§17. Thermal Characteristics of Different Foils for an Imaging Bolometer for LHD

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The imaging bolometer is useful to measure the radiative power from the LHD plasma.[1] This diagnostic already has been applied to LHD and JT-60U. This method will be applied also to KSTAR and possibly ITER. In the bolometer using a thin metal foil, a 2D distribution of temperature is formed on the foil. IR camera measures this distribution. The temporal and spatial resolutions of the measurement depend on the thermal properties such as thermal conductivity and thickness of the foil, as well as radiative power intensity and photon energy. In order to calibrate the imaging bolometer, the spatial distribution of these foil properties must be determined on the foil. This can be done by comparing the results of a finite element model of the foil with those from calibration experiments using a He-Ne laser. Absolute calibration is essential especially for using multiple imaging bolometers on LHD to perform 3D tomography on LHD.

Fig.1 shows a flowchart of the experiment and analysis for the calibration. A platinum foil blackened on both surfaces was used. The foil was irradiated by a He-Ne laser while changing the irradiation position in a vacuum, and then the spatial temperature distributions formed at each position were measured with an IR camera. The measured distributions were compared with FEM-obtained distributions using IDL software. The comparison was repeated by changing the distributions of the effective foil thickness and emissivity until the suitable distributions were convergently obtained. In the case of the conventional method, low convergence performance has been observed at the foil edges owing to the discrepancy between the position of the modeling and the laser-irradiated points, as shown in fig. 2. In this fiscal year, the irradiated points were corrected and the number of elements in FEM analysis increased in order to examine the calibration with higher convergence performance and higher accuracy than those for the conventional method.

Figs.3 and 4 show examples of thickness and emissivity distributions estimated by the conventional and the modified methods, respectively. The foil used will be installed at 6.5L port in LHD. For reference, the fractions of the deviations from the data estimated with one less repeated number are also shown. For the conventional method, the fractions were large at the foil edge. Although the fraction decreased with the increase of the repetition number, the convergence properties were low, especially at the edge. On the other hand, high convergence properties were observed even if the repeated number was 3 or 4 for the modified method. These results clearly indicate the modified method reduces the time for the convergence calculation. However, further modifications of the calibration method is still needed because there were some points with emissivity over 1.0 in the estimation for another foil.

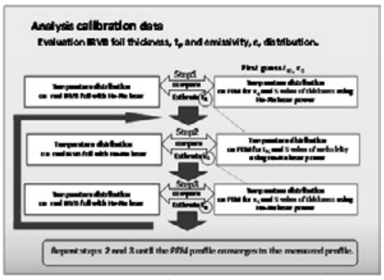

Fig.1 Flowchart of experiment/analysis for evaluations of effective foil thickness and emissivity distributions.

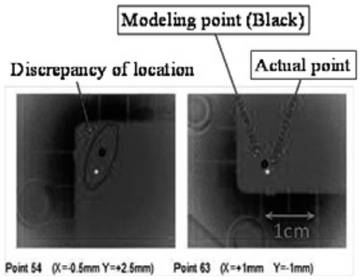

Fig.2 Photograph showing discrepancy of location.

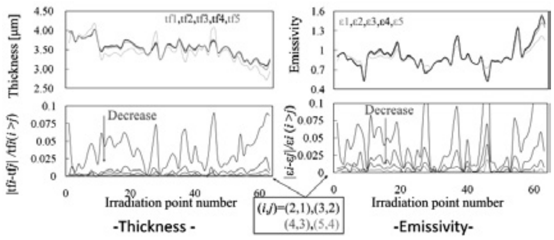

Fig.3 Distribution of foil thickness and estimated emissivity by the conventional method.

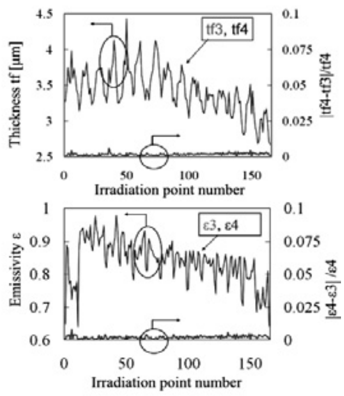

Fig.4 Distribution of foil thickness and estimated emissivity by the modified method.

1) M. Itomi, B.J. Peterson, Y. Yamauchi, R. Sano and D. Seo, Presented at Japan-Korea Seminar 2012 for Plasma Diagnostics, Jeju, Korea (2012).