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Development of physics and engineering designs for Japan's DEMO concept

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Recent design progress of Japan's DEMO is presented regarding the engineering and physics conceptual design of a steady-state DEMO with a major radius of 8 m class and fusion power of 1.5 GW level. The design concept of divertor is similar to that of ITER. By considering the neutron irradiation environment, a Cu-alloy cooling pipe is used only in the large heat flux region, while a RAFM steel cooling pipe in the small heat flux region. The divertor cassette design is developed for reducing the fast neutron flux to protect the vacuum vessel and for replacement of the power exhaust units with the tungsten mono-block and Cu-alloy pipes. The breeding blanket concept based on JA ITER-TBM is developed to increase the pressure-tightness of the modules by considering safety assessment of in-box LOCA. Regarding the TF coil design, assessment of the error field indicates that the tolerance can be mitigated by ~2.5 times as large as ITER's with correction coil current of several 100 kAT/coil. The concept of remote maintenance for the blanket segments is developed such as the stable transfer mechanism in the vertical, radial and toroidal directions. The rad-wastes generated by the maintenance can be desposed of in shallow land burial after 10-year storage. The concept of primary cooling water system is developed for effective use of thermal power removed from not only blanket but also divertor, where thermal power removed from the divertor is used for preheating the blanket coolant, and a bypass line is installed to control the coolant flow for reducing the pressure drop. As for the physics design, one of the major issues is the compatibility between the operational density and the divertor detachment. The evaluation of the lower boundary of operational density to be compatible with the capability of the heat removal and suppression of tungsten erosion indicates that the partial detachment with the acceptable peak heat load is obtained at the operational density, and that the net erosion is almost suppressed. Furthermore, plasma operation scenario is developed and indicates the importance of off-axis ECCD for controlling the internal transport barriers. It is concluded that the DEMO concept considerably mitigates power handling issues compared with the previous compact DEMO, SlimCS, although some challenging design issues remain to be resolved.

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