Fabrication and preparation of a high heat flux test with a mock-up for the first wall of the KO HCML TBM

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1. Introduction

Korea has proposed and designed a Helium Cooled Molten Lithium (HCML) Test Blanket Module (TBM) to be tested in the International Thermonuclear Experimental Reactor (ITER) [1-3]. Ferrite Martensite (FM) steel is used as the structural material and Helium is used as a coolant to cool the first wall and breeding zone. Liquid Lithium is circulated for a tritium breeding, not for a cooling purpose. Therefore, the speed of Lithium is very slow up to a few mm/sec. From the performance and safety analyses, the feasibility of this concept has been proven.

The FW is an important component which faces the plasma directly and therefore, it is subjected to high heat and neutron loads. The FW is composed of a beryllium (Be) layer as a plasma facing material and Ferrite Martensite Steel (FMS) as a structure material. In order to develop the fabrication technology for a TBM structure, several mock-ups, especially for the first wall channels, were fabricated with a HIP (Hot Isostatic Pressing), which was developed similarly to the development of the ITER blanket FW in Korea [4]. In the present paper, fabrication of a TBM FW mock-up and a high heat flux (HHF) test plan for confirming its integrity are presented.

2. Design and fabrication of the FW mock-up

The KO HCML TBM is a box of rectangular structure with a faceted first wall designed to match the surface of the ITER shielding blanket. The front surface of the module box is 444 mm in width, 1620 mm in height, and 484 mm in depth considering the ITER common frame size and their gap. The front surface of the FW channel is 444 mm in width, 1560 mm in height, and 435 mm in depth considering the KO HCML TBM dimension. There are 60 channels which size is 20 mm in height and 10 mm in width for cooling and one group consists of 10 channels, as shown in Figure 1.

With consideration of the designed TBM FW, FW mock-up was designed as shown in Figure 2. The channel sizes were preserved as the original one but the length was reduced to 100 mm. Six single channel were fabricated with wire cutting for making rectangular channel and they were fabricated with the Hot Isostatic Pressing (HIP) methods (1050 ^{o}C, 150 MPa, 2 hours), as shown in Figure 3.

After HIP, the microstructure of the mock-ups were observed but there were no pores and cracks as shown in Figure 4. It means that the mock-up was successfully fabricated with the proposed HIP conditions.

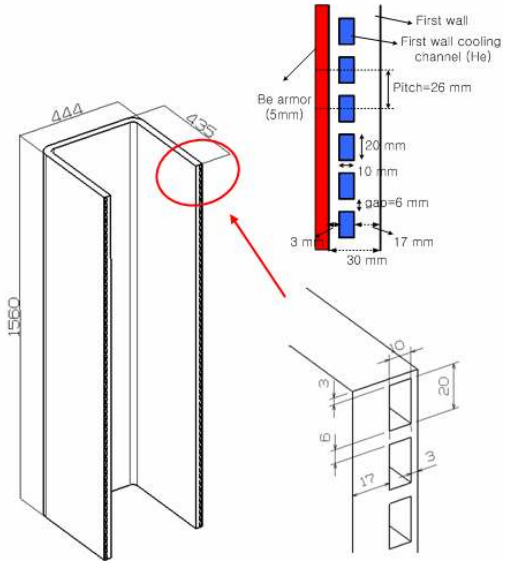

Figure 1 Schematic of the KO HCML TBM FW

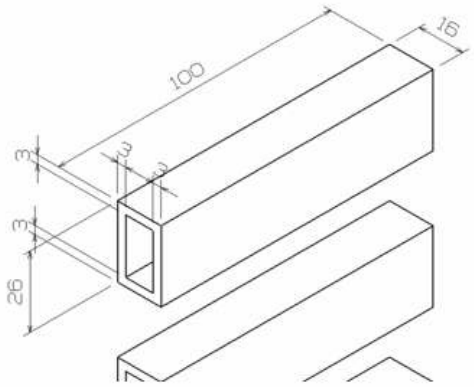

Figure 2 Schematic of the KO HCML TBM FW mock-up

3. Preparation of the high heat flux test

Since a HHF test is essential for investigating the thermo-mechanical performance of the FW including the integrity of the HIP bonded interfaces, the fabricated mock-ups will be tested in a Neutral Beam Injection (NBI) test stand, which was developed for heating up the KSTAR plasma. It can produce 4 MW of beam for 300 sec and its heat flux can be more than 30 MW/m^2. Currently, it has been modified to install the FW mock-ups and to supply the water coolant to them. And also, preliminary analysis with ANSYS code to determine the test conditions

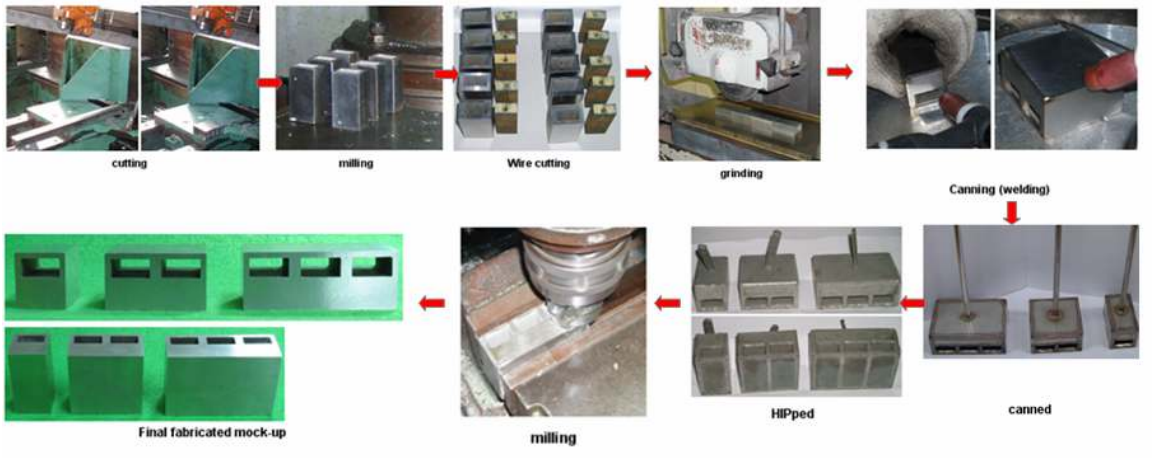

Figure 3 Fabricating procedure of the KO HCML TBM FW mock-up

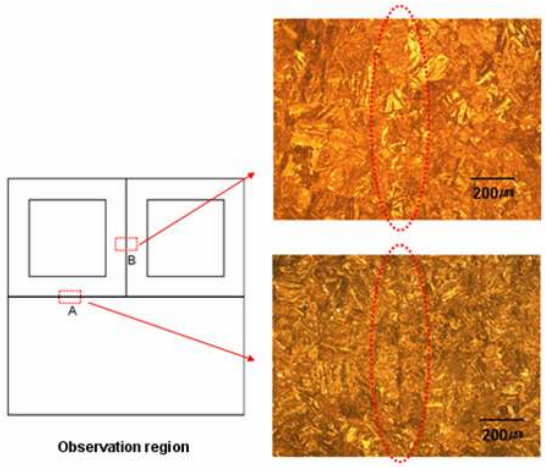

Figure 4 Microstructure observation after HIP

4. Conclusion

In order to develop the fabrication methods for the FW of the proposed KO HCML TBM design, FW mock-ups were fabricated successfully with HIP. And a HHF test with a NBI test stand has been prepared to confirm the integrity of the fabricated mock-ups and their joints.

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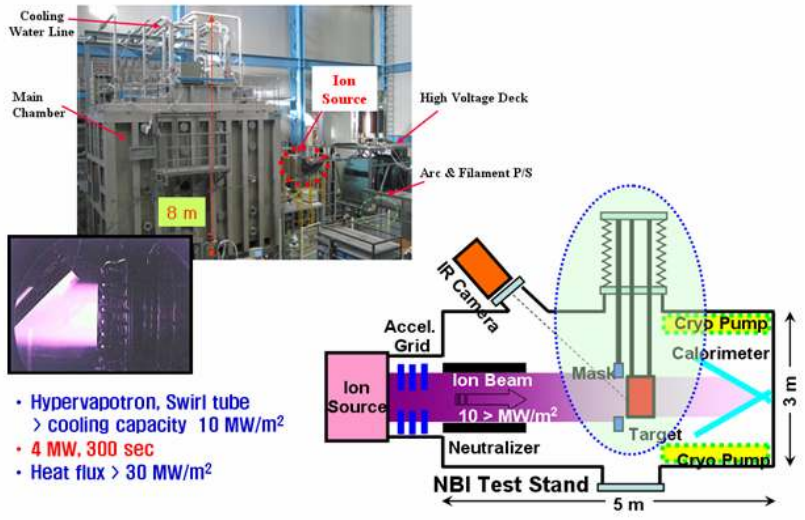

Figure 4 NBI test stand for high heat flux test