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FTP/P7-37: Divertor Heat Flux Reduction by Resonant Magnetic Perturbations in the LHD-Type Helical DEMO Reactor

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The conceptual design studies of the LHD-type helical fusion DEMO reactor, FFHR-d1, are progressing steadfastly. The LHD-type heliotron magnetic configuration equipped with the built-in helical divertors has a potential to realize low divertor heat flux in spatial average. However, the toroidal asymmetry may give more than a couple of times higher peak heat flux at some locations, as has been experimentally observed in LHD and confirmed by magnetic field-line tracing. By providing radiation dispersion accompanied with a plasma detachment, the heat flux may decrease significantly though the compatibility with a good core plasma confinement is an important issue to be explored. Whereas the engineering difficulties for developing materials to be used under the neutron environment require even further decrease of the heat flux (even though the heliotron is a unique configuration that divertor plates be largely shielded from the direct irradiation of neutrons by breeder blankets). In this respect, we proposed, in the last IAEA FEC, a new strike point sweeping scheme using a set of auxiliary helical coils, termed helical divertor (HD) coils. The HD coils carrying a few percent of the current amplitude of the main helical coils sweep the divertor strike points without altering the core plasma. Though this scheme is effective in dispersing the heat flux in the poloidal direction, the toroidal asymmetry still remains. The AC operation may also give unforeseen engineering difficulties. We here propose that the peak heat flux be mitigated using RMP fields in steady-state. The magnetic field-lines are numerically traced in the vacuum configuration and their footprints coming to the divertor regions are counted. Their fraction plotted as a function of the toroidal angle indicates that the peak heat flux be mitigated to ~20 MW per square meters at 3 GW fusion power generation without having radiation dispersion when an RMP field is applied. We note that the magnetic surfaces at the core region are not significantly affected by the RMP field. The poloidal sweeping by HD coils (with quasi-steady-state AC operation) should mitigate the erosion of divertor plates. We propose that these coils be fabricated using YBCO high-temperature superconductors operated at >20 K.

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