Electromagnetic Analysis Of The Superconducting Magnet System Of The Divertor Tokamak Test Facility

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Abstract

As part of the European Research Roadmap to the Realization of Fusion Energy [1], the Divertor Tokamak Test facility (DTT) [2] aims to study alternative divertor configurations in view of the EU-DEMO [3] power exhaust handling issues. The DTT superconducting magnet system comprises 18 Toroidal Field (TF) coils, 6 Poloidal Field (PF) coils, and a Central Solenoid (CS). The superconducting coils are connected to the current leads by a system of superconducting current feeders, which are currently being designed (figure 1). As a very first design step, it is necessary to get an estimation of the magnetic field seen by the feeders along their paths. This facilitates both the choice of the superconducting material to use and the design of the mechanical supports that counteract the Lorentz loads when the coils are energized at operation.

In this work, the magnetic field interface (mf) of the COMSOL Multiphysics® AC/DC Module has been used to calculate the magnetic field profiles along the paths of the current feeders, in some particular time instants of the most important plasma scenarios. Given the complexity of a full 3D model, we have considered the total field as the superposition of a toroidal component and a poloidal component.

The toroidal field has been calculated by means of a 3D model, by taking advantage of the 18-fold symmetry of the TF coil system. A homogenized multi-turn model with a "numeric" coil type has been used to excite the coil with 42.5 kA. In a two-step study, a coil geometry analysis has been carried out before the stationary study.

The poloidal field contribution generated by the PF and CS coils has been evaluated by using a 2D-axisymmetric component, exploiting the mf interface of the AC/DC Module with the homogenized multi-turn coils feature. In the stationary study, the different time instants of the main normal operation scenarios have been taken into account in a parametric sweep. The paths of the feeders have been drawn in a 3D component, and a General Extrusion operator (genext1) has been employed to map the magnetic field from the 2D axisymmetric domain to the 3D domain, for the calculation of the field along the feeders' paths. This procedure allows for achieving considerable computational savings.

The result of these simulations will be of great help in the design of the TF, PF, and CS feeders, in all aspects regarding the layout of the superconducting cables to use, the definition of the best paths, as well as the evaluation of the electromagnetic loads and, consequently, the design of the feeders' mechanical supports.

Figures used in the abstract

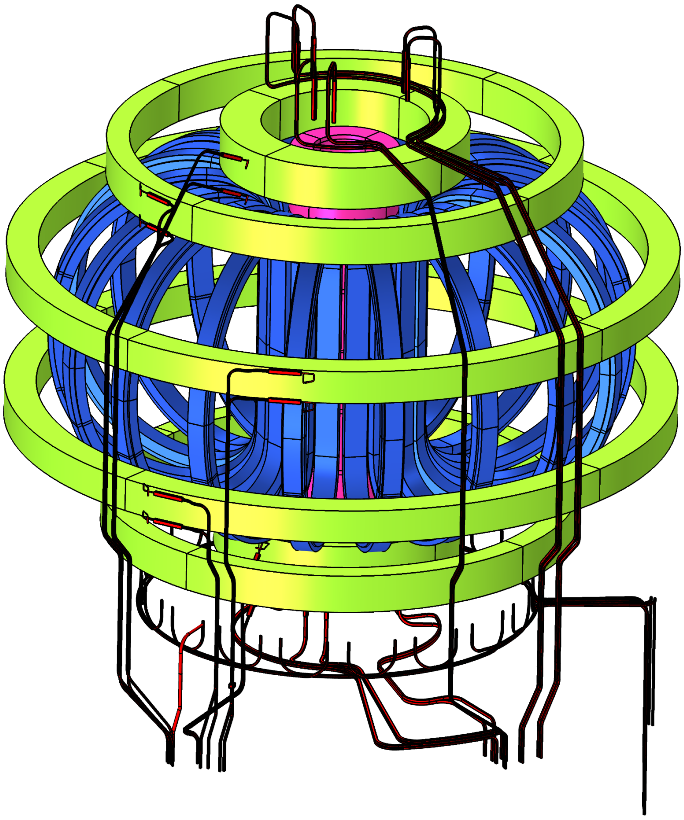

Figure 1 : The DTT magnet system and its current feeders: Toroidal Field coils (blu); Poloidal Field coils, PF (green); Central Solenoid (magenta); and current feeders (red).

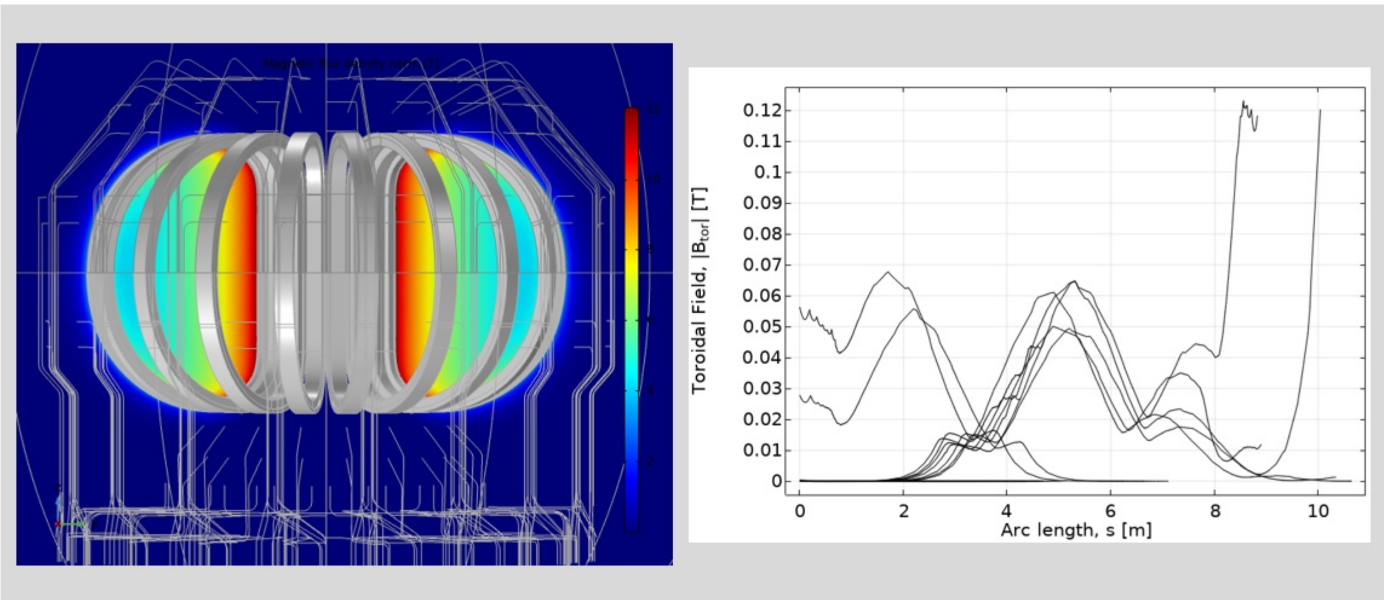

Figure 2 : Left: map of the toroidal magnetic field, |Btor|; right side: |Btor| calculated along the feeders' paths.

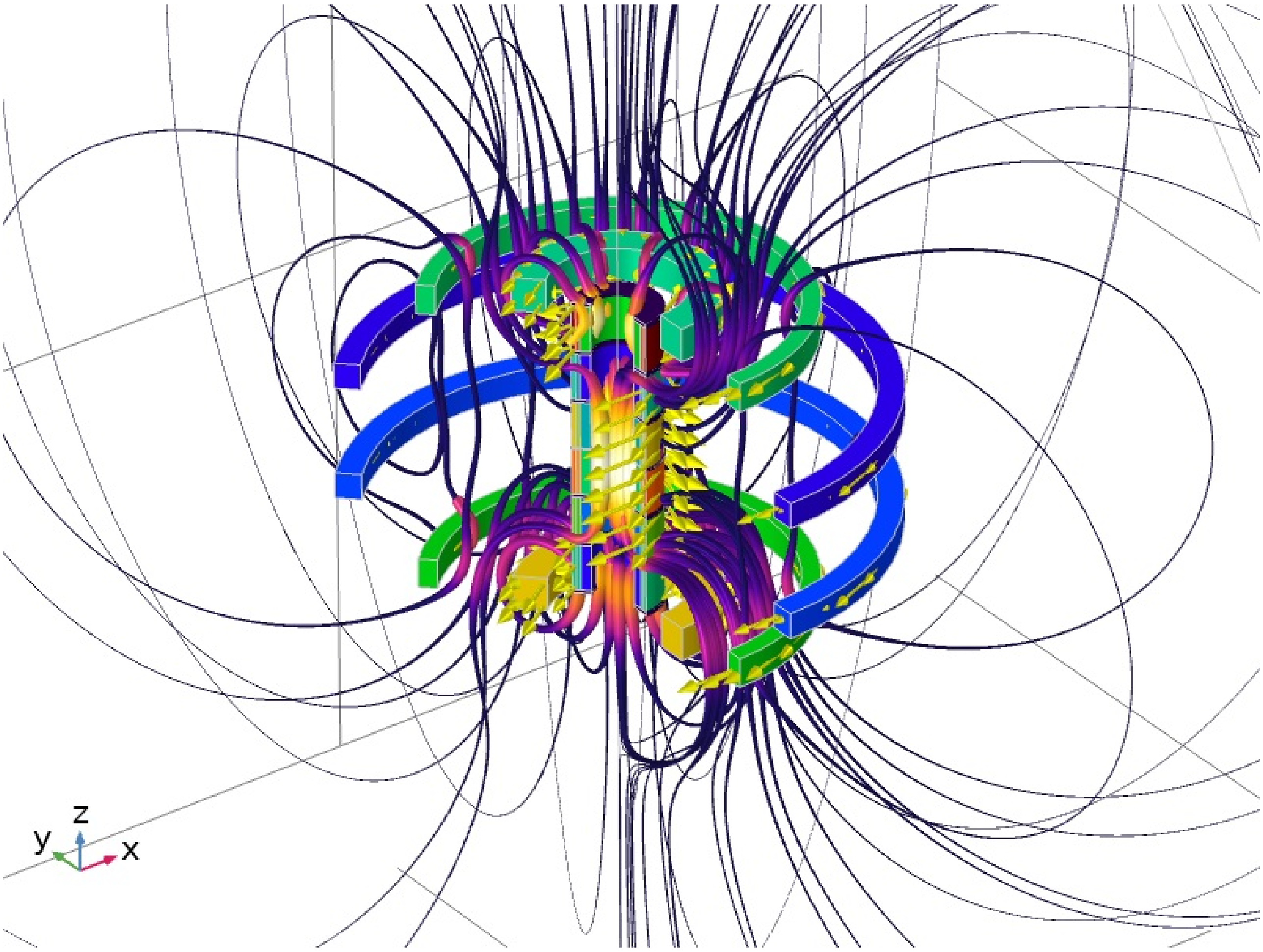

Figure 3 : Poloidal field lines for the Single Null scenario, at the Start of Flat Top.