

Solenoid-free start-up utilizing outer PF coils with the help of EBW pre-ionization and change of external inductance in VEST

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Solenoid free start-up scenario is the way to utilize loop voltage from the evolution of equilibrium field using outer PF coils. Also, it can be expected to be as an attractive start-up scheme in the fusion machines with low aspect ratio since flux from external inductance change can be utilized. The solenoid free start-up experiments using outer PF coils have been conducted in various devices, but the results show the failure of closed flux surface (CFS) formation or low plasma current with sufficient ECH power. With decreasing vertical field, the experiments for formation of CFS shows that improved pre-ionization with EBW enhances the initiated plasma current by lowering plasma resistivity. The CFS is formed successfully when the poloidal field from plasma current exceeds the vacuum vertical field and the quantitative condition for CFS formation has been derived in the consideration of pre-ionization plasma resistivity. The pre-ionization plasma with low resistivity is necessary for CFS formation. The enhanced particle confinement along mirror ratio in TPC is helpful for lowering resistivity of pre-ionization plasma near outboard and EBW collisionless heating makes possible to have lower resistivity of pre-ionization plasma due to the existence of 2nd or 3rd harmonics near outboard. After the successful CFS formation, the plasma current has been demonstrated to be ramped-up with loop voltage from outer PF coils with help of reduced external inductance. The plasma current evolution has been presented with 0-dimensional power balance modeling with consideration about force balance along plasma current. The initial plasma current evolution has difficulty due to the size of CFS that causes resistive dissipation. Also, the induction voltage from outer PF coils has limitation that it is not easy to change rapidly due to eddy current from vessel wall and causes increase of vertical field that affects to CFS formation and equilibrium. The solenoid free start-up using outer PF coils must consider the distribution between flux from external inductance and resistive dissipation. The solenoid free start-up scheme utilizing outer PF coils has been suggested considering the condition of CFS formation including the location and minor radius of CFS and resistivity of pre-ionization plasma.

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