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Two Conceptual Designs of Helical Fusion Reactor FFHR-d1A Based on ITER Technologies and Challenging Ideas

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The Fusion Engineering Research Project (FERP) in NIFS is conducting the conceptual design activity of the LHD-type helical fusion reactor FFHR-d1A. Recently, two options of "basic"and "challenging"have been newly defined. Conservative technologies including what will be demonstrated in ITER are chosen in the basic option, while new ideas that would possibly be beneficial for making the reactor design more attractive are boldly included in the challenging option, aiming at "early construction, easy maintenance and high thermal efficiency", in particular, for helical structure. In the basic option, the SC magnet coils adopt cable-in-conduit conductors with Nb3Sn strands cooled by supercritical helium at 4.5 K. The helical coils are wound by the "react and winding"method using a large-scale winding machine. The divertor system is the water-cooled tungsten monoblock divertor with cooling pipes made of Cu alloy. The blanket system is the water-cooled ceramic breeder blanket. The key technologies needed for the basic option are already well established in LHD or will be established through the R&D activities for ITER. However, we need to develop the maintenance schemes for these helical divertor and blanket with complicated 3D structures. In the challenging option, on the other hand, new technologies of the high-temperature superconductor (HTS), the liquid metal ergodic limiter/divertor, and the molten salt (FLiNaBe mixed with metal powders) breeder blanket are adopted. The "joint winding" based on the mechanical lap joint technique are applied to fabricate the helical coils by connecting segmented HTS conductors. The cooling scheme is simplified using helium gas at 20 K. A new liquid metal limiter/divertor has been proposed, where 10 units forming the molten tin shower jets stabilized by chains inside each jets are installed in the inboard side of the torus. Neutral particles are evacuated through the liquid metal shower. The blanket system using the metal powder mixed FLiNaBe is also the challenging option. The hydrogen solubility is effectively increased by adding powders of hydrogen storage metal such as Ti. Although the new technologies adopted in the challenging option can significantly ease the construction difficulties in the basic option, we have already started R&D arrangements to demonstrate them as fast as possible.

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