§2. Measurements of H-alpha Emission Profile in the Closed Helical Divertor Region in LHD

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Two test modules of the closed helical divertor (CHD) components were installed in the inboard side of the torus in the last experimental campaign (14th cycle) for verifying the performance of enhancement of the neutral particle density in the divertor region. The CHD consists of slanted divertor plates, a dome structure and target plates which are designed to enhance the neutral particle density behind the dome and to suppress the neutral particle density around the ergodic layer in the LHD plasma periphery. Fast ion gauges installed in a CHD region (9-I) and an open divertor region (6-I) clearly demonstrated that neutral particle density in the inboard side in the CHD region is higher than that in the open divertor region by more than one-order of magnitude, as predicted as an analysis using a three-dimensional neutral particle transport simulation.[1)]

One of the objects of the CHD is active control of the neutral particles in the divertor region and the plasma periphery. For preliminary analysis of neutral particle transport in the CHD region (9-I), an H-alpha filtered CCD camera (Toshiba, IK-UM44H and IK-CU44) was installed in an outer port (9-O). Figure 1(a) is a CAD (Computer Aided Design) image of the CHD components viewed from the position of the CCD camera, which shows the geometrical position of the CHD components installed in the space between two helical coil cans in the inboard side. The camera can monitor the transport of neutral particles (H_2 and H) in the inboard side of the torus around the CHD region.

Figure 1(b) shows an image of the intensity of H-alpha emission observed with the CCD camera in a plasma discharge in the case where the radial position of the magnetic axis R_{ax} is 3.60m and the plasma density n_e is ~9×10^{19}m^{-3}. This figure indicates that H-alpha emission is locally high near the strike points on the surface of the slanted divertor plates. It also shows that no observable H-alpha emission along the X-points in the inboard (around the top of the dome structure). These measurements clearly suggest that the CHD components are effective for confining neutral particles near the divertor plates locally and for reducing neutral particles at the X-points and around the ergodic layer for this magnetic configuration (R_{ax}=3.60m). It can contribute to active control of the peripheral plasma density.

Figure 1(c) gives the measurement of the image of the intensity of H-alpha emission for R_{ax}=3.75m (n_e~8×10^{19}m^{-3}). The emission at the strike points on the divertor plates is unclear compared to that for R_{ax}=3.60m. No observable suppression of the H-alpha emission along the X-points was observed in this magnetic configuration. Figure 1(d) shows the measurement of the image of H-alpha emission for R_{ax}=3.90m (n_e~1×10^{20}m^{-3}), which indicates no clear H-alpha emission at the strike points and no observable suppression of the H-alpha emission along the X-points in the inboard side. These measurements qualitatively mean that neutral particles are not locally confined near the divertor plates in the CHD region for R_{ax}=3.75m and 3.90m.

The significant difference of the measured image of the H-alpha emission in the CHD region depending on the parameter R_{ax} can be explained by the difference of the structure of the divertor plasma in LHD. Experimental results measured with a Langmuir probe array embedded in a divertor plate installed in the inboard side demonstrate that the plasma density and the ion-saturation current on the divertor plate are strongly dependent on the R_{ax}. It shows that the plasma density and the ion-saturation current significantly decrease with the R_{ax}. Neutral particles released from the divertor plates can penetrate the plasma on the divertor legs and reach to the X-points because of the low density and thin structured plasma on the divertor legs for the latter two magnetic configurations (R_{ax}=3.75m and 3.90m). It suggests that the CHD can fully demonstrate the potential for controlling the neutral particle density in the divertor region and in the plasma periphery for R_{ax}=3.60m.

The explanation for the difference of the image of the H-alpha emission in the CHD region which strongly depends on the radial position of the magnetic axis R_{ax} will be fully investigated using a three-dimensional neutral particle transport simulation code with detailed measurements of the plasma parameters on the divertor legs in the near future.

1) Shoji, M. et al.: J. Nucl. Mater. **390-391** (2009) 490.

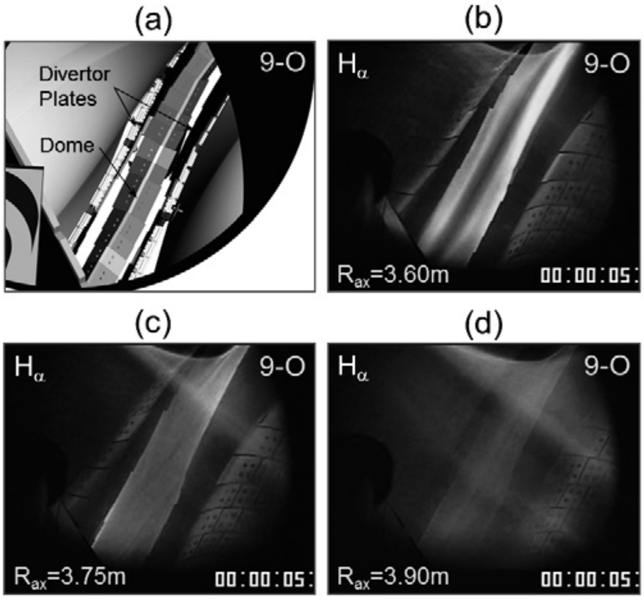

Fig. 1 A CAD image of the CHD configuration installed in an inboard side of the torus (9-I) viewed from an outer port (9-O) (a), a measurement of the image of the intensity of H-alpha emission observed with a filtered CCD camera which is installed in an outer port (9-O) for R_{ax}=3.60m, 3.75m and 3.90m, respectively (b), (c) and (d).