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DEMO fusion reactor Toroidal Field coil optimized layer-wound design

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This paper describes the design activities on the Toroidal Field (TF) conductor and coil of the DEMO Nuclear fusion power plant. As prototypes of future commercial tokamaks, DEMOs are expected to be able to produce cost-effective electrical power. In this view, an optimized design becomes a crucial aspect in the whole engineering design procedure. The 2018 baseline of DEMO reactor includes 16 TF coils. The TF Winding Pack (WP), designed by ENEA, is made-up of 6 ⊠3⊠ double-layers with steel jacket thickness progressively increased from the highest field plasma facing side to the low field but most mechanically loaded side, and a Wind & React manufacturing approach. Although this solution has been recently excluded from the down-selection of the TF coil options for the Conceptual design phase, the design activity has evidenced some interesting methodological aspects, that will be discussed here. According to the results achieved in the present work, the optimized operating conditions will include 81 kA operating current and 13.1 T peak field.
In order to optimize the design, a parametric 2D FEA model of the inner leg cross-section was implemented in an optimization procedure to achieve the maximal peak magnetic field while guaranteeing structural integrity of the components, also considering the radial allocation requirements. A 2D parametric magneto-structural FEA model for the inner leg at equatorial plane, was used in order to map the magnetic field and evaluate the stress field in the WP at the conductor detail level, implementing a generalized plane strain formulation. Finally, hotspot temperature computations and conductor design for the optimized configuration were performed.

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