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Assessment of the runaway electron energy dissipation in ITER

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Substantial fraction of the plasma current can be converted into runaway electron (RE) current in ITER disruptions. During the RE plateau stage of the disruption the kinetic energy of a runaway beam is expected to be much smaller than the magnetic one. However, at the following current termination phase, the electric field induced due to the RE loss to the wall causes the generation of new and acceleration of existing REs. Thus, some fraction of the initial plasma magnetic energy can be converted into RE kinetic energy. Preceding studies predicted significant, up to ~ 100%, conversion of the magnetic energy into kinetic one during the RE current termination phase of disruptions, i.e. when the majority of REs are lost. In the present report we assess the RE energy dissipation with the DINA disruption simulator appended with the new RE kinetic model based on the analytical solutions of the RE kinetic equation [P. Aleynikov and B.N. Breizman, Phys. Rev. Lett. 114 (2015) 155001]. The new kinetic model allows for the direct evaluation of RE kinetic energy lost to the wall due to plasma scrapping off at final stage of vertical displacement event (VDE). Generation of the halo currents was found to significantly reduce the conversion of RE magnetic into kinetic energy. Further suppression of RE regeneration at the plasma periphery is seen when an effective losses of REs are introduced in a narrow layer near the plasma boundary, mimicking the effect of external perturbations of the magnetic field. Sensitivity studies of the RE energy deposited to the wall are performed with variation of the amplitude and radial profile of the RE seed current at the beginning of the current quench (CQ). In addition, the simulations of the CQ with REs are accompanied by ideal and resistive MHD stability analysis, which allows to identify RE plasma stability boundary and to estimate the value and radial profile of the RE loss time. Finally, the mitigation of RE by injection of impurity during RE plateau is simulated with various impurity quantity and delivery time dependence as expected for massive gas or shattered pellet injection techniques.

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