

Progress in simulation of ITER First Plasma operation

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This paper presents a progress in simulation of ITER First Plasma operation since it was reported in [1]. New 0D plasma transport study was performed assuming hydrogen gas and Fe as a single impurity (stainless steel limiter), taking into account the Dreicer mechanism of runaway electron generation and their avalanche multiplication. The Fe influx to the plasma was described by physical sputtering of the limiter due to the wall bombardment by hydrogen and Fe ions. It was shown that the gas pressure lower limit, ≈ 0.3 mPa, is defined by the generation of runaway electrons. The gas pressure upper limit, ≈ 0.7 mPa (obtained using rather optimistic assumption - the plasma minor radius ≈ 1.6 m), is defined by insufficient ionization of the Fe impurity (“uncompleted burnthrough”). With the increase of the prefill gas pressure to values higher than this upper limit (e.g. to 0.75 mPa), the maximum value of the plasma current reduces very fast to less than 0.05 MA. The pressure upper limit reduces with reduction of the plasma minor radius.

A set of the First Plasma scenarios were designed using the TRANSMAX code and simulated with the DINA code (free boundary plasma equilibrium, 0D plasma transport with steel limiters). Two scenarios were designed with the goal of formation at the gas breakdown a large area with the magnetic field null. Such “wide null” magnetic configuration is preferable for the Ohmic gas breakdown. In one scenario the center of the breakdown region was located at $R = 5.7$ m, $Z = 0$. In another scenario, the center of the breakdown region was shifted vertically by 1.5 m ($R = 5.7$ m, $Z = 1.5$ m). Another two scenarios of PF system operation were designed to get at the gas breakdown in the breakdown region vertical magnetic field $B_z \approx 1.5$ mT and 2.5 mT corresponding to the “Shafranov” field of plasmas with the currents 0.03 MA and 0.05 MA, respectively. Such magnetic configurations may be preferable for plasma initiation with ECRF assist. The simulations take into account the vertical magnetic field produced by magnetized steel rebar of the Tokamak Complex producing at First plasma operation about 10 mT of vertical magnetic field opposite to the direction of “Shafranov” field.

[1] A.B.Mineev, et al., Study of ITER First Plasma initiation using a 3D electromagnetic model, 25th IAEA Fusion Energy Conference, St. Petersburg, Russia, 2014, PPC/P3-20.