§5. Evaluation of ICRF Heating Characteristics in the LHD

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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 $1x10^{19}$ 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. In this study, the ICRF heating efficiency was calculated by the modulated plasma stored energy during the ICRF power modulation under the conditions of the LHD long pulse operation.

As the results of the ICRF heating efficiency measurement, the heating efficiency found to be strongly depends on the minority ratio (shown in Fig. 1) and antenna current phase (shown in Fig. 2). These results are measured in the long pulse discharges more than 30 seconds in order to adopt to the steady-state condition and increase the heating efficiency during the steady-state operation. As the suggestion for the current LHD steady-state operation, under the condition of minority ratio less than 0.15, the higher minority ratio is better for the heating efficiency and the antenna current phase should be chosen carefully for good heating efficiency. As the future works for the next LHD experimental campaign, the minority ratio monitor and control system should be developed. The physical reasons of the difference between the toroidal and poloidal array antenna also should be considered.

1) Kasahara, H.: Proc. of 25th IAEA fusion energy conference, EX /7-3 (2014)

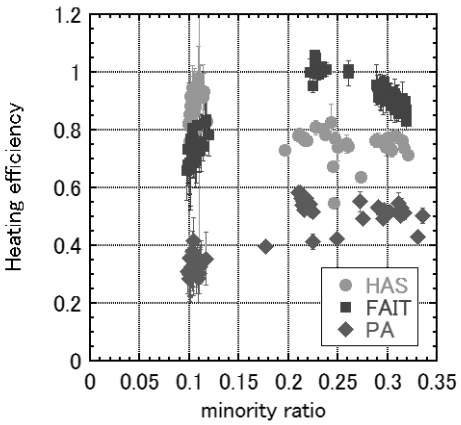

Fig. 1. Heating efficiency in various minority ratio. Toroidal array antenna (HAS) and Poroidal array antenna (FAIT and PA) has different tendency.

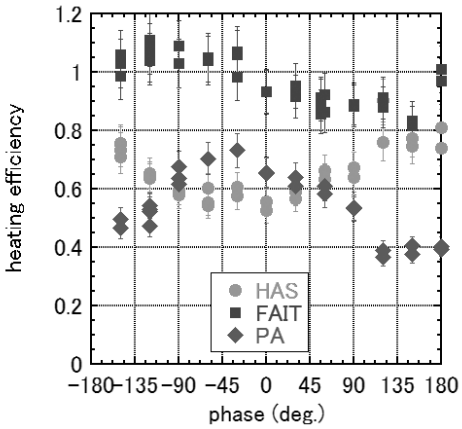

Fig. 2. Heating efficiency in various antenna current phase measured in the 40 seconds discharges with minority ratio of 0.25-0.3. The heating efficiency strongly depends on the antenna current phase.