heat flux becomes more important for long-time irradiation. In this study, the unsteady analysis method of heat flux developed for fusion plasmas is applied to the field of applied plasmas.

In reference [2], the neutral beam power used to heat fusion plasmas is evaluated using a target with two embedded thermocouples This method is called the gradient method.

In reference [3], a method is proposed to approximate the time variation of the heat flux by superposition of time-constant pulses of heat flux and to optimize the magnitude of each pulse to reproduce the measured target temperature variation, which is applied to divertor plasmas in large helical devices. This method is referred to as the pulse decomposition method, and experiments with GAMMA10 have compared the two methods.

In the experiments in Reference [3], a one-dimensional temperature response function that considers the temperature distribution in the target was used because of the short discharge time. However, the target was not actively cooled, and the effect of cooling was not considered in the derivation of the response function. In the applied plasma, the plasma irradiation lasts more than a minute (1000 s), so the response function was redefined to consider the cooling effect, even if the temperature distribution in the target is ignored, and a 300 s irradiation experiment was conducted in the plasma jet to apply this improved method.

Figure 1 shows the temperature variation of the irradiated glass target, and Figure 2 compares the heat flux values for the two evaluation methods.

Comparing the two methods, the pulse decomposition method showed large overshoots and undershoots, the causes of which will be investigated and reported.

This work was partially supported by the NIFS Collaborative Research Program (NIFS22KUGM171/ NIFS22KUHL107), and the joint usage / research program, cLPS (25040).

[1] H .Matsuura et al.; 42nd SPP (Ohita, 2025)30a-5.

[2] M. Osakabe *et al.*, *Review of Scientific Instruments*, vol. 72, no. 1, pp. 586–589, 2001.

[3] H. Matsuura et al., IEEE Trans. Plasma Sci. 47 (2019) 3026-3030.

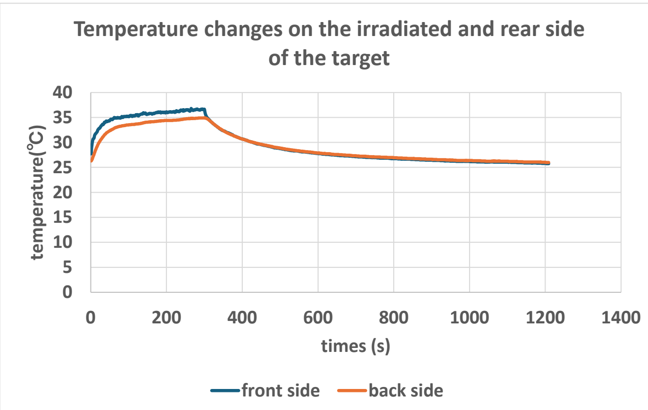

Fig1. Temperature change of a target when irradiated with Ar plasma jet to a glass target.
(Blue: irradiated frontside, Orange: back side)

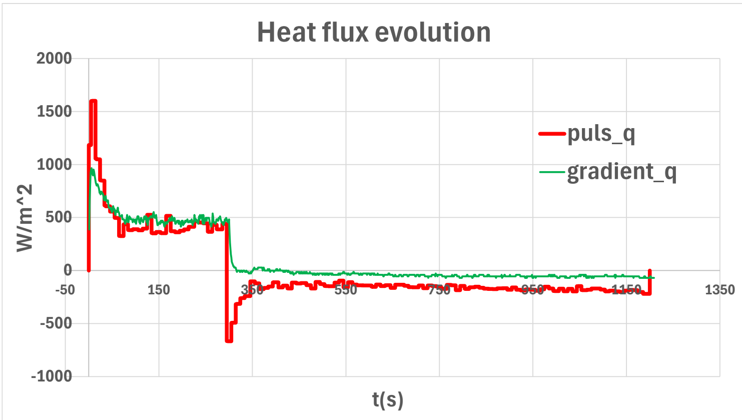

Fig2. Heat flux evaluation by gradient method and pulse decomposition method.
(Green: gradient method, Red: pulse decomposition method)