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Updated design of the water cooled breeder blanket for CFETR

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The Chinese Fusion Engineering Testing Reactor (CFETR) will be operated in two phases. Phase I focuses on Pfusion=200 MW, Qplasma=1–5, TBR>1.0. Phase II emphasizes DEMO validation, which means Qplasma>10, Pfusion>1 GW (e.g., 1.5GW). CFETR has updated its core parameters in 2018. The major /minor radius have been changed from R=5.7m/a=1.8m to R=7.2m/a=2.2m. It is also required that one blanket design can cover operation of both phases of CFETR. However, fusion power in Phase II is 5~7.5 times larger than that in Phase I, which brings great challenges.

To meet CFETR Phase I and II operation conditions at the same time, a new water-cooled ceramic breeder (WCCB) blanket scheme is proposed in ASIPP, based on making trade-offs in the design considering TBR, tritium release temperature in breeder, and heat removal capability of coolant. The new scheme still employs the mixed breeder pebble bed of Li2TiO3 and Be12Ti, RAFM steel as structural material, and tungsten as armor material of the first wall. Pressurized water of 15.5MPa is chosen as coolant with 285oC inlet/325oC outlet. The unique feature of this design is that it has two independent cooling routes. When CFETR operates at the lower power for Phase-I, only coolant circulating system 1 is employed and coolant circulating system 2 is set idle with no feeding coolant. This can increase operation temperature of tritium breeder and consequently benefit the tritium release process. When CFETR operates at the higher power for Phase-II, both cooling systems are put into use to enhance the heat transfer of the coolant and ensure that the temperature of blanket materials stay lower than the allowable limits.

In this contribution, the updated WCCB blanket design is presented corresponding to the latest core parameters and requirements of CFETR. Its feasibility is evaluated and validated from the aspects of neutronics and thermo-hydraulics.

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