Evaluation of ICRF Heating Characteristics in the Large Helical Device

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In the steady state operation in Large Helical Device (LHD) experiments, ion cyclotron range of frequencies (ICRF) minority ion heating is used for sustaining the plasma. We achieved a long pulse up to 48 minutes in the electron density of more than $1\text{x}10^{19}$ m^{-3}[1]. In the long pulse discharges of more than several tens of minutes, the uncontrollable gas fueling or large impurity flake from the heated wall or divertor extinguished the plasma. In order to avoid the local heat load near the ICRF antennas, it is important to inject the ICRF heating power not to the peripheral region but to the plasma core region and thus average the heat load on the divertor.

Minority ion heating was adopted in helium majority and hydrogen minority in the LHD. In the ICRF minority ion heating, the efficiency strongly depends on the minority ion ratio. The heating efficiency also depends upon the resonance layer, plasma loading, plasma parameter, and antenna shape such as with/without faraday shield (FS) because these parameters change the fast ion tail, the absorption layer and/or heating power to peripheral region. We summarized heating efficiency of ICRF minority ion heating in terms of minority ion ratio, electron density and temperature, magnetic field strength, ICRF phase, and plasma-antenna distance in the short pulse (less than 10 sec) and in the middle pulse (approximately 40 sec) discharges. As a results of these investigation, heating efficiency increased more than 90% by changing the minority ion ratio. In the case without FS, there was no significant difference of heating efficiency when the gap between plasma and antenna was small. On the other hand, when the gap between plasma and antenna was large, the heating efficiency decreased than other antennas with FS.

[1] H. Kasahara *et al*., Proc. of 25th IAEA fusion energy conference, EX /7-3 (2014)