§ 49. Assessment of Heat Load on Divertor Plates

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In the previous section it was found that the local temperature increase in the inboard-side divertor plates almost up to 400°C was experimentally observed. The thermo-couple is installed to 90 plates among 1,700 divertor plates aligned along the helical divertor traces. The measured point is 10mm beneath the surface of the divertor plate [1]. The large temperature increase is observed at the inboard divertor plates in both the heating methods, i.e., the neutral beam (NBI) heating and the ICRF heating. An asymmetry of the temperature increase in the divertor plates is observed in the toroidal direction as shown in Fig.1. In this figure the temperature distribution of another long pulse plasma discharge (the duration time of 127s, #26195, the ICRF heating power, P_{ICH}~0.4MW, the electron density n_e~$8x10^{18}m^{-3}$) is also plotted with that in this 150s long pulse discharge (#36194, P_{ICH}~0.5MW, the electron density n_e=5~$6x10^{18}m^{-3}$). In both plasma discharges the uncontrollable density increase prevented the discharge from continuing the steady state discharge. It is found that the temperature increase is remarkable in 2-I and 3I divertor plates; here it should be noted that the ICRF heating antenna is located at the vacuum ports of 3.5U&L.

The long pulse plasma discharge was carried out in the best heating mode of the ICRF heating: This is the case of R_{ax}=3.6m, B=2.75T. The cyclotron resonance layers are separately located on the saddle points in the mod B surface. In this magnetic configuration the behavior of high-energy ions started at the cyclotron resonance layer is examined using the full orbit calculation [2]. Two thousands high-energy ions with its energy of 100keV are started from the upper and the lower ion cyclotron resonance layers just inside of the last closed magnetic surface, respectively. The starting position ranges from R=4.14m (ρ=1.05) to of R=4.17m (ρ=1.1) with their pitch angles from 45° to 135 °. Many the high energy-ions hit the divertor plates within several circulations along the toroidal direction. The numbers of high-energy ions hitting at each ten divertor plates of the inboard side are plotted in Fig.2 to compare the measured temperature increase as shown in Fig.1. It is found that the loss ions flow dominantly to 2-I and 3-I as shown in Fig.2. Here loss particle numbers are counted separately i.e., for started from the upper ion cyclotron layer (open circles) and the lower ion cyclotron layer (open squares). There is a difference in the numbers of loss ion between the upper and the lower ion cyclotron resonances. The temperature increase in 2-I will be larger in using the upper ICRF heating antenna. The total count is largest in 2-I using both antennas. When comparing these data with the experimentally measured temperature increase and this tendency agree with data of #26195, in which the plasma was sustained only by the upper ICRF heating antenna. However in 36194 the maximum temperature was observed in 3-I, which disagrees with the calculation result. If the ICRF heating power radiated from the lower antenna is three times larger than that from the upper one, the temperature increase could have been interpreted. It is not known that there is a disagreement between the experimental date on #36194 and the calculated high-energy ion loss. However the mitigation of the divertor heat load will be tried by changing the location of the ion cyclotron layer, because the high energy-ions started from the inboard layer calculated to equally scattered on the divertor plates.

It is not assure what is the cause of the Hα signal increase and the uncontrollable electron density increase, which was described in the previous section. However the local temperature increase in the 2-I and 3-I divertor plates is considered to be a feasible candidate of the uncontrollable density increase. We are installing a graphite sheet having a good heat conductance between the divertor plates and the heat sink made of copper [3].

References
[1] Masuzaki, S., et. al., Nuclear Fusion, 42(2002)740.
[2] Watanabe, T., in Japanese, J. Plasma Fusion Res., **34** (1998) 267.
[3] Kubota, Y., private communication.

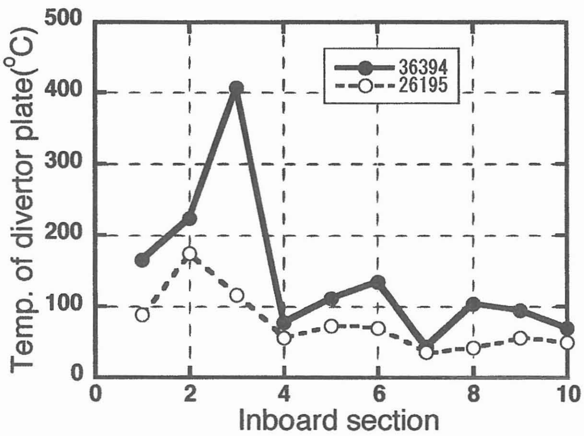

Fig.1 Toroidal distribution of the graphite temperature of the inboard side divertor plates.

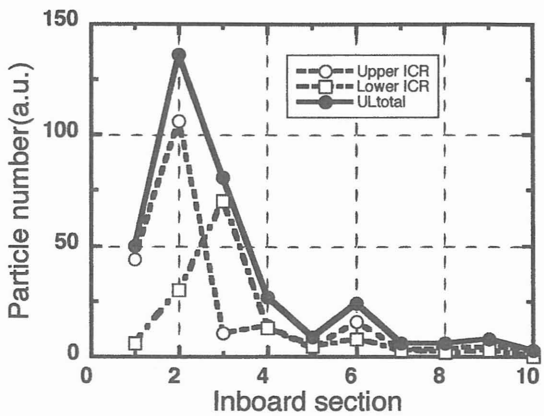

Fig.2 Counts number of high-energy ions hitting divertor plates calculating an orbit of ions started from the cyclotron resonance layer near the last closed magnetic surface.