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# Preliminary Test and Evaluation of High Heat Flux Test Facility for ITER Blanket System

Suk-Kwon Kim[a*], Hyung Gon Jin[a], Kyu In Shin[a], Bo Guen Choi[a], Eo Hwak Lee[a], Jae-Sung Yoon[a], Dong Won Lee[a], Seungyon Cho[b]
[a]*Korea Atomic Energy Research Institute, Daejeon, Republic of Korea*
[b]*ITER Korea, National Fusion Research Institute, Daejeon, Republic of Korea*
[*]*Corresponding author: skkim93@kaeri.re.kr*

## 1. Introduction

Korean high heat flux test facility for the plasma facing components of the nuclear fusion machines will be constructed to evaluate the performance of each component. This facility for the plasma facing materials will be equipped with an electron beam system of 60 kV acceleration gun. A 300 kW power supply system, a vacuum test chamber and beryllium filtration system for ITER first wall mockups will be assembled in this system. Firstly, the commissioning test is scheduled to establish the installation and preliminary performance experiments of the copper hypervapotron mockups to evaluate the thermo-hydraulic specifications. Secondly, the qualification test will be performed to evaluate the CuCrZr duct liner in the ITER neutral beam injection facility and The ITER first wall small-scale mockups of the semi-prototype, up to 1.5 and 5 MW/m$^2$ high heat flux, respectively. This electron beam system will be used in order to qualify the specifications of plasma facing components in the KSTAR tokamak and other fusion devices.

## 2. Methods and Results

ITER FW, in addition to plasma-facing components (PFC), plays a great role in a fusion reactor, and very extensive researches have been performed to develop these PFC materials. We have fabricated and tested the first wall mockups to qualify the manufacturing process, which makes the bonding between beryllium, as a PFC, and heat sinkers, such as Cu and stainless steel (SS). These types of mockups were tested using the international round-robin test [1] in several electron beam facilities of the US [2], EU [3], Russia [4], etc. In 2009, through the contracts between the ITER Organization and all parties, each party has fabricated the first wall qualification mockups for the heat flux test in the US and EU. The US test facility is an EB-1200 of the Sandia National Laboratory [2], and the EU facility is JUDITH-2 [3] in the Forschungszentrum Juelich of Germany. For preparing the qualification program and more, obtaining the procurement eligibility and fabrication methods for the FW has been developed in Korea [5]; various joining methods were investigated for an improvement of the bonding performances between Be tile and Cu alloy, and Cu alloy and the SS block, respectively, and finally, a Hot Isostatic Pressing (HIP) bonding method was chosen considering the complex geometry of the FW. Various samples such as Be/Cu and Be/Cu/SS blocks with coating layers in Be tile were fabricated to find the optimized bonding conditions. Various mockups with different dimensions and coating layers were fabricated to find an optimized bonding condition and canning methods for the HIP. Also, cyclic HHF tests were performed for a validation of the joining integrities of the mockups using various test facilities [6-9].

### *2.1 Electron Beam System*

The ITER FW includes beryllium armour tiles joined to a CuCrZr heat sink with stainless steel cooling tubes. The first wall panels are one of the critical components in the ITER machine with a surface heat flux of 5 MW/m$^2$ or above. Thus, a qualification program needs to be performed with the goal of qualifying the joining technologies required for the ITER First Wall. Based on the results of these tests, the acceptance of the developed joining technologies will be established. The results of this qualification test will affect the final selection of the manufacturers for the ITER First Wall.

We will construct an electron beam facility, as shown in figure 1, with an 800 kW electron gun power (from Von Ardenne GmbH, Germany) for a high heat flux with a maximum electron beam power of 300 kW power, maximum accelerating voltage of 60 kV, and maximum target size of 700 × 500 mm$^2$ (the maximum heat load for a scanning area of 300 × 20 mm$^2$ is about 5 MW/m$^2$).

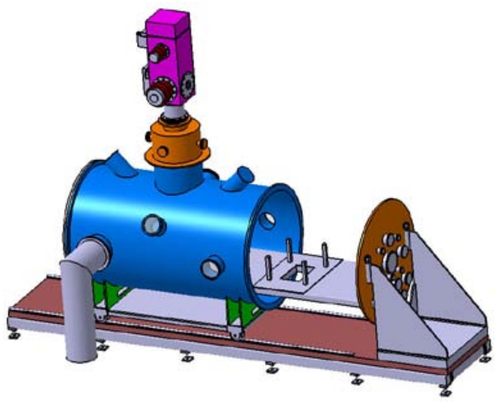

Fig. 1. Design and fabrication of electron beam facility for high heat flux tests.

### *2.2 Test Facility*

Several facilities are now operating at EU FZJ [3], US SNL [2], and RF Efremov institute [4]. We will perform a non-destructive test for a small-scale mockup using this electron beam facility. Also, figure 2 shows the high heat flux test facility for plasma facing components using an electron gun and helium cooling system. The methods used to measure the temperature of this system will be selected with the calorimetry for the coolant temperature and heat flux, the thermocouples for the bulk temperature of the test mockups, and IR camera and pyrometers for the mockup surface temperature to the normal directions.

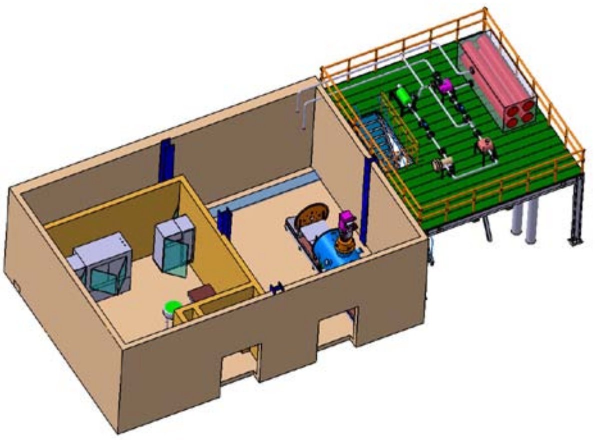

Fig. 2. High heat flux test facility for plasma facing components using an electron gun and helium cooling system.

The commissioning of test facility has been scheduled to establish the installation and preliminary performance experiments of the copper hypervapotron mockups and evaluate the thermo-hydraulic specifications. Second, a qualification test will be performed to evaluate the CuCrZr duct liner in the ITER neutral beam injection facility and the ITER first wall small-scale mockups of the semi-prototype, at up to 1.5 and 5 $MW/m^2$ high heat flux.

### 3. Conclusions

A Korean high heat flux test facility for the semi-prototype qualification of an ITER first wall will be constructed to evaluate the fabrication technologies required for the ITER FW. These Korean high heat flux tests for the plasma-facing materials will be performed using an electron beam, a power supply system, a vacuum test chamber, and a beryllium filtration system. The ITER first wall qualification test at up to a 5 $MW/m^2$ high heat flux will be performed using this electron beam facility in Korea. Also, this system will be used to test other PFCs for ITER and materials used for tokamak reactors.

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