**Research Progress and Challenges for CFETR Fusion reator**

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To promote the development of fusion energy in China, there is ongoing research on the China Fusion Engineering Test Reactor (CFETR). As the next generation of fusion experimental facility in China, the physical and engineering design of the CFETR is currently being developed. In comparison, the ITER is still an experimental reactor and not for commercial purposes. The CFETR is proposed to bridge the gap between the ITER and commercial fusion power plants, and thus, the CFETR is a crucial complement of the ITER. The key challenges for the CFETR to achieve its aims are steady machine operation under a high duty factor. According to the latest CFETR parameters, it is larger in size and exhibits a higher toroidal field towards steady-state operation [1,2]. The gas load of the CFETR is higher than that of the ITER. Therefore, it can be said that control of the gas throughput is a critical factor that influences achievement of the scientific objectives of the CFETR.

The main objectives of CFETR are steady-state operation, full cycle of fusion power, and T fuel [1]. The CFETR aims to produce steady-state and self-sufficient burning plasmas with significant fusion power of ≥1 GW through the D–T reaction, high fusion gain, Q>10, a duty cycle of approximately 0.5, and a tritium breeding ratio (TBR) >1.0. Most of the heating power is provided by alpha particle heating with a fraction of approximately 80%. The overall scientific and technological goals of CFETR are to achieve self-sufficient fusion energy production, study fusion science, materials, and components, build up a nuclear database, and establish a nuclear safety and standard system for converter reactors. To accomplish these missions, a machine size has been defined as major/minor radius R = 7.2 m/a = 2.2 m with a toroidal magnetic field Bt = 6.5 T [1,2].

In the past several years, considerable progresses have been made in the CFETR design project. Over 30 institutes/universities/commercial companies in China have joined in the CFETR design, with more than 800 researchers. Primary engineering design, i.e. magnetic coils, vacuum chambers, cryogenic system, fuel cycle, blanket[3,4], remote handling[5], diagnostics, pumping and fuelling[6], plasma control, power supply, have been carried out for CFETR. Cooperation with the field of fission, energy conversion systems, waste technology, safety analysis and regulation has been discussed and embedded in the CFETR design. Specially knowledges in nuclear materials and nuclear protection have been transferred from fission field to fusion field.

To actually built CFETR, there are still many needs and challenges, especially higher field superconducting magnet, materials and equipment in a long-term nuclear environment, etc. In order to push the fusion energy research, Comprehensive Research Facility for Fusion Technology（CRAFT）, one of the national big science and technology facility in China, was approved for implementation. Its objectives are explore and master fusion DEMO level key technologies, establish the method and standard for manufacture the key material, components and system, building key prototype systems for CFETR, testing and validating the method, technology and system for a successful construction of CFETR. CRAFT consists 20 different facilities which address most of key technology and system of CFETR.

In a summary, to bridge the gap between the ITER and commercial fusion power plants, the CFETR is proposed and designed. Beyond ITER, there are some challenges should be addressed with the support of CRAFT and technology collaborated with fission field.

References

1. J. Li, G. Luo, R. Ding, et al., Plasma facing components for the Experimental Advanced Superconducting Tokamak and CFETR, Physica Scripta (2014) T159.
2. G. Zhuang, G.Q. L.i, J. Li, et al., Progress of the CFETR design, Nucl. Fusion 59 (2019).
3. S. L. Liu, L. Chen, X. B. Ma, et al. Design of the Water-Cooled Ceramic Breeder Blanket for CFETR, Fusion Eng.& Des. 177 (2022) 113059
4. K. Xu, M. Lei, S. Xu, et al. Preliminary design and analysis of the back supporting structure of CFETR QCCB blanket, Fusion Eng.& Des. 177 (2022) 113057
5. Y. Cheng, Y. Song, H. Wu, et al. Overview of the CFETR remote handling system and the development progress, Fusion Eng.& Des. 177 (2022) 113060
6. J.S. Hu, Z. Cao, G.Z. Zuo, et al. Progress of engineering design of CFETR vacuum systems, Fusion Eng.& Des. 177 (2022) 113058