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Study of ITER First Plasma Initiation Using a 3D Electromagnetic Model

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The First Plasma operation is expected to be performed in ITER without blanket modules (with temporary limiters), with a toroidal magnetic field of 2.65 T at 6.2 m (half of the nominal value), starting from a partly charged central solenoid (producing half of the nominal poloidal magnetic flux). The First Plasma initiation will be more challenging in ITER than in present tokamaks. One reason is due to high stray magnetic fields caused by 1.5 MA of eddy currents induced in the vacuum vessel and by 70 MA of currents in the central solenoid (CS). Moreover, the First Plasma initiation is complicated by a low value of the toroidal electric field (0.3 Vm-1), by a high volume of the vacuum vessel (1700 m3) and by a high content of impurities. On the other hand, several MW of ECRF heating will be available to assist plasma breakdown and burnthrough. Nevertheless, a carefully tuned poloidal field (PF) scenario will be essential to assure successful plasma initiation. The PF system should reduce the stray magnetic fields to about 2 mT in a large breakdown region with a minor radius of about 1.6 m and support a stable plasma equilibrium with increasing plasma current after the breakdown.

Taking into account all of the above mentioned difficulties of plasma initiation in ITER, it is important to develop numerical tools to design a proper scenario of PF operation. So far, the design of scenarios of the PF system operation during plasma initiation and simulations of the plasma initiation were performed with the TRANSMAK code using 2D axisymmetric models of ITER conducting structures and 0D plasma transport model. In this paper, another approach is presented with first results of the design and simulation of PF scenarios of the First Plasma initiation using a 3D electromagnetic model developed on the basis of the TYPHOON codes. This model includes 3D conducting structures of the vacuum vessel and cryostat, the toroidal field (TF) coils, and the ferromagnetic inserts located between the shells of the vacuum vessel.

The values of connection lengths confirm a good quality of the magnetic field null obtained using the 3D electromagnetic model: in the breakdown area with the effective minor radius 1.8 m the toroidally averaged components of the magnetic field is less than 2 mT and the connection length averaged over the boundary of this region is 2000 m.

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Primary author: Dr MINEEV, Anatoly (Joint Stock Company "D.V.Efremov Institute of Electrophysical Apparatus")

Co-authors: Dr BELOV, Alexandre (Joint Stock Company "D.V.Efremov Institute of Electrophysical Apparatus"); Dr KAVIN, Andrey (Joint Stock Company "D.V.Efremov Institute of Electrophysical Apparatus"); Dr LAMZIN,

Evgeny (Joint Stock Company “D.V.Efremov Institute of Electrophysical Apparatus”); Dr LOBANOV, Konstantin (Joint Stock Company “D.V.Efremov Institute of Electrophysical Apparatus”); Dr SYTCHEVSKY, Sergey (Joint Stock Company “D.V.Efremov Institute of Electrophysical Apparatus”); Dr BELYAKOV, Valery (Joint Stock Company “D.V.Efremov Institute of Electrophysical Apparatus”); Dr GRIBOV, Yury (ITER Organization)

Presenter: Dr MINEEV, Anatoly (Joint Stock Company “D.V.Efremov Institute of Electrophysical Apparatus”)

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