§17. Core-SOL-Divertor Model Based on JT-60U Recycling Database and Application to EAST Operation Space

Hiwatari, R. (CRIEPI), Hatayama, A. (Keio Univ.), Takizuka, T. (JAEA), Zhu, S. (ASIPP), Tomita, Y.

The transport models applied to Core-SOL-Divertor (C-S-D) model are a 0D core plasma model based on ITER physics guidelines and a usual two-point model for SOL-divertor region. The key issue of this C-S-D model is how to combine the two-point model with the 0D core plasma model. In the C-S-D model, the particle balance for SOL-divertor region including the neutral transport is solved to evaluate the upstream SOL density n_s. The detail of C-S-D model was shown in the previous report[1]. We assume that all neutral particles originate at the divertor plate at the rate proportional to the total particle flux to the divertor plate. Consequently, total neutral source rate at the edge region is as follows:

$$N_n = C_n \frac{1}{2}\left(1-\frac{1}{e^2}\right) n_d M_d C_s 2\pi R \Delta_n \sin(\psi) + N_{puff} \qquad (1)$$

where Δ_n is the density decay length and ψ is the angle of the magnetic field to the divertor plate. The coefficient C_n is a calibration factor.

To calibrate the factor C_n, the JT-60U divertor recycling database[2] was utilized. The total ion flux on the plate and the total neutral flux from the divertor region are the key parameters in this simple neutral model, and their values were compared between the C-S-D model (P_{NBI}=0.5~4.0MW, B_t=4T) and database (P_{NBI}=1~12MW, B_t=2~4T). The result from C-S-D model with C_n=1 is quantitatively consistent with database, and it also reproduces the nonlinearity of total ion flux against the plasma density (Fig.1). It was found that C_n=0.5 is preferable for a better agreement with the database. The comparison of the total neutral flux is shown in Fig. 2, where C_n=0.5 is chosen. Comparison with B2-EIRENE was carried out on the JT-60U plasma configuration (Fig.3), and it is shown that the calibration with the database (C_n=0.5) improved the agreement for the high recycling regime in comparison with the previous result[1].

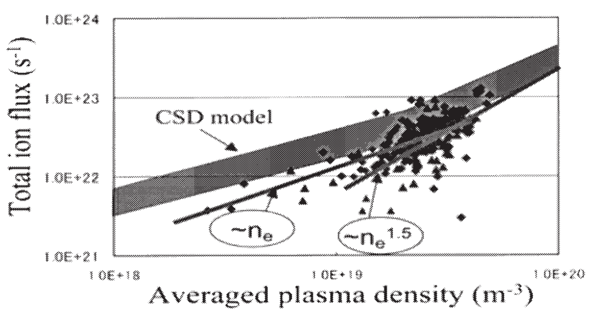

Fig.1 Total ion flux to divertor plates: C-S-D model (shaded region) and JT-60U recycling database[2] (dots).

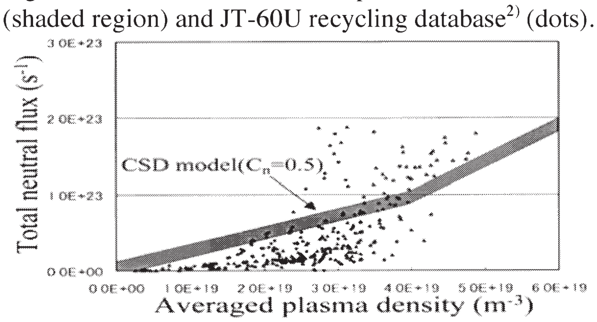

Fig. 2 Total neutral flux from divertor region.

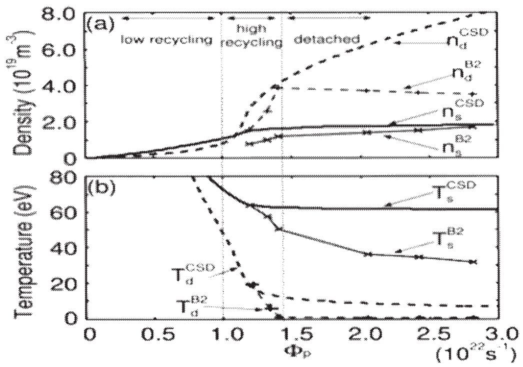

Fig.3 SOL-divertor parameters, (a) density and (b) temperature, v.s. particle flux from core plasma Φ_p, obtained by the C-S-D model and the B2-EIRENE.

By using this C-S-D model, we explore the possible operation space of EAST in the space of the total particle flux Φ_p and the total heat flux Q_{in} across the separatrix. The operational space is demonstrated in Fig. 4[3], and each boundary is the operation condition as for (1) max. heat load to the divertor q_{div}<3.5MW/m^2, (2) LH transition condition Q_{in}>P_{thr}, (3) available LHCD power P_{LHCD}<3.5MW, and (4) power balance condition P_{LHCD}<Q_{in}. The upper boundary of Q_{in} is limited to 3.0~3.5MW by q_{div}<3.5MW/m^2. The boundary of q_{div}<3.5MW/m^2 for Q_{in}<3.0MW region implies the low recycling state. The upper boundary of the particle flux Φ_p is dominated by the power balance requirement for the low Q_{in} region, while it is limited by the available LHCD power for higher Q_{in}. In other words, the available power for the LHCD tends to be a key parameter to extend the operation density of the core plasma in this high Q_{in} regime.

This work was partly supported by JSPS-CAS Core-University Program on Plasma and Nuclear Fusion, and was also carried out as the joint research using nuclear fusion research facilities of JAEA.

Reference

1) Hiwatari, R. et al., Annual report of NIFS Apr.2004-Mar.2005, p344, (2005)
2) Takizuka,T. et al., "Development of Database for the Divertor Recycling in JT-60U and Its Analysis" JAERI-Research 2003-010 (2003) (in Japanese)
3) Hiwatari, R. et al., Plasma Science and Technology 8, p114, (2006)

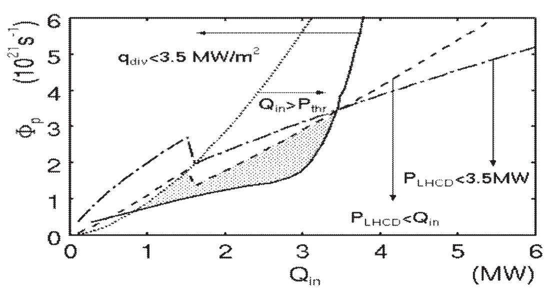

Fig. 4 Qualitative features of EAST operational space.