Contribution ID: **518** Type: **Poster**

The effect of electron cyclotron heating on thermal and fast-ions transport in high beta-poloidal discharges at KSTAR

Friday 26 October 2018 08:30 (4 hours)

For the realization of the fusion reactor, solving issues for high beta steady-state operation is one of the essential research topics for the present superconducting tokamaks and as a candidate of steady-state scenarios, characteristics of, so called, 'high beta-poloidal'discharges[1] is analyzed in depth for the capability of fully non-inductive operation with high bootstrap current fraction. Through the scans of plasma current (Ip ~ 0.4-0.6 MA), toroidal field (BT ~ 1.8-2.7 MA), additional heating (PNBI+ECH ~ 3-5 MW), and plasma density(ne), the access conditions are identified for each parameters for the discharges. Interestingly it is revealed experimentally the discharge characteristics is rather sensitive on the position of EC deposition layer in the core region. Only in a narrow range of the deposition layer, high beta-poloidal regime with H89 ~2.1 is accessible and sustained, while low beta-poloidal regime with H89 ~1.6 exists either without ECH or with outside deposition of the narrow layer. The difference confinement is investigated with MHD activities and the confinement degradation is strongly correlated with high frequency (> 100 kHz) oscillations which are identified as Alfven Eigenmodes (AEs) and also with D-D reduction of neutron rate which suggests the large decrease of fast ion pressure. Therefore, the thermal and fast-ion confinement are analyzed with TRANSP with the measured kinetic profiles and total beta from EFIT magnetic reconstruction. To model the fast-ion transport, ad-hoc diffusion coefficient of fast ions (Dfast) is introduced and determined by detailed comparison of the results of TRANSP and EFIT and the validity of the derived value of Dfast is also confirmed in parallel by neutron rate measurements. In addition, the linear stability of AEs are also examined with MEGA for the onset condition and toroidal mode numbers. According to the analysis, the difference of total confinement(i.e., H89=2.1 and 1.6 respectively) is mainly due to the increased transport of fast ions (i.e., Dfast =0.4 and 1.2 respectively), while there is minor effect from the thermal transport channel (i.e., H98 = 1.1 and 1.0 respectively). Finally, based on the present analysis, the performance enhancement of the high beta-poloidal discharge is predicted for the case with more heating power (PNBI+ECH ~ 10 MW) which is envisaged in two years.

Country or International Organization

Korea, Republic of

Paper Number

EX/P7-5

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Session Classification: P7 Posters