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Optimizing fast-ion confinement in NBI plasma for long-pulse operation of EAST

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It has been observed that lost fast ions in NBI plasma will hit the first wall of the device to affect the long pulse steady-state operation. The fast-ion loss mechanisms include prompt loss, ripple loss and resonant loss due to MHD instabilities[1]. Also, MHD instabilities are closely related to fast-ion beta βf [2-3]. In our research, we focused on the simulation and experimental investigation about fast-ion confinement by optimizing plasma shape to reduce prompt loss and ripple loss and adjusting plasma parameters to avoid MHD instabilities. Firstly, the influence of gapout in plasma shape on fast-ion confinement is analyzed. The simulation and experimental results show that larger gapout helps to improve fast-ion confinement due to the beam deposition moving inward, which leads to less trapped particles. Also,the prompt loss and ripple loss of fast ions are reduced. Meanwhile, the larger gapout leads to bigger shafranov shift and better confinement (higher βp and H98). Secondly, the fast-ion beta and gradient variation with beam energy and electron density have been achieved when Ip˜500kA, Bt˜-2.5T, q95˜5.3. Simulation results show that average fast-ion beta increases with beam energy ENBI and decreases with electron density due to longer slow time. When Bt˜1.6T and q95˜4.4, the average fast-ion beta is about doubled. The gradient of fast ion profile is larger at lower density, which leads to the appearance of TAE and EP in EAST NBI experiments [3]. Therefore, in order to avoid the abnormal transport of fast ions caused by MHD instability, the background plasma with high Bt and high density should be selected in the long pulse experiment with NBI. In the end, the longest about 60s MHD quiescent NBI plasma has been achieved based on above optimized configuration and plasma parameters with Bt˜-2.4T, fGW˜0.65.

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