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Design Concept of K-DEMO In-Vessel Components

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As a way to realize a large-scale fusion energy, a DEMO device has been considered as a next step after the international ITER device. Pre-conceptual DEMO studies are being carried out by international fusion community including China, EU, Japan and Korea (with participation of US). Early in 2007 in Korea, Fusion Energy Development Promotion Law (FEDPL) was enacted to settle down the legal base of fusion energy development. As a following step, a pre-conceptual design study for the Korean fusion demonstration reactor (K-DEMO) has been initiated with the uniqueness of high magnetic field (B_0 = 7.4 T), R=6.8 m, a=2.1 m, and steady-state tokamak.
K-DEMO tokamak plasma will be operated in double-null configuration with high elongation (κ = 2) and triangularity (δ = 0.625). Pressurized water is used as coolant for in-vessel components.
Blanket modules are toroidally subdivided into 16 inboard modules and 32 outboard modules, in order to allow the vertical maintenance. Each blanket module consists of plasma-facing first wall, layers of breeding parts, shielding and manifolds. Vanadium is placed as interlaying material between tungsten first wall and RAFM structural material. K-DEMO blanket system adopts ceramic breeders using Li4SiO4 pebbles with beryllide as neutron multiplier to ensure better safety with water coolant. Layers of breeders and multipliers were optimized by MCNP simulations to achieve global TBR > 1.05. Material selection and thickness of shielding are optimized to maintain the nuclear heating to the superconducting magnets below allowables. Heat load on blanket first wall by core plasma radiation is maintained below ~0.5 MW/m2. Approximately 60% of plasma power is handled in divertor region. To maintain the target peak heat flux below 10 MW/m2, ~90% of divertor plasma power should be radiated in divertor region with 10degree of target tilting angle and a power decay length λq = ~1.5 mm as expected by recent result. Tungsten-based target is used with steel-based structural material carrying pressurized water coolant. In line with the blanket toroidal segmentation for vertical maintenance, upper and lower divertor modules are also subdivided into 32 toroidal modules, respectively.
The results of thermo-hydraulic and structural analyses are presented to support the developed design concepts.

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