Evaluation of applicability of 2D iron core model for two-limb configuration of GOLEM tokamak

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GOLEM tokamak (R = 0.4 m, a = 0.085 m, Bt < 0.5 T, Ip < 4 kA) is a small, iron core, ohmically heated, limiter tokamak operated in a university environment. Its iron core is composed from only two iron limbs thus, implying a strong toroidal inhomogenity of the set-up. Generally, the in-vessel poloidal magnetic field components in iron core tokamaks are more complex to model, compared to the air core devices, due to the non-negligible influence of iron-air boundary. Sudden transition of permeability located along this boundary may amplify the generated magnetic field densities, especially if the source of field is located close to this boundary. Poloidal magnetic field coils located close to the unsaturated ferromagnetic core of the tokamak may yield (in some areas within its chamber) significantly stronger magnetic field compared to the predictions of models neglecting the core.

On GOLEM, we observed a longstanding systematic discrepancy between in-vessel magnetic field distribution measured by various types of magnetic probes and results of vacuum field model which neglects the presence of iron core. As a result, the new model of GOLEM iron core was developed based on the algorithms published in Ref. [1] and [2]. The model itself is based on the standard approach of simulating iron-air transition by coupled currents on the transformer surface. This represents condition of tangential magnetic field component continuity across the boundary of different magnetic media. The iron core is assumed to be toroidally symmetric to simplify the implementation of the model and to improve calculation speed. Strong toroidal asymmetry of the iron core material present in the real experiment is handled by varying size of two artificial ferromagnetic discs, placed at the ends of the central iron core column. The size of the discs is the function of the toroidal angle at which the modelled poloidal plane is located. Additionally, the problem is assumed to be linear, i.e. the permeability of iron is set as a known and given parameter, instead of being local function of magnetic field.

Proposed contribution will describe the model in detail with emphasis on its elements which allow successful application of this 2D model to properly describe intrinsically 3D iron core set-up of GOLEM. Results of extensive benchmarking of the code predictions with the experimental data will be presented as well.

[1] M. Gryaznevich et al, "Effect of ferromagnet on the equilibrium of a tokamak plasma," *Sov. J. Plasma Phys.*, vol. 2, No. 6, 1983.
[2] C. V. Atanasiu, L. E. Zakharov, "Description of the magnetohydrodynamic equilibrium in iron core transformer tokamaks," *Nucl. Fusion.*, vol. 30, No. 6, 1990.

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