§17. ACT2: a High Heat Flux Test Facility using Electron Beam for Fusion Application

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ACT2 (Active Cooling Teststand 2), a high heat flux test facility has been upgraded from ACT facility[1] and started its operation. A newly installed electron gun and data acquisition systems of ACT2 enables powerful and flexible experiments for R&D activities of plasma facing components (PFCs) for DEMO and beyond such as FFHR-d1. In this report, hardware upgrades, installation of new measurement devices and performance of ACT2 facility were introduced.

Thermo-mechanical properties, heat removal performance and reliability of plasma facing components (PFCs) are crucial for long-term operation in future fusion reactors. High heat flux testing with reactor relevant heat flux with actively cooled PFCs is essential for R&D of PFCs and fundamental researches of material response to high heat flux. A high flexibility of electron beam control is also required to test components in various scale and shape. The original ACT facility was established in 1994[1]. Nominal power and flexibility of beam control system of ACT was not sufficient for resent requirement for heat flux test facility. ACT was upgraded into the ACT2 to satisfy these demands. Focused electron beam scans defined area using high frequency deflection lenses. 300 kW beam power and 60 degree of deflection angle of ACT2's electron gun allow to apply reactor relevant heat flux (~20 MW/m2) into defined area up to 100 × 100 mm2. The pumping and feedthrough system of cooling water circuit was also redesigned. It allows continuous heat removal even in high power experiments and higher flow rate of cooling water (typically over 5 m/s, it is changed by geometry of cooling channel of the tested component). In order to remove the effect of inhomogeneous heating at the edge of scanned area, a water-cooled "beam limiter" made of copper with specific aperture is located above the sample surface. The edge of scanned area is scraped by the limiter. Absorbed heat flux is calculated from electron current through the sample and irradiated area defined by limiter's aperture.

For temperature measurements during heat load tests, eight type-K thermocouples and two pyrometers are installed. A single-color pyrometer can obtain surface temperature in the range from 423 to 973 K. Another two-color pyrometer measure between 673 and 2273 K. Temperature of inlet and outlet of cooling water are measured by thermocouples for calorimetric estimation of absorbed heat flux.

To characterize the electron beam of ACT2 facility, beam profile is measured by electrostatic probes. The probes made by graphite with spherical head with 2 mm in diameter were embedded in a graphite tile. Two probes located 30 mm apart. Beam scanned on the two probes. Beam profile was obtained by time profile of current through probe and beam velocity calculated from delay of current through two probes. Obtained beam profile is shown in Fig.1. The beam profile was Gaussian-like peaked profile with the spot size about 9 mm in full width at half of maximum (FWHM).

Due to automatic beam transfer system of ACT2, both steady state and transient (~ms) heat load are capable. Pulse heat load tests without scanning, like demonstration of ELMs, VDE and disruption, are achievable due to the fast beam transfer. Cyclic heat loads for thermal fatigue test are achieved by automatic routinely beam transfer between defined areas with each dwell time. Actual example of cyclic heat load test is shown in fig.2. In this case, beam scanned on the target for 50 s, then transferred to beam dump for 30 s. Dislike cyclic tests in ACT facility[2], cyclic tests without turning on/off of the beam is achievable on ACT2.

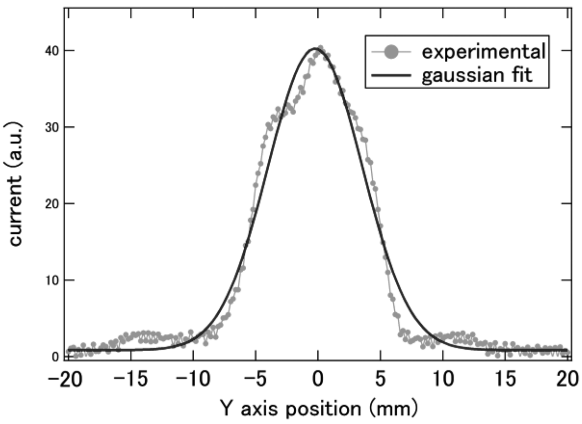

Fig. 1. Obtained beam profile by electrostatic probes.

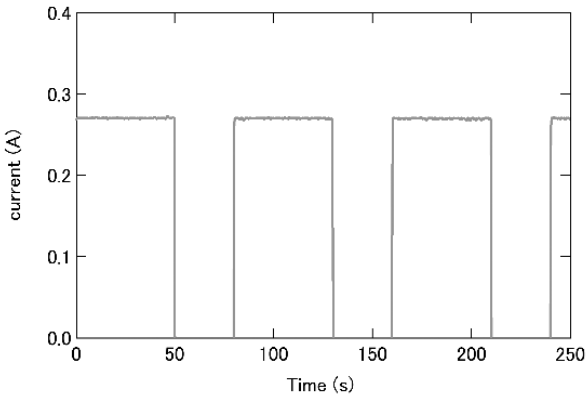

Fig. 2. An example of cyclic heat load test. The current is promotional to applied heat flux on the component.

1) Y. Kubota *et al*, Fusion Eng. Des. 39-40 (1998) 247–252.
2) K. Tokunaga *et al*, Fusion Eng. Des. 49-50 (2000) 371–376.