Low Heat Flux Test Facility at KAERI

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1. Introduction

The plasma facing components (PFCs) of a fusion device such as the first wall (FW), test blanket module (TBM), and divertor, will suffer a high heat load from the plasma and a nuclear heating. Therefore in order to develop the first wall of the ITER (International Thermonuclear Experimental Reactor), it is essential to have the technology and a facility for a heat load test. In order to test a PFC at a high heat flux relevant to the ITER condition, we need a high power beam facility such as JUDITH (Germany), JEBIS (Japan), EBTS (USA), and TSEFEY (Russia) [1,2]. As a part of the ITER project, we need to build such a facility in the near future. As a preliminary work, we constructed a small scale heat load test facility by using a halogen lamp and we performed a heat flux test for the ITER first wall mockup which was made with Cu-alloy and STS316L.

2. Low Heat Flux Test Facility

The facility consists of a halogen heater system, a movable sample holder, and a water cooled mask as shown in Fig. 1, which are enclosed in a box-type test chamber. The heating element consists of two halogen lamps which are connected to an electrical power supply in parallel, and its maximum heating power is 2 kW. The effective heating area is 30 mm x 75 mm. The heat flux is easily controlled by the power supply, and the heat flux is varied by changing the distance between the heater and the sample.

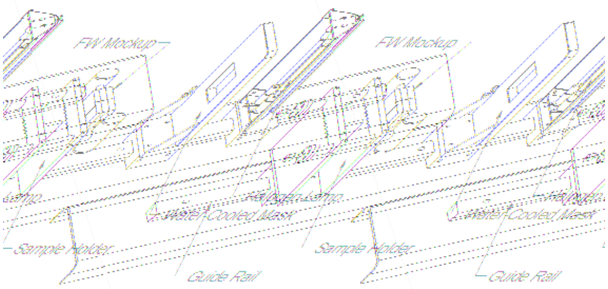

Fig. 1. Heat flux test set-up for an ITER first wall mockup

The box-type test chamber has a dimension of 0.3 m x 0.3 m x 1.2 m. The chamber has a large front door, two thermocouple feedthroughs, two coolant ports, and two power feedthroughs. The door has two viewing ports. The test set-up is equipped with two independent cooling loops; one for the water-cooled mask and the other for the test component. The low power heat flux test facility constructed at KAERI is shown in Fig. 2. The heat flux was calibrated by using a commercial heat flux sensor, and the results are shown in Fig. 3.

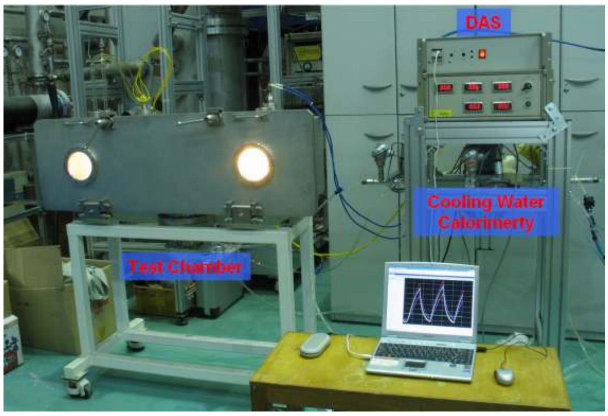

Fig. 2. Low heat flux test facility constructed at KAERI.

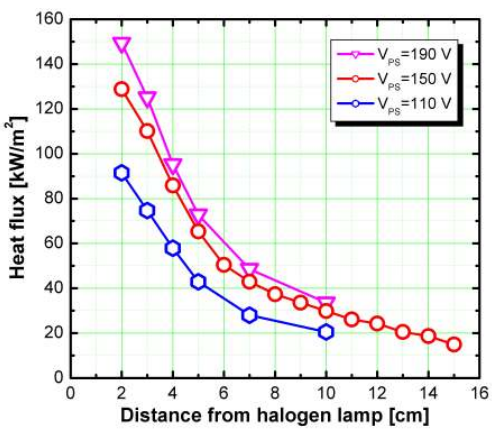

Fig. 3. Heat flux as a function of the distance from the halogen lamp.

3. Heat Flux Test of FW Mockup

We fabricated the ITER FW mockups as shown in Fig. 4, which was made to verify the HIP bonding technology to bond Cu-alloy (CuCrZr) with SS (STS316L) base [3]. The fabricated mockup was installed in the test stand as shown in Fig. 1, and the thermal cycle tests were performed. In order to maximize the temperature difference with a limited heating power, we carried out a lot of experiments for various heating and cooling conditions. Finally we determined the heating time of 5 min with a cooling water velocity of 0.1 m/s and the cooling time of 4 min with 0.3 m/s cooling water. Its result is shown in Fig. 5. The maximum temperature difference was 44 ℃.

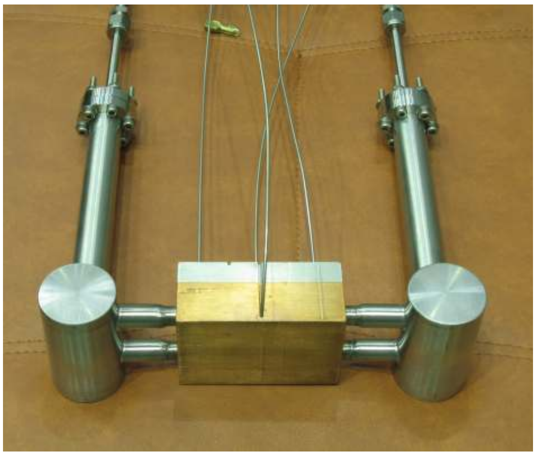

Fig. 4. FW mockup mounted with four thermocouples.

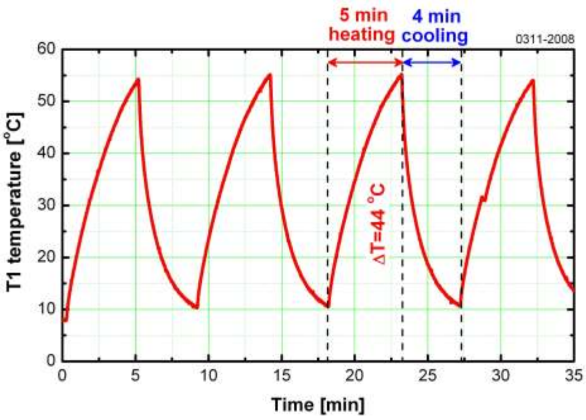

Fig. 5. Measured temperature by using a thermocouple embedded at 5 mm beneath from the front surface of the Cu-alloy.

Calculation of the expected temperatures was performed by using a commercial 2-D FEM code (QuickField). A calculated temperature profile of the mockup at the end of heating duration is shown in Fig. 6. Calculated result fairly agreed with the measured.

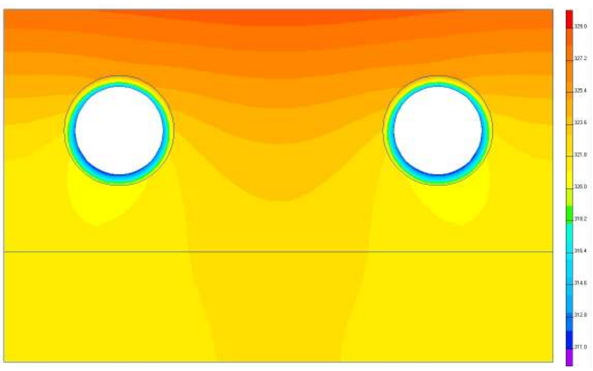

Fig. 6. Temperature profile of the mockup at the end time of a heating duration of 5 min.

4. Conclusions

A low heat flux test facility using a halogen lamp heater was built at KAERI and its performances were studied. Its maximum heat flux was 150 kW/m^2 at a 2-cm distance. We performed thermal cycle tests for a FW mockup, and also performed some calculations to compare with the measured results. They agreed well with the calculated ones. Even though the heat flux of this facility is lower than the existing high heat flux test facilities in other countries, it can be used for a screening test for plasma facing components. As a future work, we will construct a high heat flux test facility with a higher heat flux (> 0.5 MW/m^2) and a larger heating area.

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