

Development of welding technology for TBM First Wall fabrication without permanent backing strip using laser welding

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1. Introduction

One of the most important goals of the ITER project is to experimentally investigate the heat and tritium extraction in test blanket modules (TBMs) [1-7]. Korea has developed a helium cooled ceramic reflector test blanket module for fusion reactors [8]. An advanced reduced activation alloy has been developed as a structural material [9, 10] and various joining methods such as electron beam welding, tungsten inert gas (TIG) welding, laser welding, and hot isostatic pressing have been applied to establish its fabrication method and procedure. Based on the current design of the TBM and breeding blanket, TIG and laser welding were selected as the main joining methods, and the U-shaped first wall (FW) was adopted. For welding of the breeding blanket, a special joining technique without a permanent backing strip with simultaneous full penetration welding in accordance with the design rules of class N2_{RX} of RCC-MRx is required for the pressure vessel. For the U-shaped FW, a permanent backing strip should not be formed when joining the front plate and the cover plate. In this study, laser welding conditions were checked to determine the bonding method without a permanent backing strip, and small mock-ups were fabricated using these conditions. The manufactured small mock-ups were subjected to a non-destructive inspection using radiographic test (RT) and a visual inspection on the weld surface of the joint after cutting. The results of the visual observation of laser welding show that the welding is normally done without a permanent backing strip on the joint surface, and the proposed fabrication method is applicable to the development of the FW fabrication procedure. Currently, Korea are discussing with EU the research topics and development of a TBM jointly. The welding method without permanent backing strip used in this paper will also be applied to the Korea-EU joint TBM production in the future.

2. Design and Fabrication of FW Small Mockup

To perform welding without a permanent backing strip, a straight small mock-up of 300 mm in length with 8 channels and a curved small mockup of 160 mm in length with 2 channels were designed. The small mock-ups consist of a body and a cover with cooling channels.

For assembly, the cooling channel cover and body have a 0.5mm wide backing strip, and it is necessary to

find welding conditions so that there is no backing strip by performing laser welding. Figure 1 shows the shape of the designed curved small mock-up. Welding characteristics were observed by fabricating small mock-ups using laser welding for the fabrication of a FW without a permanent backing strip. The small mock-ups were fabricated for both straight and curved structures, and the characteristics of the weld surface were observed through non-destructive testing and cross-section cutting. Figure 2 shows the fabricated small mock-ups of a straight and a curved ones, in which the mock-ups were already cut for visual observation of the welded region.

Figure 3 shows the cross-sectional view after cutting the welding surface for both mock-ups. In both mock-ups, there is no permanent backing strip but we can find some unstable overlapped welding parts for a curved mock-up.

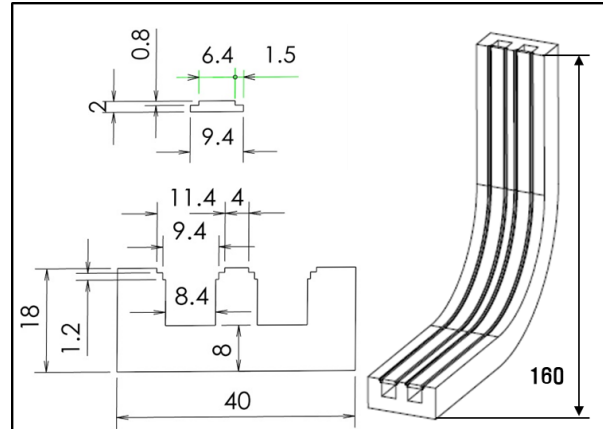


Fig. 1. Designed curved-type small mock-up

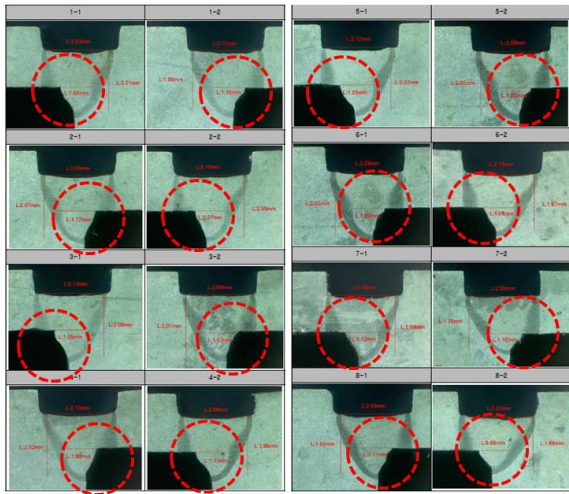


(a) Straight mock-up

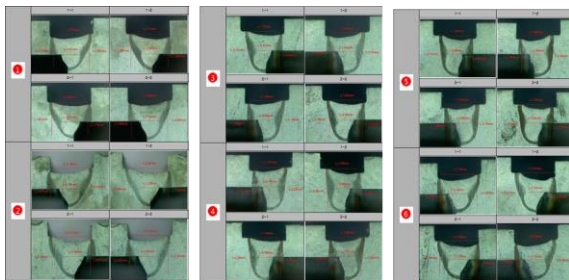


(b) Curved mock-up

Fig. 2. Welded small mock-ups; straight and curved ones



(a) Straight mock-up



(b) Curved mock-up

Fig. 3. Cross-sectional view of both mock-ups.

3. Conclusion

A welding method without a permanent backing strip was developed and confirmed by fabricating the straight and curved mock-ups. We found that there is no permanent backing strip by visual observation after cutting of the welding region for both mock-ups. Some unstable region will be tested and then the method will be applied to ITER TBM production.

Acknowledgments

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