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Design and R&D Progress of Chinese HCCB TBS Program

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The current design of Chinese Helium-cooled Ceramic Breeder Test Blanket Module (HCCB TBM) with 1×4 configuration scheme, it includes 4 independent breeding sub-modules with 10mm gap (for thermal expansion) between each other along the poloidal direction. These sub-modules are connected with a big back plate containing auxiliary connection pipes for coolant and purge gas, shear keys and flexible supports to form a whole TBM. And the TBM is connected to the Helium Cooling System (HCS) and Tritium Extraction System (TES) by means of pipes in the back plate. A 3-D neutronics calculation for the updated TBM module design has been completed. Preliminarily a simplified analysis model for the sub-module of TBM is adopted.

In order to validate the design of CN HCCB TBS (module and system), a lot of R&Ds on materials has been performed according to technical requirements. The RAFM material of Chinese Low Activation Ferritic (CLF-1) steel has been developed and is scaled up to 5 ton ingot, which is used for the structure material certification. At the same time, 1 dpa neutron irradiation test in high flux test reactor and its PIE experiment has been performed. Based on the CLF-1 steel, some mock-ups have been fabricated by the different techniques and tested. A 1/3-size mockup of TBM module is under fabrication and will be tested soon. The fabrication techniques for the functional materials, such as beryllium and Li₄SiO₄, have been also developed and the related properties have been obtained. The fabrication of back plate system could be the current largest challenge for HCCB TBM. Several welding technologies and manufacture process are investigated on different size plates, including Laser Welding (LW) process for the BP and the FW, HIP welding for FW. The welding of the CLF-1 with the 316 L(N) IG (ITER Grade) is dissimilar welding process for assembling TBM module and shield block. For the manufacturing solution of FW, Hot Isostatic Pressing (HIP) is a realistic process, and the base welding experimental researches for the HIP joining of RAFMs CLF-1 are being carried out to prepare for the next forming welding practices of FW at present. A small-type Helium Gas Testing Loop (HGTL) is under construction, which will be used for the future component testing and operation testing. The design temperature is 300°C and the pressure of He gas is 8MPa.

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