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Sat-Mo-Or2-04: A Parametric and Multi-physics Workflow for the Design of High-Field Magnets for optimized Stellarators

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A candidate of fusion reactor using magnetic confinement is the stellarator, which has an inherently steady-state nature. Among the various stellarator types, the optimized stellarator represents a promising topology. One challenge is the complex coil shapes required to create the necessary magnetic field to confine the plasma. As the achievable fusion power increases with the strength of the magnetic field, it is also of importance to scale up the magnetic field for the next generation of stellarators.
This work presents a parametric approach for the magneto-static and mechanical analysis of stellarator coils, considering a 13 T peak-field, based on Nb3Sn or 18-20 T peak-field, based on HTS in the winding pack. In the mechanical simulation, the stresses and strains of coil cases and the support structure are investigated and evaluated. In addition, a thermal-hydraulic simulation for the winding pack is performed, which includes the steady state analysis and the determination of the hotspot temperature during a quench. An exemplary winding pack design for the LTS and HTS option is illustrated and analyzed with the finite element method (FEM).
The complex and non-planar 3D geometry is one of the stellarator-specific difficulties for the design. Given the existence of various stellarator configurations, the development of a parametric tool for magnetic design would significantly accelerate the overall stellarator design process and its evaluation.
The parametric tool has been benchmarked with former analysis for the HELIAS configuration, which shows a good agreement. Furthermore, its applicability to another stellarator configurations is illustrated and analyzed. We discuss and evaluate the magnet design of high field stellarators based on the HELIAS configuration and point out possible challenges/risks.

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