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# Fabrication of ITER Semi-Prototype Blanket First Wall for the Final Qualification

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## 1. Introduction

The ITER semi-prototype was designed to qualify the manufacturing technology for the ITER blanket first wall. According to the design of the semi-prototype, its fabrication is expected to face great difficulty. The blanket first wall consists of three different materials, i.e., beryllium (Be), CuCrZr, and stainless-steel (SS), which are joined into one part. For fabrication of these multi-layered structures, hot isostatic pressing (HIP), which is one of the diffusion bonding methods, has been considered as a promising technology to realize sufficient mechanical integrity of a joint under the anticipated high neutron and stress fields. HIP provides high dimensional accuracy, low residual stress during the joining process, and the joining of three-dimensionally complex structures in comparison with other joining methods. Even though the joining technology for the different materials had been developed in the first stage of the qualification [1-4], the joining is still a key issue for the fabrication of the semi-prototype.

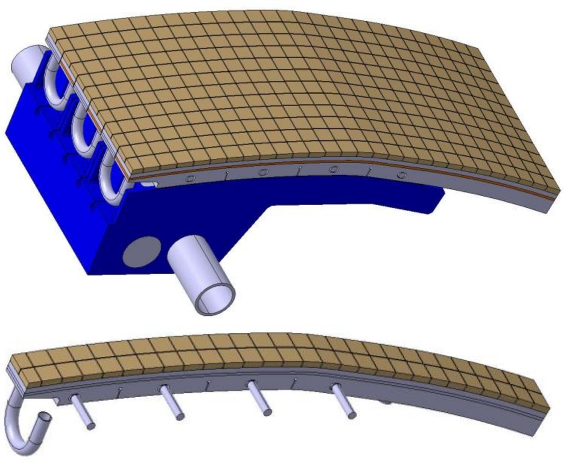

Fig. 1. Design of the ITER semi-prototype blanket first wall.

## 2. Methods and Results

### *2.1 Materials*

Beryllium with a grade of S-65D VHP (Materion Brushwellman, USA) was used for the fabrication of the mock-ups. Be tiles with various dimensions were coated with Ti(1 μm)/Cr(0.5 μm)/Cu(5 μm) interlayers by the manufacturer. For CuCrZr and SS (316L), a block with the designated dimensions was cut from the bulk material. The grade of used CuCrZr was Elbrodur G (KME, Germany).

For the joining of CuCrZr/SS, CuCrZr, and SS were HIP joined at 1050°C and 100 MPa for 2 h. Subsequently, the CuCrZr/SS joint was solution annealed at 980°C for 30 min and then quenched. In the case of Be/CuCrZr, HIP was performed at 580°C and 100 MPa for 2 h. In addition, welding on SS using an electron-beam (EB), and drilling, grooving, and slitting were performed.

### *2.2 Manufacturing Process*

A cooling channel laid between the CuCrZr and SS can be formed by HIP joining the CuCrZr/SS and then grooving the channel. In the first stage of the fabrication, CuCrZr/SS was HIP joined, and then Hypervaportron was machined as shown in Fig. 2. Simultaneously, SS structural part was prepared by machining cooling channels along with cover plates. The cover plates were EB welded as shown in Fig. 3.

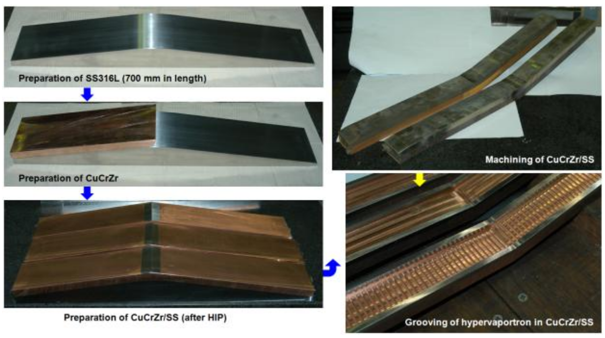


Fig. 2. Stage I: preparation of the CuCrZr/SS cooling part.

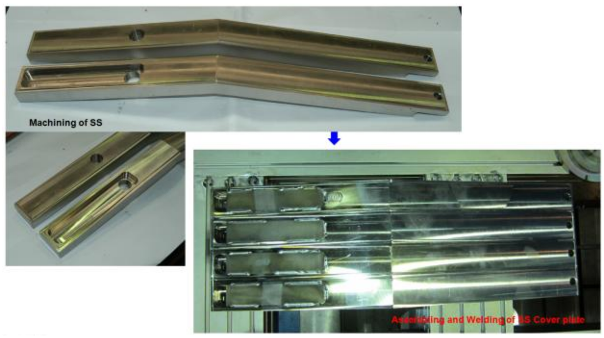


Fig. 3. Stage II: preparation of the SS structural part.

Then, the prepared CuCrZr/SS cooling part and SS structural part were assembled to join together (Fig. 4). EB welding was applied for that joining. The weld interface was SS to SS, which was designed on purpose not to deteriorate the properties of CuCrZr. After fabricating the CuCrZr/SS joint, multiple Be tiles were attached onto angular facets of CuCrZr using a HIP method (Fig. 5). Finally, the joined Be tiles were silted into smaller sizes, and back plate was machined to be fixed with key holders. Fig. 6 shows the final machining process for the semi-prototype. A set of semi-prototype is consisted of two units of Be/CuCrZr/SS joint. The fabricated Be/CuCrZr/SS is connected with U-shaped tubes to form the serial cooling environment.

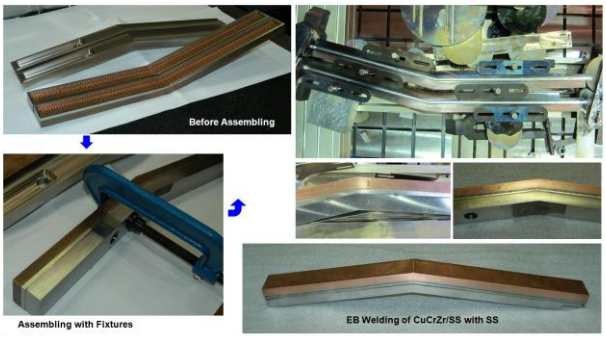


Fig. 4. Stage III: EB welding of the CuCrZr/SS joint.


Fig. 5. Stage IV: HIP of the Be/CuCrZr/SS joint.

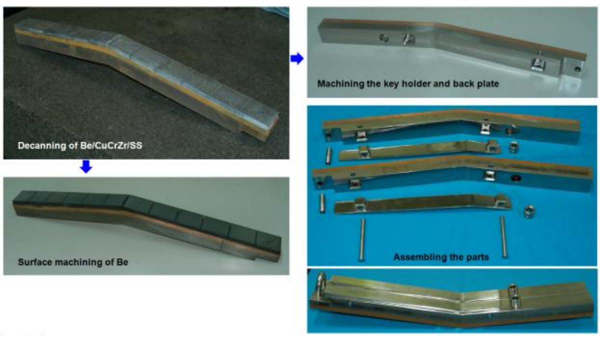


Fig. 6. Stage I: final machining.

## 3. Conclusions

The ITER semi-prototype blanket first wall was fabricated based on the developed joining and machining technologies. Fig. 7 shows the fabricated semi-prototype in its single channel form. For the fabrication, two times of HIP was performed for the joining of CuCrZr/SS and Be/CuCrZr/SS. Specific canning design was required for the HIP processes because of the size and shape of the semi-prototype. In addition, EB welding was introduced to weld the CuCrZr/SS cooling channels with SS structural part. In the future, destructive tests for the additional small mock-up will be performed for the qualification of joining process.


Fig. 7. Fabricated ITER semi-prototype blanket first wall.

## Acknowledgment

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## REFERENCES

[1] J.-Y. Park, B.-K. Choi, S.-Y. Park, H.-G. Kim, J.-H. Kim, B.-G. Hong, Y.-H. Jeong, HIP joining of Be/CuCrZr for fabrication of ITER first wall, Fusion Eng. Des. 82 (2007) 2497–2503.
[2] J.-Y. Park, B.-K. Choi, J.-S. Lee, D.W. Lee, B.G. Hong, Y.H. Jeong, Fabrication of Be/CuCrZr/SS mock-ups for ITER first wall, Fusion Eng. Des. 84 (2009) 1468–1471.
[3] D.W. Lee, Y.D. Bae, S.K. Kim, B.G. Hong, H.K. Jung, J.Y. Park, Y.H. Jeong, B.K. Choi, High heat flux test with HIP bonded Be/Cu/SS mock-ups for the ITER first wall, Fusion Eng. Des. 84 (2009) 1160–1163.
[4] Y.-I. Jung, J.-S. Lee, J.-Y. Park, B.-K. Choi, Y.-H. Jeong, "Ion-beam assisted deposition of coating interlayers for the joining of Be/CuCrZr, Fusion Eng. Des. 85 (2010) 1689–1692.
[5] Y.-I. Jung, B.-K. Choi, J.-Y. Park, S.-K. Kim, D.W. Lee, B.Y. Kim, Fabrication of small mock-ups reflecting the design features of the ITER semi-prototype, Fusion Eng. Des., in press (2012).