§13. Estimation of the Divertor Wetted Area in the FFHR-d1

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The estimation of the divertor wetted area in the FFHR-d1 was conducted by using the magnetic field line tracing calculation. The estimation of the wetted area is necessary for the design of the divertor components. This estimation is based on the understandings obtained in the LHD experiments.

In the helical divertor configuration with which is naturally equipped in heliotron-type devices, the magnetic field line structure in the open field lines region outside the last closed flux surface is complicated. In the region, there are the stochastic layer, remnant magnetic island chain, the edge surface layer and the laminar layer. The magnetic field line structure in the divertor legs consists of the edge surface layer and the laminar layer as shown in Fig. 1. In the former layer, the connection lengths of the field lines are longer than 1000 m in the LHD case. On the other hand, they are much shorter in the laminar layer. In the LHD experiments, the divertor particle and heat fluxes profiles have been measured by the Langmuir probe arrays embedded in the divertor plates. The profiles are strongly related to the profile of the connection length of magnetic field lines (L_c) as shown in Fig. 1. The width of the particle and heat fluxes profiles can be estimated by the width of the L_c profiles with the definition of the L_c threshold. For example, in the case of Rax3.9m in Fig. 1, the width of the particle flux profile is about 10mm if the L_c threshold is defined to be 10m. The wetted area can be roughly estimated by the integration of the L_c profile width along the helical direction.

The magnetic field lines tracing was conducted for the open field lines region in FFHR-d1, and the wetted area was estimated. Figure 2 shows the summary of the estimation. The wetted area changes 1 order of magnitude with the L_c threshold. If the threshold is 20 m, the area is 1000m^2. If the threshold is 60m, the area is 100m^2. Figure 3 shows the calculated wetted region on the divertor with the L_c threshold of 20, 30, 50 and 60m. The region becomes small with the threshold becomes long. In this calculation, the number of the tracing field lines was possibly not enough to estimate the wetted area for the large L_c threshold.

The averaged divertor heat flux in the FFHR-d1 can be estimated using the wetted area. If the power to the open field lines is 500 MW, the averaged divertor heat flux is around 10 MW/m^2 with the L_c threshold of 100m. That means the peak heat flux can be several 10 MW/m^2. Thus the heat load reduction operation such as the radiative divertor and the divertor detachment have to be considered for the design of the divertor in the FFHR-d1.

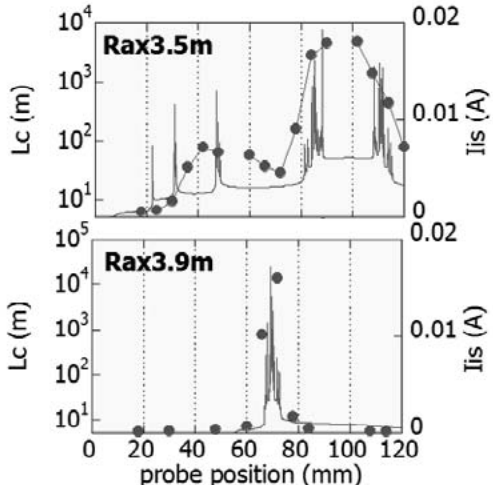

Fig. 1. Connection length (Lc) and ion saturation (Iis) current profiles on a divertor plate in LHD

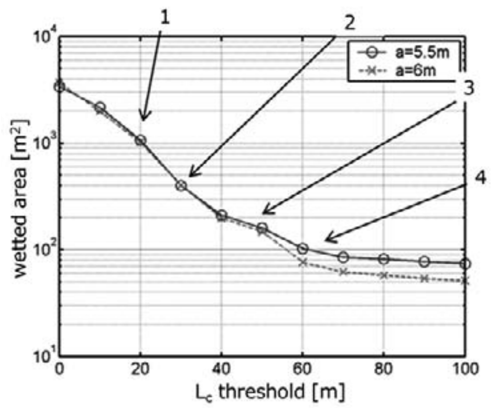

Fig. 2. Estimated wetted area in FFHR-d1 as a function of the L_c threshold. The radial position of the divertor is "a".

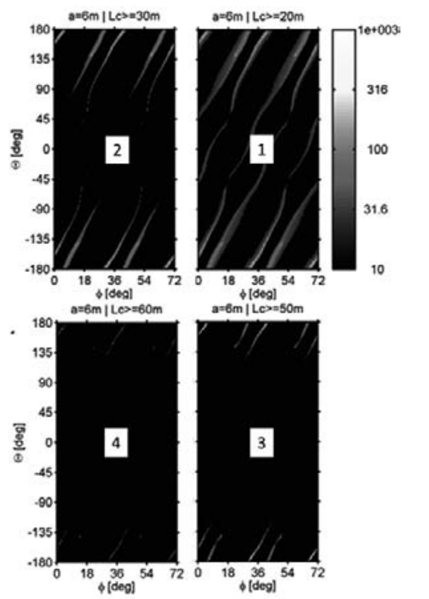

Fig. 3. The wetted region on the divertor for different L_c threshold cases. The numbers of 1-4 corresponds to the number in Fig. 2.