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Current Status of Chinese Solid Tritium Breeder TBM & Improved Design and Analyses of CN HCCB TBM

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A

China had promised to test its TBM modules during different ITER operation phase and have signed the CN HCCB TBMA with ITER IO recently. Related design and R&D activities for each TBM modules with auxiliary systems and interface with ITER facility were introduced. The preliminary conceptual design of CN HCCB TBM has been completed while the design optimization is in progress. Basic characteristics and main design parameters and technical characteristics of CN HCCB TBM are introduced briefly.

The neutron multiplier Be pebbles of kg-scale are fabricated by the Rotating Electrode Processing (REP). Be alloy are prepared by powder metallurgical (PM) methods. Be pebbles of diameters 0.5 mm and 1.0 mm as the neutron multiplier are fabricated. Related performance test is ongoing. The fabrication of pebble bed container and performance experiment of breeder pebble bed has being started. The lithium orthosilicate, Li_4SiO_4 pebbles with lithium 80% enriched in δLi as tritium breeding materials of HCCB TBM have been fabricated at laboratory level by melt-spraying method. Chinese Low-activated Ferritic/martensitic steel, CLF-1, as TBM structural materials is developing from laboratory scale towards industrially level. The structure material CLF-1 of ton-scale was recently produced by vacuum induction melting and electro-slag re-melting method. The mock-up fabrication and component tests by using the CLF-1 steel for Chinese test blanket module have being developed. Recent status on the fabrication technology development of CN HCCB TBM module was also reported.

Chinese HCCB TBM will be tested in Port #2 of ITER test ports with the India LLCB TBM simultaneously. Two TBMs and its associated ancillary systems will be integrated on same Port as well as interfaced with ITER buildings and sub-systems. The design and fabrication of related ancillary system with ITER facility are being performed.

B

Chinese helium-cooled ceramics breeder test blanket module (CN HCCB TBM) is improved to reduce its structural material to ~1.3 ton to meet the TBM impact assessment and to increase tritium production while recessed 12 cm from the surface profile of the shield blanket along with recent TBM Frame. It consists of a big backplate and 4 sub-modules arrayed in poloidal direction with 10mm gap between sub-modules. All sub-modules are welded to big backplate. A sub-module is bounded by First Wall (FW), 2 caps in top and bottom, and its own backplate. In a submodule, there are a middle plate and two double-layer U-shaped cooling plates. Middle plate is used to strengthen the TBM structure to meet criteria of level D criteria in case of loss of primary coolant accident inside the submodules. These two U-shaped structures are used to hold Lithium orthosilicate as tritium breeder and outside them are beryllium pebbles adopted as neutron multiplier. Distance between the two layers in the double-layer U-shaped structure is 2cm. The ferritic/martensitic steel, CLF-1, is chosen as the reference structure material. FW facing plasma has two optional structures corresponding with its coolant sources: one with coolant He distributed by big backplate and the other with coolant He distributed by submodules' backplate. Coolant's flow rate into TBM is 1.04kg/s and 0.45kg/s goes out of TBM by bypass. The rest 0.59kg/s are distributed by submodules' backplate to cool middle plate and caps and then cool two double-layer U-shaped structures. Performance analyses are done for this TBM. It's tritium production rate (TPR) is 66.1 mg/FPD. Maximum temperature of RAFMs, Be and Li_4SiO_4 pebble beds are 542°C, 509°C and 760°C respectively.

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