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The ion cyclotron range of frequencies (ICRF) heating in LHD is investigated using three-dimensional full code. The full wave code, TASK/WM, was developed by Vdovin\(^{1}\) and Fukuyama\(^{2}\). The wave equation is solved assuming the finite Larmor radius effect. Thus, the ion cyclotron damping and the Landau damping are included but the mode-converted ion Bernstein wave is not described. The plasma configuration is given by the MHD equilibrium code, VMEC. The calculation is carried out on the non-orthogonal flux coordinates \((\psi, \theta, \varphi)\), \(\psi\) is the minor radius direction, \(\theta\) is the poloidal direction, and \(\varphi\) is the toroidal direction. The number of mesh of \((\psi, \theta, \varphi)\) is 200, 16, and 4, respectively.

Figure 1 shows the dependence of absorbed power on the position of the ion cyclotron resonance layer. In this calculation, the central electron density and temperature are \(1\times10^{19}\) m\(^{-3}\) and 2 keV. The helium plasma with 10% of hydrogen ion is assumed. The absorption by the hydrogen ion is very strong. Most of absorption is generated by the hydrogen ion if the ion cyclotron resonance layer of hydrogen exists in the plasma. The ion cyclotron resonance layer is located at the saddle-point of the magnetic field at the 2.75 tesla. This case is standard for the ICRF heating and the best heating result are obtained in the experiment. In the calculation, the larger hydrogen absorption is observed around 2.6 tesla. In this case, the ion cyclotron resonance layer is located near the plasma center. We compared the radial absorption profile at the four toroidal angles.

Figure 2 shows the power absorption profile along the normalized plasma minor radius at the four different toroidal angles. The main absorption is conducted by the hydrogen ions. The power absorption mainly occurs at the toroidal angle of \(\varphi=0^\circ\), where the ICRF antenna is located. In this case, it looks like that the optimization of the heating is attained only at \(\varphi=0^\circ\). Figure 3 shows the power absorption profile at 2.6 tesla, where the hydrogen absorption is peaked in the calculation. The power is absorbed at all toroidal angles and it is quite different from the saddle-point heating case. The wave power that is not absorbed near the ICRF antenna can be absorbed at the different toroidal angles. The difference of the power absorption in the toroidal direction may affect on the property of the total hydrogen absorption.

Fig.1. Dependence of power absorption on the magnetic field strength, i.e., the position of the ion cyclotron resonance layer.

Fig.2. Power deposition profile as a function of the normalized plasma radius in the case of the saddle-point heating. Lines are same as Fig.1.

Fig.3. Power deposition profile as a function of the normalized plasma radius in the case of the best heating in the calculation. Lines are same as Fig.1.

References