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Importance of divertor physics modeling in system design of LHD-type helical reactor

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Helical systems inherently have a suitable feature as a future fusion power plant in terms of steady state operation because of no need of the plasma current drive. Among several configurations, conceptual design study of the LHD-type helical fusion reactor has been conducted and the design of the commercial scale power plant FFHR-d1, which can be operated with a fusion power of 3 GW, has been proposed.
Because there is a gap between the present knowledge and the requirements on future power plants in terms of both plasma physics and fusion engineering, the design parameters of the future fusion power plant will be changed by reflecting the latest knowledge from the plasma physics and engineering researches. Construction and operation of one or more intermediate machines are desired to ensure steady progress to the commercial power plant. In this respect, parametric scans of design parameters using a systems code are still important. On the other hand, calculation model of SOL and divertor plasma has not been implemented in the systems code for the LHD-type helical reactors. Because present LHD-type reactor design is a simple scale-up of the LHD, magnetic field line structure is also scaled by the reactor size. Assuming strong correlation between the divertor magnetic field structure and the divertor heat load distribution, the divertor heat load of LHD-type helical reactor is estimated from the total power to the SOL region and the divertor wetted area scaled from LHD. In the case of FFHR-d1 with a major radius of 15.6 m (4 times larger than LHD), the total divertor wetted area is estimated to be $\sim$32 m^2 from that of LHD ($\sim$2 m^2). The total power to the SOL region is estimated to be $\sim$550 MW considering the Bremsstrahlung loss of ˜50 MW. Then average divertor heat load becomes $\sim$10 MW/m^2 assuming the 30% radiation cooling in the SOL region, which is not so difficult to achieve. However, divertor heat load has a strong inhomogeneity in the toroidal direction and local heat load can be several times higher than the average value, which cannot be accommodated by the conventional tungsten divertor. Then radiation cooling in SOL region and divertor detachment play an important role, and the modeling of these condition which is related to the design parameters handled in the systems code is required for the design window analysis by parametric scans of wide-ranged multiple design parameters.
In the presentation, the latest status of the systems code and system design of LHD-type helical reactor will be reviewed and preferred modeling from the view point of system design will be discussed.

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