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Current Status of HCCR TBM Design for the Preliminary Design Phase Preparation

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1. Introduction

Helium cooled ceramic reflector (HCCR) TBM-set will be installed in the equatorial port #18 of ITER inside the vacuum vessel directly facing the plasma. TBM-set refers the TBM and associated shield and connecting support, as shown in Fig. 1 [1, 2]. After the Conceptual Design Review (CDR), Helium Cooled Ceramic Reflector (HCCR) Test Blanket Module (TBM) design is being updated for the preparation of the preliminary design phase. The manufacturability is considered based on the TBM-set model of the conceptual design phase.

In this work, the design changes for each component of the TBM-set is described in comparison with the CD phase. The current design direction and details is presented.

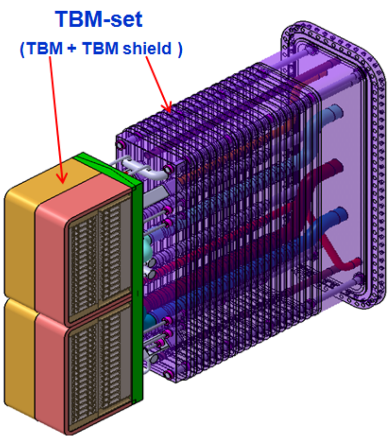
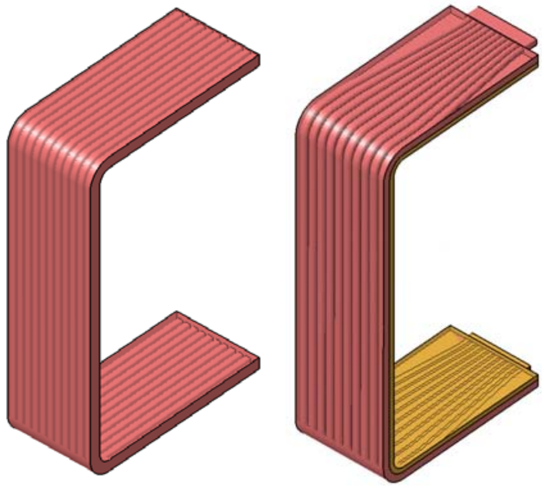


Fig. 1. HCCR-TBM-set configuration at CD phase

2. TBM Components

2.1 First wall (FW)

Figure 2 shows the design changes in the first wall of TBM. The first wall (FW) is component facing the plasma directly. This component should have a superior cooling performance. The 11 cooling channel with same geometry was designed in the CD phase. The 4 FW components will be connected to the back manifold (BM) [3]. The FW should ensure the enough area to weld to BM. The number of He cooling channels is reduced from 11 to 10. Additionally, the gap between the channels is designed to be narrow approaching the interface with BM. The current FW design has the port plug to enhance the connection with BM. Although the cooling performance deteriorates in comparison with previous model, the temperature requirement for the material strength is satisfied with current FW design by using the CFD.

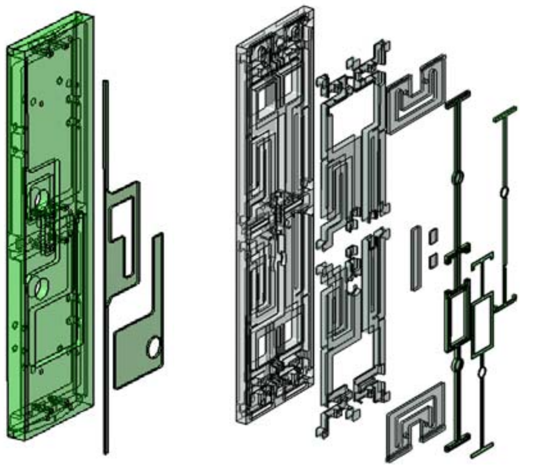


(a) CD model (b) Current model

Fig. 2. CD and current design model of FW

2.2 Back manifold (BM)

The back manifold supports the 4 TBM sub-modules. The thickness of BM should be designed to be thick. The interface line for the helium coolant between the sub-modules is formed in BM structure. Additionally, this interface line functions as the cooling channel for BM itself. BM is the structure that reacts with the neutrons. The significant heat is generated in BM. The formation of the effective cooling channel is focused in the current preliminary design (PD) phase. In CD model, the line related to the tritium extraction system (TES) is formed on the outside of BM. The design is on progress to make the helium cooling channel and the TES line together in BM structure. There ae some reasons for this design direction. First one is to retain the enough space between the TBM and TBM-shield. The connecting supports should be installed in this space. Detailed design about the connecting support like the size, shape and coupling method is not determined. The enough margin of space was designed to eliminate the interference with other components. Last one is to limit the boundary of accident which is In-TBM LOCA-IV (In TBM box Loss of Helium Coolant Accident). If the interface between the high pressurized He coolant and TES line is broken, the pressure of TES line boundary will be increased. The TES line is embed in BM to reduce a volume located outside the BM structure. These design considerations is reflected in Fig. 3.



(a) CD model (b) Current model

Fig. 3. CD and current design model of BM

2.3 Reflector

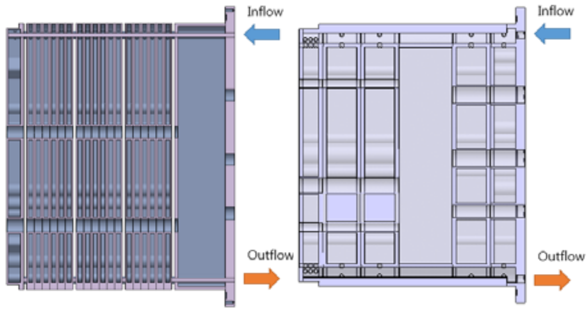
One of the feature for HCCR-TBM is the utilization of a reflector. The material for the reflector is a graphite. It is the traditional material for the moderator or reflector. Thick graphite reflector is located in front of the BM structure so that its nuclear efficiency can be maximized. The pebble bed formed reflector was considered in CD phase. The brick formed reflector was selected in the current design due to the cost and a fire hazard. The radial distance of modified reflector is shorter than the original model because of different density. The enlargement of the space between the TBM and TBH-shield or the expansion of TBM-shield is advantage to design the TBM-set. The first option has the positive effect to design the connecting support. The second option be able to reduce the dose rate [4]. The second design option was selected in current design considering the safety for maintenance access used in ITER.

3. Connecting support

The connecting support is device located between BM and TBM-shield. The connecting support is the component receiving the highest load based on the structural integrity analysis performed in CD phase. The design work for the connecting support was focused on the only size to ensure the structural integrity for the combined loads like thermal, pressure, seismic and electro-magnetic load. The detained shape and the coupling method will be determined through the structural integrity assessment at this design phase.

4. TBM-shield

Figure 4 shows the cross-section of TBM-shield at CD and current PD phase. 5 blocks is assembled with the cooling pipes not each other. One block consists of several sub-blocks. The water with 4 MPa, 70 °C is injected into the inflow pipe [5]. The inflow pipe has the several hole. The water could be distributed to the separated blocks through these holes. After distributed water cooled down the structure, the water is discharged into the channel of outflow. The purpose of the TBM-shield is to make the condition with the allowable neutron flux level. The manufacturing of CD model is difficult because of the limited access to the welding region. The shield blocks changed to have the initially channel-shaped geometry. After assembling the shield blocks, the channel cover plate would be welded with the shield blocks to prevent the water leakage. The manufacturability is enhanced by changing the welding location. The overall manufacturing process is simplified compared with the previous process of CD model.



(a) CD model (b) Current model

Fig. 4. Cross-section of TBM-shield design

5. Further work

Present Helium Cooled Ceramic Reflector (HCCR) Test Blanket Module (TBM) design was described in comparison with the CD model. The manufacturability was considered in current PD phase. The detained design of the connecting support will be determined reflecting the load assessment. The structural integrity will be confirmed with a various load condition.

Acknowledgment

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REFERENCES

[1] S. Cho et al, Design and R&D progress of Korea HCCR TBM, Fusion Engineering & Design, 89 (2014)

[2] M.Y. Ahn et al., HCCR-TBS Conceptual Design Description (QQ2R5R v1.0), 2014

[3] D.W. Lee et al., HCCR-TBS CD Structural Integrity Report for TBM-set (QQLY7N v1.0)

[4] C.W. Lee et al., HCCR-TBS CD Neutronics Analysis Report for TBM-set (QQ3KQS v1.0), 2014

[5] D.W. Lee et al., HCCR-TBS CD Thermal-hydraulic Analysis Report for TBM-set (QQJMTT v1.0), 2014