Progress in Physical and Engineering Designs for Chinese First Quasi-axisymmetric Stellarator

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The Chinese First Quasi-axisymmetric Stellarator (CFQS) is a joint project of international collaboration. It is designed and fabricated by the Southwest Jiaotong University (SWJTU) in China and the National Institute for Fusion Science (NIFS) in Japan. The CFQS attempts to offer novel solutions for confining high-β plasmas by combining the best features of advanced tokamaks and optimized stellarators [1, 2]. The target parameters of CFQS are chosen as follows: the toroidal period number N_p = 2, major radius R_0 =1.0 m and magnetic field strength B_t =1.0 T. Via the scan of major radius (1.0-1.5 m), aspect ratio (3.2-5.0) and coil numbers (12-24), the target parameters of the CFQS configuration are determined by comprehensively considering physical and engineering constrains on equilibrium, MHD instabilities, neoclassical and turbulent transport, etc [3-6]. It turns out that the configuration for a 16-coil system with N_p =2, R_0 =1.0 m, a=0.25 m, B_t =1.0 T and aspect ratio A_p =4.0 is the most preferable. The comparison of the magnetic flux surface, iota and magnetic well profiles and Fourier spectrum of the magnetic field strength generated by modular coils with the target ones shows good agreement. From the core region to the edge, the rotational transform is designed between 2/6 and 2/5, which is favorable to avoid low-order rational surfaces. The presence of a magnetic well across the entire plasma radius is beneficial to stabilize MHD instabilities and reduce the island widths. The MHD equilibrium of the configuration is almost stable up to β = 1%. The neoclassical transport in 1/ν regime of CFQS is comparable with that in tokamaks. The turbulent transport in the nonlinear phase estimated by the GKV code appears to be less than in an equivalent tokamak. In addition, the engineering design for the modular coils, the vacuum vessel and support structures of the CFQS has also been performed preliminarily.

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