Development of an Advanced Magnetic Equilibrium and Confinement Model for Fusion Reactor Systems Codes

F. Franza[a*], I. Landman[a], S. Pestchanyi[a]

[a]*Karlsruhe Institute of Technology, Hermann-von-Helmholtz-Platz 1, 76344, Eggenstein-Leopoldshafen, Germany*

**Corresponding author: fabrizio.franza@kit.edu*

Fusion systems codes are vital computational tools for the assessment of the key design parameters of a fusion power plant. The main goal is to capture the key physics and technology aspects, pushing the solution to comply with physics and engineering requirements and constraints. On these assumptions is normally based the entire magnet system, which is designed to match the requirements on magnetic equilibrium and confinement, as well as the technological constraints on superconductive coils. A dedicated research campaign has been recently launched at Karlsruhe Institute of Technology (KIT) to set up a newly developed computational tool for fusion reactor systems analyses, relying on advanced physics and technology modules. In this paper, the focus is addressed to the magnetic equilibrium and confinement module, which was recently derived from the already existing plasma simulation tool TOKES (also developed at KIT) and developed in collaboration with Max-Planck-Institute for Plasma Physics, Garching. The model first attempts finding a solution for the magnetic configuration within a target confining region and subsequently calculates the currents in Poloidal Field Coils (PFCs) to achieve such a configuration. The latter relies on some prescribed profile for toroidal current density and on a given magnetic flux value on the separatrix boundary, depending on the pulse operational phase. Moreover, the solver constraints the solution on PFCs currents to fulfil some technological limitations on superconductive coils, such as peak current density, magnetic field and Lorentz forces in the coils cross section. In this paper, the key modelling aspects are illustrated and the main results, in terms of PF coils currents and pulse duration, are compared with some reference DEMO scenario calculation.

Keywords: systems code, DEMO, magnets, equilibrium, confinement

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