

Current Status and R&D Plan on ITER TBMs of Korea

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1. Introduction

One of the main engineering performance goals of International Thermonuclear Experimental Reactor (ITER) is to test and validate design concepts of tritium breeding blankets relevant to a power-producing reactor. The tests foresee on modules include the demonstration of a breeding capability that would lead to tritium self-sufficient in a reactor and the extraction of high-grade heat suitable for electricity generation.

The test blanket modules (TBMs) have been proposed by several parties. Japan proposed three options such as a solid breeder blanket cooled by pressurized water, a solid breeder blanket cooled by helium gas, and an aggressive blanket system based on liquid breeder cooling considering its merits like a simple structure and a high accommodation to radiation damage. In the EU, two blanket concepts have been chosen for further development; a helium cooled pebble bed ceramic blanket and a water cooled lithium-lead blanket. By Russian Federation, lithium cooled and helium cooled TBMs have been proposed.

The proposed TBMs by each party will be located in the common frame of ITER ports such as port no. 1, 2, and 18 as shown in Fig.1. The own TBMs of Korea are being designed according to the common frame sizes and their ancillary system in order to test during ITER operation. In this paper, the proposed TBM designs and its research plans are introduced as follows;

2. Proposed Design of TBMs

In Korea, solid breeder is the first option because other parties have interests in this type and it is assumed to be technically mature. An advanced option is a liquid breeder in which several materials have been considered such as Helium Cooled Liquid Lithium, Self-cooled PbLi, He-cooled Li/FS, Molten salt and so on. Among them,

conceptual design of Helium Cooled Molten Lithium is being studied in Korea.

Currently, we are participating the development of the selected TBM concepts with partners in order to contribute to the development and possible improvements of TBMs. And also, we are trying to develop the independent submodule for testing from Day-1 of ITER operation.

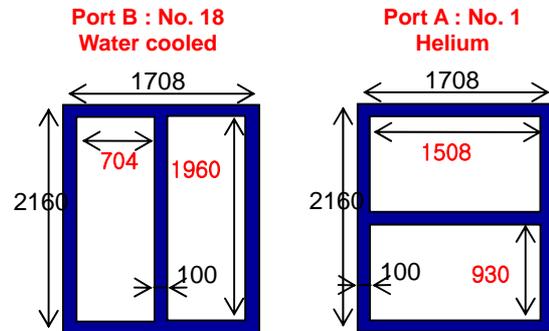


Figure 1. Expected phenomena in the downcomer of APR1400 during the LBLOCA reflood phase

2.1. Helium Cooled Solid Breeder (HCSB)

Lithium ceramics have been utilized as the breeding materials in the breeder design. Because Lithium provides a limited Tritium Breeding Ratio (TBR) performance, Be is usually used as a neutron multiplier. Be has a high multiplication efficiency and is regarded as one of the best neutron reflector materials. However, natural resource of Be is very limited and hazardous to human being as well. Consequently, the cost of Be is very high and is highly reactive with water, generating hydrogen gas. Therefore, in the present design, the amount of Be is reduced by replacing the graphite as a reflector as shown in Fig. 2. Figure 2 shows the schematic and concept of proposed HCSB in Korea. As a breeder and multiplier, Li_4SiO_4 with 90 % TD and 62 % of packing fraction, and Be with 95 % TD and 80 % of packing fraction are used, respectively. And more, Graphite with 85 % of packing fraction is used

as a reflector. The array and each size are determined by investigation with regard to neutronics, and now, the array and size of pipes are being determined through the thermo-hydraulic investigation with FEM and CFD codes.

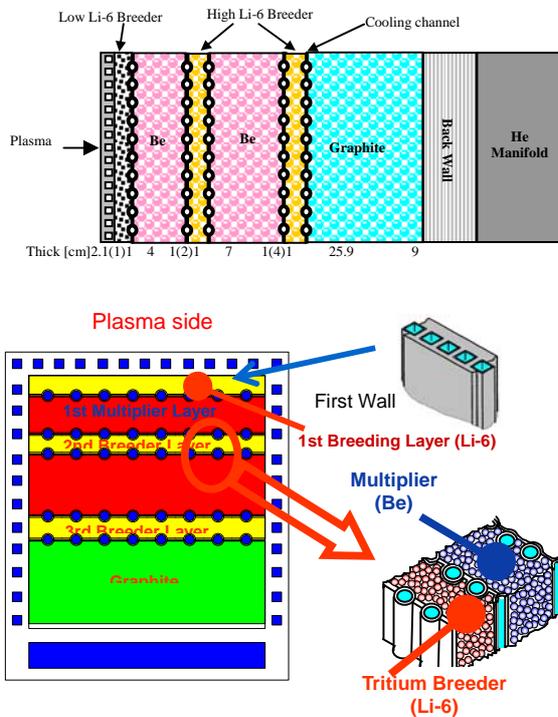


Figure 2. Conceptual design of HCSB

2.2. Helium Cooled Molten Lithium (HCML)

From the investigation to find the optimal configuration of an HCML blanket from the TBR point of view, Be appears to be far superior to others. However, taking into account the material availability and potential safety features, a high-density graphite reflector can be a practical choice for a high-performance HCML blanket. A graphite reflector significantly improves the TBR and neutron shielding in the HCML blanket. Therefore, the other TBM of Korea is designed as shown in Fig. 3 with graphite reflector. Graphite is filled with as a pebble-bed type, which has a multiple size to increase the packing fraction. The array and its size are determined by investigation in terms of neutronics, and now, the array and size of pipes are being determined through the thermo-hydraulic investigation with FEM and CFD codes as the same as the procedure of HCSB design.

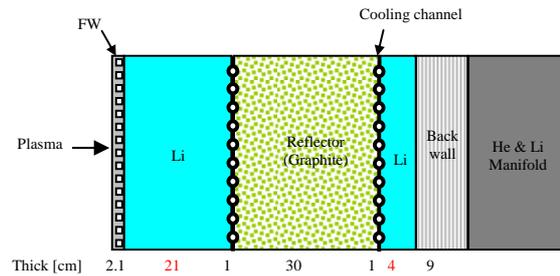


Figure 3. Conceptual design of HCML

3. R&D Plan of the proposed TBMs

Submodules are being designed for electro-magnetic test and neutron-tritium test at Day-1 and D-D phase of ITER operation, respectively. Their sizes will be 1/4 port or smaller and several instrumentation devices will be installed. And also, thermo-mechanical TBMs are being designed for D-T phase operation and their sizes will be 1/2 port. Ancillary system for them will be shared with other parties. In accordance with the TBM R&D and test plan, the followings will be developed; tritium recovery, fabrication of mock-ups, MHD coating, V-alloy and so on.

4. Conclusions

In order to participate the test program of tritium breeding blanket in ITER, we have been designing our own TBMs. So far, we proposed HCSB and HCML with regard to the Be amount and Graphite application, and the concepts are investigated in terms of neutronics. The detailed design work is being performed through thermo-hydraulic investigation. And more, R&D plan for ITER TBM is established to participate the ITER program according to the ITER test plan.

References

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