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Development of Shield Design and Fabrication Procedure Considering Manufacturability for Test Blanket Module

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1. Introduction

Korea has been developing a helium-cooled ceramic reflector (HCCR) breeding blanket for the Korean nuclear fusion demonstration reactor and fusion reactor development [1]. As part of this effort, Korea is collaborating with Europe to develop an HCCP Test Blanket Module (TBM) for installation and testing at ITER. Reduced-activity ferrite/martensitic (RAFM) steels are one among the candidates for fusion reactor structural materials, and countries conducting fusion reactor research have developed several types of RAFM steels, including EUROFER [2] and F82H [3]. In Korea, a RAFM steel grade called Advanced Reduced Activation Alloy (ARAA) has been developed for fusion reactor components, including ITER's HCCP TBM [4-7].

The shape of the HCCP TBM is divided into a TBM box and a TBM shield structure. The HCCP TBM box is made of RAFM steel, specifically EUROFER-97, while the HCCP TBM shield is made of SS316L(N)-IG. The production of HCCP TBMs for ITER is being divided between Korea and Europe. Korea is responsible for manufacturing the TBM box internal elements (Breeder Units) and TBM shields, while Europe is responsible for manufacturing the TBM box envelope and TBM manifold structure. The final assembly will be carried out by Europe. The structure and geometry of the HCCP TBM are shown in Fig. 1.

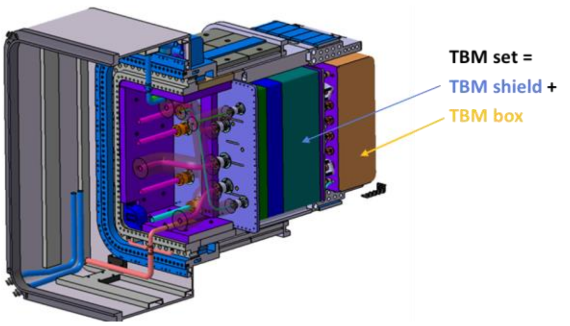

Fig. 1. HCCP TBM geometry diagram

2. HCCP TBM Shield Fabrication Procedures and Methods

The design of the HCCP TBM was carried out by Europe, and based on this design, Korea and Europe agreed to co-produce it. The HCCP TBM set consists of a TBM box and a TBM shield. The roles of Korea and Europe in the production of the HCCP TBM are as follows: Korea is responsible for the production of the internal elements of the TBM box (Breeder Unit) and the TBM shield, while Europe is responsible for the production of the TBM box body, the TBM manifold structure and the integrated assembly of the TBM set. To manufacture the HCCP TBM, the performance of the HCCP TBM must be verified through design and structural analysis, and a manufacturability review is required to confirm the manufacturing procedures and methods. This study aims to validate the HCCP shield design, verify the fabrication process, and evaluate the fabrication method. The HCCP TBM shield structure consists of three blocks and pipe connections consisting of water inlet/outlet pipes, helium inlet/outlet/by-pass pipes, purge gas inlet/outlet pipes, and NAS I&C pipes running through the three blocks and connecting to the TBM manifold. Figure 2 illustrates the HCCP TBM shield geometry. The existing HCCP shield design is composed of multiple reinforcing plates, which are expected to be difficult to weld and fabricate. Therefore, there is a need to devise an improved design that increases fabrication convenience while maintaining the structural stability of the existing design. In this study, we proposed an improved design of the existing HCCP shield, evaluated its stability through structural analysis, and proposed a new fabrication method.

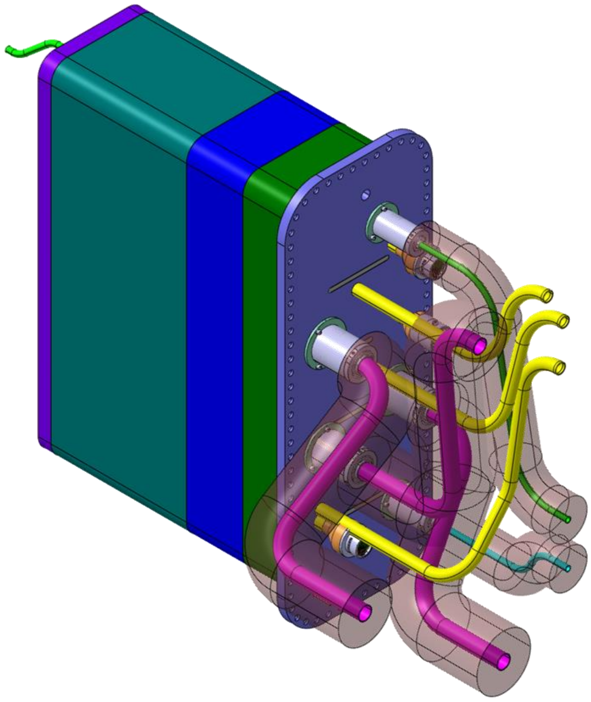

Fig. 2. Schematic of HCCP TBM Shield

3. Conclusions

The existing HCCP TBM shield design is composed of multiple reinforcing plates, which are expected to be difficult to weld and inspect. Therefore, there is a need to devise an improved design for this. In this study, we proposed a design that simplifies the existing HCCP TBM shield internal structure, evaluated its structural integrity through structural analysis, and proposed a new fabrication method that reduces the number of reinforcement plates. This improvement aims to enhance fabrication convenience while maintaining the structural integrity of the current design.

Acknowledgments

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