Fabrication of a 1/6-scale mock-up and manifolds for the Korea first wall in the ITER

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1. Introduction

Korea has developed and participated in the Test Blanket Module (TBM) program of the International Thermo-nuclear Experimental Reactor (ITER). The first wall (FW) of the TBM is an important component that faces the plasma directly and therefore it is subjected to high heat and neutron loads. To fabricate the TBM FW, the Hot Isostatic Pressing (HIP) bonding method has been investigated [1-3]. In the present study, the manufacturing method of the TBM FW is introduced through the fabrication and testing of a 1/6-scale mock-up. To distribute fluid uniformly in the mock-up, a manifold was designed and fabricated using the ANSYS-CFX analysis. After the mock-up was fabricated and its fluid distribution tests performed, we compared the results of tests with the simulated results.

2. Fabrication of the 1/6-scale mock-up for developing the fabrication procedure

A 1/6-scale mock-up was designed and fabricated to verify the manufacturing method of the ITER TBM FW. The 1/6-scale mock-up consists of three components: a front part with a cooling channel 20 mm in width and 10 mm in height, a front cover plate, and a back plate. The mock-up was fabricated using a SUS 316 block. The height of the mock-up is 260 mm and its width and length are 444mm and 435 mm, respectively. The fabrication of the 1/6-scale mock-up has been processed according to the procedure of the small mock-up. A diagram of the three parts and manufacturing process of the 1/6-scale mock-up is shown in Fig. 1.

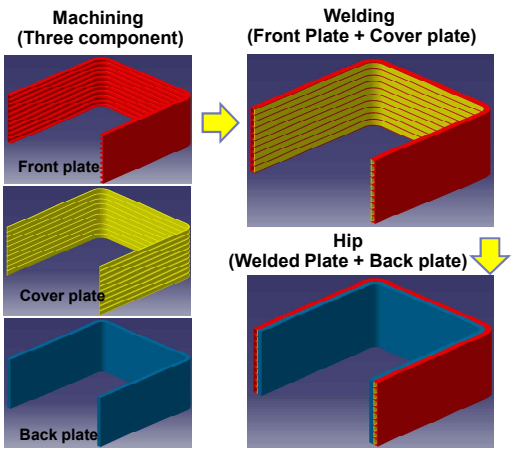

Fig. 1. Schematic diagram of the manufacturing process of the 1/6-scale mock-up

The 1/6-scale mock-up underwent a helium leak test after the fabricating of each parts of the mock-up and welding the front and cover plates. After performing the helium leak test, the welded part and back plate were jointed using HIP. A photo of the helium leak test and manufacturing process is shown in Fig. 2.

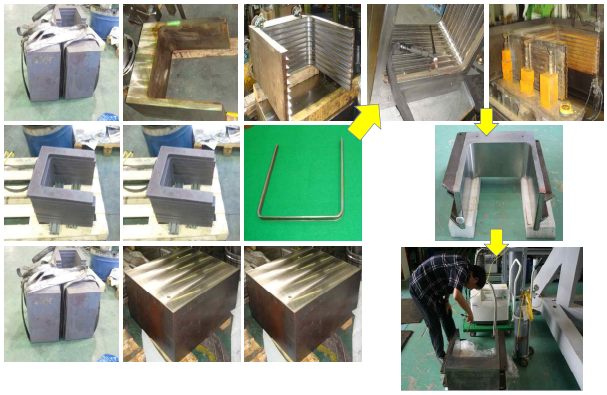

Fig. 2. Manufacturing process for a 1/6-scale mock-up

3. Fabrication and testing of the manifold

A manifold was designed and fabricated to distribute fluid uniformly to 1/6 scale mockup using the ANSYS-CFX analysis. The manifold consists of a channel inlet, ten-channel outlet, and four partition plates between the inlet and outlet. The manifold consists of two parts components: a body block with an inlet channel 26 mm in width and 18 mm in height, four partition plates, ten channels outlets, and a cover plate. The body block and cover plate are bonded using TIG welding. The fabricated manifold is shown in Fig. 3. The outlet of the manifold was grooved for assembly with the cooling channels of the TBM FW. The expected flow distribution in the manifold and outlet with an inlet velocity of 1.4 m/sec based on a CFX analysis are shown in Fig. 4.

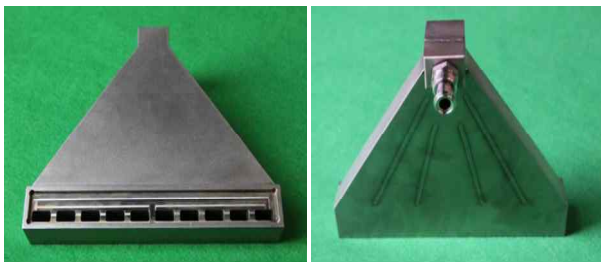

Fig. 3. Photo of the fabricated manifold

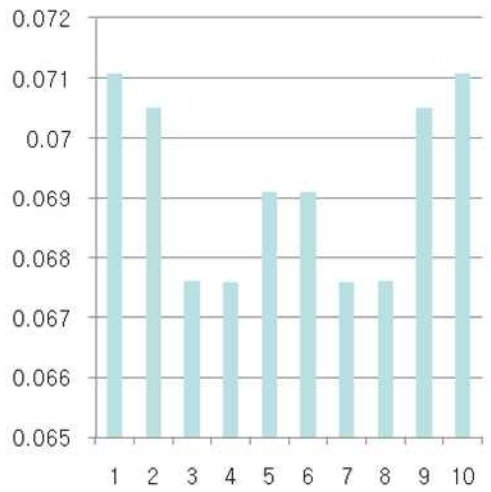

Fig. 4. Expected flow distribution by CFX analysis

A flow distribution test was performed using the fabricated manifold and the 1/6-scale mock-up. The performance tests of the fabricated manifold were carried out using a pressurized water tank, pump, valve systems and 10 channel water reservoir. The water in the pressurized water tank passed the valve system, then flowed to the manifold, and was stored in the 10-channel water reservoir. The flow distribution for the manifold was tested at an inlet flow rate of 0.5 Kg/sec. The flow distribution tests for the manifold showed a similar trend compared with the simulated results, but a little different value showed at quantitative value. The measured values at the water reservoir were normalized in order to compare the simulated values, and comparison graph for the manifold and simulation is shown in Fig. 5. The experimental system for the manifold test is shown in Fig. 6.

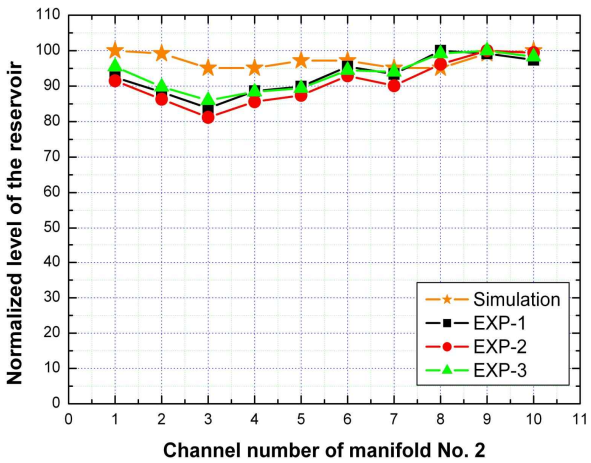

Fig. 5. A fluid distribution test with manifolds.

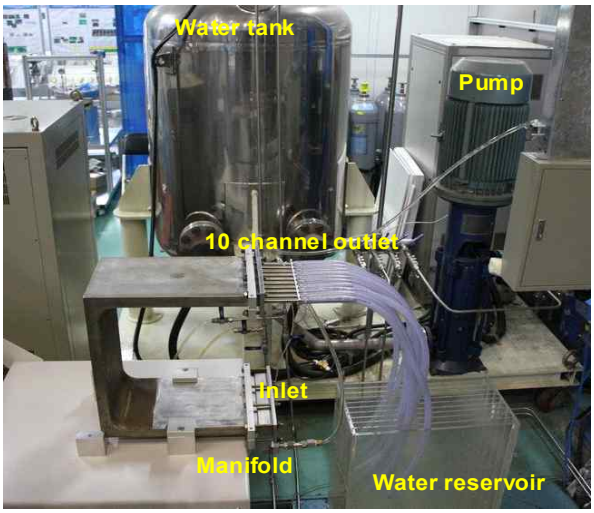

Fig. 6. An experimental loop for the fluid distribution test of the manifold.

4. Conclusions

A 1/6-scale mock-up was designed and fabricated to verify the manufacturing method of the ITER TBM FW. The 1/6-scale mock-up was fabricated using TIG welding and hipping. A 1/6-scale mock-up was fabricated using the same fabrication procedure of the small mock-up. The height of the mock-up is 260 mm and its width and length are 444mm and 435 mm, respectively. A manifold was designed and fabricated to distribute fluid uniformly to the 1/6 scale mockup using ANSYS-CFX analysis. A series of fluid distribution tests of the manifold was carried out. The flow distribution tests for the manifold showed a similar trend compared with the simulated results.

REFERENCES

[1] Dong Won Lee, Young Dug Bae, Suk Kwon Kim, Bong Guen Hong, Jong Hyuk Lee, Jeong Yong Park, Yong Hwan Jeong, Byung Kwon Choi, High heat flux test with the HIP bonded Cu/SS mock-ups for the ITER first wall, Fusion Engineering and Design, Vol. 83, p.1038, 2008.
[2] Dong Won Lee, Young Dug Bae, Suk Kwon Kim, Bong Guen Hong, Hyun Kyu Jung, Jeong Yong Park, Yong Hwan Jeong, Byung Kwon Choi, High heat flux test with HIP bonded Be/Cu/SS mock-ups for the ITER first wall, Fusion Engineering and Design, Vol. 84, p.1160, 2009.
[3] Suk-Kwon Kim, Young-Dug Bae, Hyun-Kyu Jung, Yang-Il Jung, Jeong-Yong Park, Yong-Hwan Jeong, Dong Won Lee, Fabrication and high heat flux test of large mockups for ITER first wall semi-prototype, Fusion Engineering and Design, Vol. 86, p1766, 2011.