§10. Divertor Configuration Study of LHD and FFHR

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For realizing stable operation with high performance core plasmas in magnetic fusion devices, the divertor should provide the following functions : a) high neutral compression in the divertor plenum for obtaining good pumping efficiency and for reducing impurity release from the first wall by sputtering by charge-exchanged neutrals, b) mitigation of the power load on the divertor plate to protect the material from melting and thus to reduce impurity release and c) impurity retention to protect the core plasma from impurity contamination.

The divertor performance of LHD was studied for the LID[1] and HD[2] configurations. It is shown that both divertor configurations play an important role for obtaining high performance plasmas in LHD : the large pumping capability of the LID to keep the low edge plasma density in the IDB-SDC plasma[3], the large wetted area and the flexibility of strike point sweep of the HD to reduce power load on the divertor plates in long pulse operations[4]. It is found that, however, for the future upgrade of LHD, they still need improvements on their divertor functions, i.e. improvement of power load dispersal in LID and of pumping efficiency in HD, respectively. The impurity retention capability has been investigated using the 3D modelling. The results indicate the possibility of impurity flushing by the drag force of the plasma flow in the ergodic layer at reasonably high density. It still needs experimental confirmation.

The LHD-type heliotron power reactor, Force Free Helical Reactor (FFHR) has been proposed[5], with the design concept being based on the physical and engineering developments in LHD. The major and averaged minor radius of the plasma are 14.0 and 1.73 m, respectively[6]. The power conducted to the edge region will be ~ 300 MW with the upstream density (around LCFS) of ~ 1×10^{20} m^{-3}. In order to predict the plasma transport characteristics in the divertor region, the 3D edge transport has been applied to the configuration. The magnetic field structure and the divertor position at the horizontally elongated section, are shown in Fig. 1.

The divertor is located around the outer separatrix of m = 10 magnetic islands. The divertor rotates with the helical coil windings but is situated only at the inboard side. There is a short connection length region with L_C ~ 10 m outside of the islands, and this region will mainly serve as SOL to divert the plasma to the divertor. Indeed, the 3D computations show that ~ 95 % of plasma particles and heat are diverted to the divertor plate. The obtained T_e profile is plotted in Fig. 2, where the upstream (LCFS) temperature is ~ 400 eV and the pattern follows the island structure of m = 10. In such a high temperature and density, the neutral screening is very effective even in the open structure of the divertor and thus ~ 99% of recycling neutrals are ionized outside the LCFS. The position and the shape of the divertor will be checked in the following assessment, taking into account the power load onto the plates, pumping efficiency and the impurity retention.

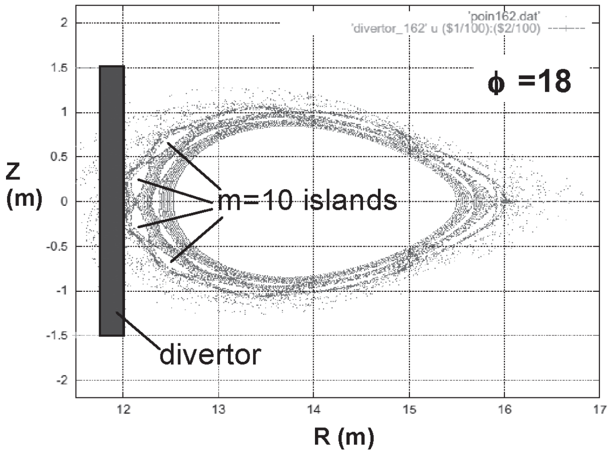

Fig. 1. Divertor configuration of FFHR at the horizontally elongated section.

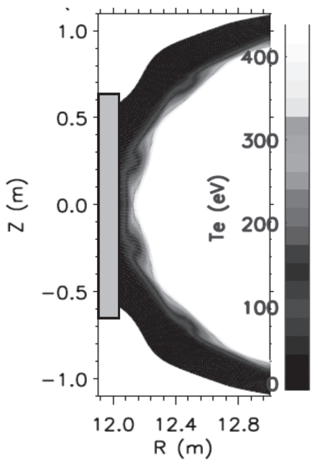

Fig. 2. T_e profile around divertor at the horizontally elongated section, obtained by the 3D modelling.

Reference

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