§2. Strike Point Distribution in a Closed Helical Divertor Configuration Optimized for Efficient Particle Pumping in LHD

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The control of the peripheral plasma density has been recognized to be essential for sustaining the internal diffusion barrier (IDB) and for enhancing the plasma confinement property in LHD. For efficient particle pumping in the plasma periphery, a closed helical divertor configuration (CHD) is planned. A H_α emission detector array with polarization separation optics indicates that the neutral particle density is relatively high in the inboard side of the torus for R_{ax}=3.60m in which good energy confinement has been achieved. It suggests that installation of CHD components in the inboard side is preferable to the efficient particle pumping.

Neutral particle transport calculations using a three-dimensional simulation code (EIRENE) with a one-dimensional plasma fluid analysis (volume sources by plasma recombination are included) proposed a possible candidate of the CHD which consists of divertor plates (baffle plates), a dome and target plates in the inboard side along the space between two helical coils. The simulation predicts that the pressure of the neutral hydrogen molecules behind the dome is enhanced up to more than the order of 0.1Pa, which is enough for the efficient particle removal for vacuum pumping systems installed behind the dome.

We designed a more realistic CHD configuration which includes supporting structures of the divertor plates, heat sinks, gaps of the divertor plates and cooling pipes, etc. Figure 1 gives a three-dimensional simplified model of the realistic CHD configuration in one toroidal pitch ($0°<\phi<36°$). The CHD in this model are represented as chains of totally 122 carbon plates. For the first step to check the CHD potential, the distribution of strike points is calculated by magnetic field line tracing from the LCFS including a diffusion effect in various magnetic configurations. Small colored dots in Figure 1 (a), (b) and (c) represent the strike point distribution in various radial positions of the magnetic axis (R_{ax}), coil pitch parameters (γ) and a quadruple magnetic components (B_q), respectively. While the strike points in various R_{ax} cases almost locate on the divertor plates, the strike points in low γ case deviated from the divertor plates. Most of the positions of the strike points for extremely low and high B_q are not on the divertor plates.

Figure 2 is histograms showing the ratios of the number of the strike points on the divertor plates to the total number of the strike points in various magnetic configurations (white bars). The ratios of the number on CHD components in the inboard side are also indicated (gray bars). It can be an indicator for the particle pumping efficiency because the peripheral plasma is neutralized at the strike points and pumping out in the CHD region. The histograms show that:

1. The ratio of the strike points on the CHD components reaches to about 0.7 for low R_{ax} (<3.65m), and it gradually decreases in R_{ax},
2. In low γ cases, most of the strike points on the divertor plates are concentrated on the CHD components,
3. The ratio of the strike points on the CHD components becomes high (0.8) in a range ($67\%<B_q<100\%$).

It indicates that the CHD configuration will fully demonstrate the function in a range of the magnetic configuration that R_{ax}<3.65m, γ~1.254 and $67\%<B_q<100\%$.

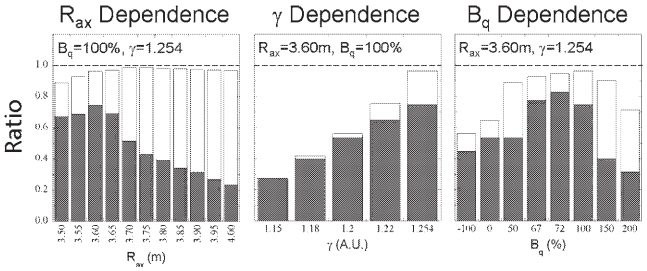

Fig. 2. The ratios of the number of the strike points on the divertor plates (white bars) and on the closed divertor components (gray bars) to the total number of the strike points in various magnetic configurations.

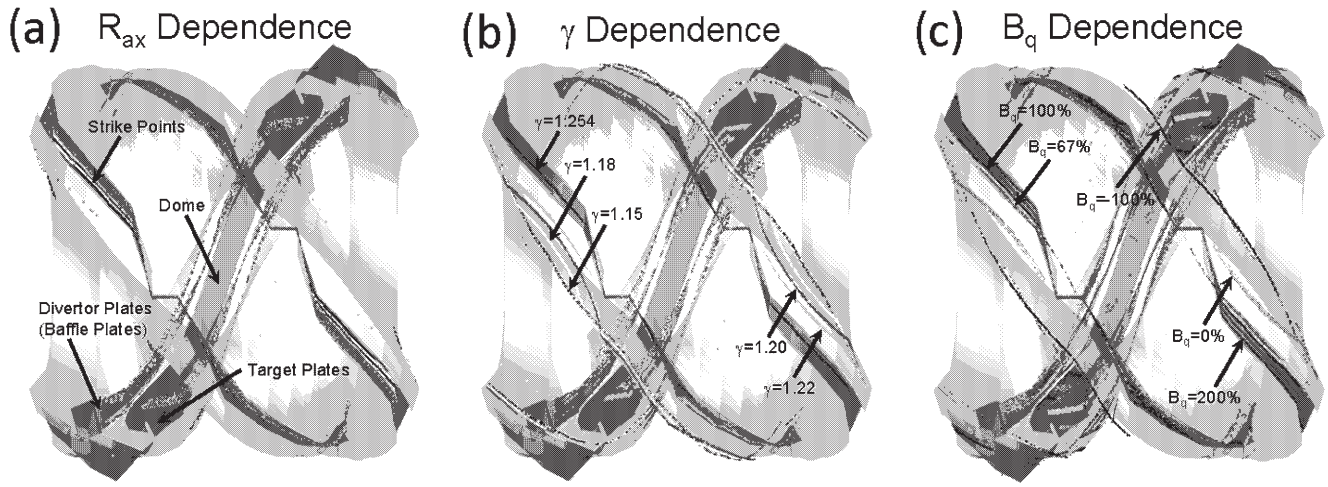

Fig. 1. The distribution of the strike points in the three-dimensional simplified realistic model of the closed helical divertor configuration in various R_{ax} (a), γ (b) and B_q (c) cases.