Development of coil-shaping-based optimization code and its application to helical coil stellarator

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Optimization of magnetic configuration is an essential process in designing fusion reactors based on stellarator/heliotron concept. The numerical optimization schemes and codes based on the parameterization of the boundary magnetic surface shape by Fourier modes have been developed and applied to the design of the advanced stellarators. The linear and nonlinear coil optimization codes have also been progressed. Although the combination of these two processes is well established and sophisticated, the separation of boundary-shape and coil optimization processes causes the difficulty in the inclusion of the error magnetic fields, free-boundary equilibrium, edge magnetic field structure in the numerical optimization loop. The direct coil-shaping optimization scheme, where the MHD equilibrium is calculated for the vacuum magnetic field given by the external coil current, can naturally include these effects. We have developed the coil-shaping-based optimization code, OPTHECS (OPTimizer for Helical Confinement Systems). In this paper, the progress of the development and applications of the OPTHECS code will be presented. The inclusion of the width of the ergodic layer outside of the last-closed flux surface enabled to find the new designs of helical coil configurations with increased blanket space. The effect of inclusion of the free-boundary equilibrium in the optimization loop will also be shown. In the previous study, we have found that helical coils can produce the magnetic configurations of optimized stellarators [1]. Based on these findings, we are working on designing a new concept of helical coil stellarator that offers easy access to the vacuum vessel and robust divertor legs, while maintaining the core physics properties common to the optimized stellarators.

[1] H. Yamaguchi et al., 2021, Nucl. Fusion **61** 106004