Fabrication and Inspection of Small-scale Mockups for ITER Blanket First Wall Semi-prototype Qualification

Suk-Kwon Kim [a*], Eo Hwak Lee [a], Jae-Sung Yoon [a], Byoung-Yoon Kim [b] and Dong Won Lee [a]
[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

The ITER first wall (FW) design process has established that first wall panels are required to withstand design heat fluxes up to 4.7 MW/m^2. During operations, all areas of the ITER FW are not subject to the same level of heat flux and it is therefore possible to split the panels into two distinct groups. The two groups are normal heat flux (NHF) FW panels up to 2 MW/m^2 and enhanced heat flux (EHF) FW panels up to 4.7 MW/m^2. The design provided by ITER organization (IO) shall be used to withstand levels up to 4.7 MW/m^2. The goal shall be to develop and optimize the design using joining processes developed in the FW Qualification program where possible and utilizing a heat sink with enhanced heat removal capability. The design shall be based on the implementation of a heat sink using hypervapotron technology.

2. Methods and Results

This paper details the requirements of the qualification activities for enhanced heat flux (EHF) FW panels comprising heat flux technologies up to a design value of 4.7 MW/m^2.[1] To complete this qualification program, each country shall fabricate the semi-prototype (SP) for ITER FW and perform the high heat flux test. In this work, we'll describe the design, fabrication procedure, and mockup inspections.

The primary objective of the ITER FW semi-prototype (SP) qualification program is to demonstrate that the supplying country can provide FW components of acceptable quality and that the components are capable of successfully passing the formal test program including heat flux tests. The components shall be supplied with complete documentation packages and within the defined schedule.

Secondly, each country shall define and agree (with the IO) a program of development and verification necessary to establish technological feasibility of their approach to manufacture and assembly of EHF FW panels. The level of work required will be dependent on the expertise, experience and maturity of technologies to be utilized. Documentation and reports shall be available for review to justify the basis of the development plan.

Thirdly, the intent of this program is to implement a more formalized approach to the processes and documentation. This type of approach will be used for production of final in-vessel components. Each country is encouraged to utilize industrial and commercial resources in this program such as will be necessary for the final in-vessel components, using this approach all parties become familiar with the rigor necessary to provide these critical components.

The formalized approach shall be fully implemented on the essential part of the SP namely the HHF fingers, inlet and outlet features and its attachment to the FW supporting structure. The supporting FW beam structure may be manufactured to a quality level sufficient to ensure performance of the SP and HHF tests campaign are not impacted. This approach is anticipated to be a good balance between performance, schedule and cost.

2.1 Design and Model

Each semi-prototype (SP) mockup shall comprise a minimum of 3 full length pairs of FW fingers integrated with a central beam on which the fingers shall be attached, as shown in Fig. 1. The reasoning for inclusion of the beam is to allow the demonstration of the mechanical attachments and assembly. All 3 finger pairs on the mock up shall utilize the same grade of beryllium. The tile thickness shall be 6 mm to minimize beryllium surface temperature and evaporation under high thermal loads.

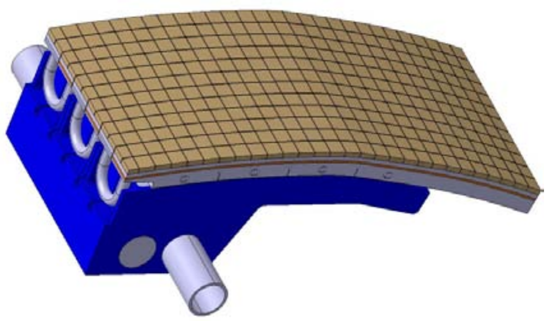

Fig. 1. 3D model of the generic first wall semi-prototype.

The small-scale mockup shall be part of the qualification program and used to validate performance of the key manufacturing technologies before production of larger scale components, and this mockup shall utilize the hypervapotron heat sink and manufacturing processes developed for the semi-prototype (SP) design. The small-scale mockup shall include a minimum of 3 beryllium armour tiles (50 mm x 50 mm or equivalent area if other tiles sizes are selected) capable of withstanding the specified heat flux values. In this work, 12 tiles of 25 mm x 25 mm were used for the small-scale mockups in Fig. 2. The tile thickness shall be 6 mm to minimize beryllium surface temperature and evaporation under high thermal loads. The small-scale mockup shall utilize an ITER approved and qualified beryllium.

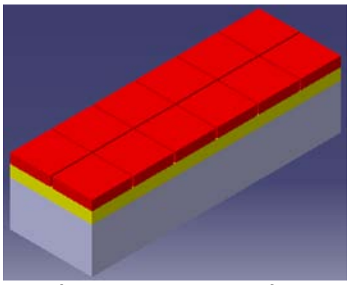

Fig. 2. 3D model of small scale mockup for high heat flux test.

2.2 Fabrication

The fabrication process [2-5] of the small scale mock-up is shown in Fig. 3 and briefly described in this section. As shown in Fig. 2, small-scale mockups are consisted with beryllium, Cu plate with hypervapotron, stainless steel (S.S.) plate, S.S. cover and S.S. main structure. The manufacturing procedures will be described below and Fig. 3;

a. Machining the Cu plate (for hypervapotron), S.S. plate, S.S. cover, S.S. main structure

b. Cu plate and S.S. plate will be HIPped and machined to make the hypervapotron channels

c. S.S. cover and S.S. structure will be welded with electron beam welding method

d. Cu-S.S. hypervapotron plate and S.S. structure from step -3 will be welded with EBW

e. Finally beryllium tiles will be attached in main structure from step-4 by HIPping method.

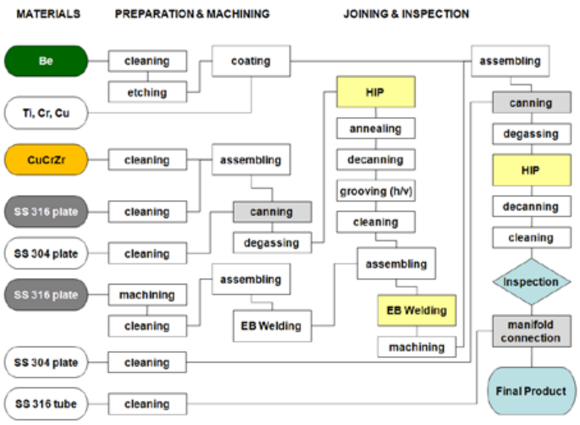

Fig. 3. Fabrication process of the small scale mockup.

2.3 Inspection

Prior to the initiation of the heat flux tests [6] for the small-scale mockups, a formal inspection test shall be performed to ensure that all manufacturing and pre test requirements have been met. The small-scale mockups shall be tested by visual inspection, dimension inspection, cold helium leak test, pressure test, and beryllium contamination test.

3. Conclusions

This work details the requirements of the proposed voluntary activities in Korea for enhanced heat flux (EHF) flux technologies up to 4.7 MW/m^2. It shall be noted that this work is not related to international pre-qualification activities and is undertaken based on the Korean R&D strategy to extend the knowledge and skills in the development and testing of plasma facing components (PFC).

REFERENCES

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