Current Status and Performance Tests of Korea Heat Load Test Facility KoHLT-EB

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1. Introduction

Korean high heat flux test facility(KoHLT-EB; Korea Heat Load Test facility – Electron Beam) by using an electron beam system has been constructed in KAERI to perform the qualification test for ITER blanket FW semi-prototype mockups, hypervapotron cooling devices in fusion devices, and other ITER plasma facing components. The commissioning and performance tests with the supplier of e-gun system have been performed on November 2012. The high heat flux test for hypervapotron cooling device and calorimetry were performed to measure the surface heat flux, the temperature profile and cooling performance.

2. Methods and Results

An electron beam facility with 800 kW electron gun (from Von Ardenne, Germany) for a high heat flux with a maximum beam power of 300 kW, maximum accelerating voltage of 60 kV, as shown in figure 1.

2.1 High heat flux test facility

We have constructed the electron beam facility (KoHLT-EB; Korea Heat Load Test facility – Electron Beam) with 800 kW electron gun (from Von Ardenne, Germany) for a high heat flux with a maximum beam power of 300 kW, maximum accelerating voltage of 60 kV, This electron beam facility using a 60 kV electron gun from Von Ardenne GmbH (model EH800V) will be constructed using a power supply system of 300 kW (model HS300/60MF), which is capable of continuous operation, and the pulsed operation of a cyclic heat load and controllable heat load, where the allowable target dimension is 70 cm × 50 cm in a vacuum chamber (about 140 cm diameter, 250 cm length). Table I shows the specifications of this high heat flux test facility.

Also, this facility needs a cooling system for a high-temperature target and decontamination system for beryllium filtration. We have selected the power supply and electron gun according to the maker's specifications and the extension of power supply up to 800 kW will be scheduled in the next upgrade period of our institute. This machine will be utilized for a cyclic heat flux test of plasma facing components. Several facilities are now operating in EU FZJ (JUDITH-2; 200 kW) [1], US SNL (EB-1200; 1,200 kW) [2], and RF Efremov institute (TSEFEY; 200 kW, IDTF; 800 kW) [3]. Each facility is dedicated to unique targets of their own purposes in each country. KoHLT-1 (Korea Heat Load Test facility) and KoHLT-2 test facilities using graphite heater were constructed to perform the high heat flux test of small mockups for ITER first wall and plasma facing components.[4-6]

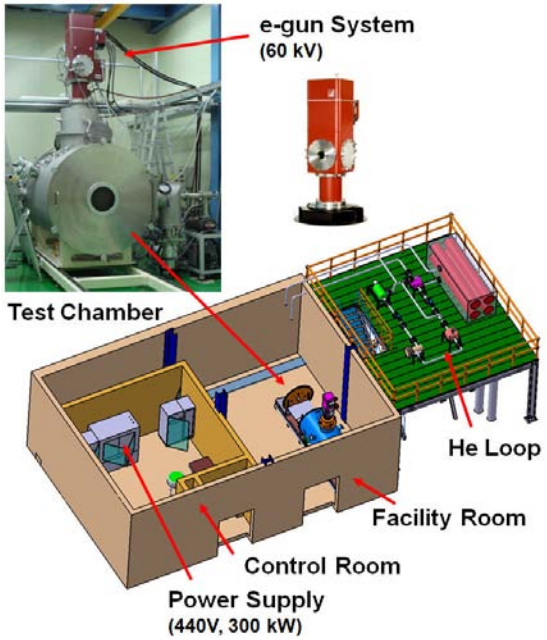

Fig. 1. High heat flux test facility for plasma facing components by using an electron gun and helium cooling system.

2.2 Test plan

KoHLT-EB was constructed to carry out the qualification test of ITER blanket first wall and the performance test of plasma facing components and ITER test blanket module (including FW and thermo-hydraulic test).

We will perform a non-destructive test for a small-scale mockup by using ultra-sonic test (UT) in this electron beam facility. Also, figure 1 shows the high heat flux test facility for plasma facing components using an electron gun and helium cooling system. The methods 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.

Table I. The specifications for high heat flux test facility

Facility	Electron Beam HHFT Facility
Major Target	PFCs development
Heat Flux	5 MW/m^2 (300×200 mm^2)
Heat Source	Electron Beam (MAX 60 keV)
Power Supply	300 kW (DC 60 kV)
Test Chamber	Cylindrical chamber (Φ1.4m×D2.5m)
Filling Gas	Vacuum condition
Vacuum System	1,900 lps TMP (base pressure < 10^{-6} mbar)
Coolant supplying System	Water: ~ 120 ^{o}C, 3 MPa, He gas: ~ 500 ^{o}C, 9 MPa

2.3 Test Results

Table II shows the parameters of this electron beam system. The specifications of our high heat flux test facility were fixed after the commissioning test on November 2012. Next performance test up to 300 kW electric powers is scheduled to start in the early of 2013.

Table II. Operational parameters for the electron beam system

	Electron Beam System
Beam power	150 kW (300 kW max.)
Acceleration voltage	0-60 kV
Mid-frequency high voltage power supply	300 kW max.
Beam diameter	< 10 mm (focused)
Pulse length	1 msec
Scanning area	700 mm x 500 mm
Scanning frequency	10 kHz

In the first commissioning, the beam patterns, profiles and shapes were selected from the conventional rectangular type of the maker (Von Ardenne). For our own operation, we will make patterns and profiles for our test mockups. The performance tests were completed up to 60 kV accelerating voltage and 150 kW (50 kV) electric power, which is equivalent to 2.5 MW/m^2 (at 400 mm x 150 mm surface area).

3. Conclusions

Korean high heat flux test facility for the plasma facing components of 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 with a 60 kV acceleration gun. A commissioning test has been scheduled to establish the installation and preliminary performance experiments of the copper hypervapotron mockups. And 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. Also, this system will be used to test other PFCs for ITER and materials for tokamak reactors.

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