Design and integration of China Helium Cooled Ceramic Breeder Test Blanket System in ITER

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The conceptual design of Chinese Helium Cooled Ceramic Breeder Test Blanket Module (CN HCCB TBM) had been almost completed for the last few years. The current progresses on Test Blanket System (TBS) design are focused on investigation of ancillary systems and its integration. In this article, the preliminary design of ancillary systems for TBM testing in ITER was introduced briefly, includes Helium Cooling System (HCS), Tritium Extraction System (TES), etc. These systems/subsystems are mainly reserved in Port Cell area and Tokomak Coolant Water System (TCWS) vault. In addition, the supporting analyses of above design are presented, such as thermal dynamic analysis. Based on the dose rate calculation, a maintenance strategy of Port Plug, pipe forest, Ancillary Equipment Unit (AEU) was proposed. Finally, the accident analyses are performed to accomplish the license application for TBS.

Keywords: ITER; Helium Cooled Ceramic Breeder; Test Blanket System, Port Cell

1. Introduction

The Helium Cooled Ceramic Breeder Test Blanket Module (HCCB TBM) is one of the major concept blankets selected for DEMO in China, which will be used for testing tritium production and high-grade energy access technologies in ITER dedicated ports. As it had been endorsed that CN TBM will be tested in ITER after the first plasma shutdown as an objective, the development of CN HCCB TBM and its ancillary system were performed with industrial companies. This article shows the recent progresses on Test Blanket System (TBS) investigation, which consists of TBM, shield block, pipe forest, Ancillary Equipment Units (AEU), Helium Cooling System (HCS), etc.

As had been approved port allocation strategy, China and India TBS will share the space of Port Cell area, part of space in Tokomak Coolant Water System (TCWS) vault, L2 of tritium building. The arrangement of above space had been confirmed after several times discussion with both TBM parties and ITER International Organization (IO). In all these space, interfaces between TBS components and ITER buildings are needed to be investigated, which are essential for design of ITER subsystems and CN TBS.

Based on the original CN HCCB TBM design, some modifications are undergoing due to the need of mitigation of ferromagnetic steel and fabrication feasibility. The basic principle and key parameters are kept for TBM testing objectives. Hence, the study of associated systems for TBM can be simultaneously started from last year.

2. Preliminary design for ancillary systems

The preliminary design of CN HCCB TBS had been performed, which was focused on components investigation with domestic industrial companies. CN TBS is comprised of three major parts: (1) Helium Cooling System (HCS), which is dedicated for TBM heat removal. (2) Tritium Extraction System (TES), which is dedicated for Tritium extraction both from its independent lines and HCS. (3) Plant Instrumentation & Control System, which is connected to ITER I & C system, Central Interlock System, Central Safety System for monitor and control. Fig 1 shows the schematic view of CN HCCB TBS and the locations of all the components.

The HCS is adopted an “8” shape circuit \cite{1}, which could easily maintain the inlet helium temperature of compressor below 100°C and low thermal stress on pipes in TCWS vault. Larger scope selection and high efficiency for compressor can be obtained under the operation temperature mentioned above due to this design. The major components in HCS include compressor, heater, cooler, recuperator, dust filter, valves, and pipe lines. Most of these components are accommodated in TCWS vaults, a part of components are accommodated in Port Cell area for emergency control, such as valves, control elements.

As already mentioned previously, China HCCB TBM will be tested in Port number 2 with India TBM simultaneously. Each TBM and its associated ancillary systems are in charged by domestic parties, and interfaced with ITER buildings and systems. The most urgent activities at present are identification of interface data corresponding to systems of ITER and assessment of the arrangement in restricted space of Port Cell area and TCWS vault annex, which is prepared for ITER building construction contract. Thus, the arrangement of components of CN TBS in identified space was performed. The above TBS interfaces should be confirmed as early as possible, because it is important and urgent for some parts of ITER building design and