Contribution ID: **715** Type: **Poster**

Physics and Engineering Design for Chinese First Quasi-axisymmetric Stellarator(CFQS)

Thursday, 25 October 2018 08:30 (20 minutes)

The Chinese First Quasi-axisymmetric Stellarator (CFQS) is a joint project of international collaboration. It is designed and fabricated by Southwest Jiaotong University (SWJTU) in China and National Institute for Fusion Science (NIFS) in Japan. The target parameters of CFQS are as follows: toroidal periodic number N = 2, major radius R = 1.0 m, aspect ratio R/a = 4.0 and magnetic field strength B=1.0 T.
Via the scan of major radius (1.0m-1.5m) and aspect ratio (3-5), the target parameters of CFQS configuration are determined by comprehensively considering physics and engineering constrains. The toroidal periodic number N = 2 is selected, which guarantees to form the tokamak-like configuration. A low aspect ratio is one of the important features of the CFQS design because of the advantage of compactness and economy, which could be used in future commercial reactors. From the core region to the edge, the vacuum rotational transform is designed between 2/6 and 2/5 which is advantageous to avoid low-order rational surfaces. In addition, the presence of a magnetic well is capable to stabilize the MHD and reduce the island widths.
In order to achieve the target magnetic configuration, a modular coil system is necessary to be designed to reproduce the plasma boundary. According to the Neumann boundary condition, the accuracy of the magnetic configuration induced by the coil system depends on the normal component of the magnetic field on the plasma boundary. Via the minimization of the normal component of the magnetic field on the plasma boundary, the modular coil geometry is optimized. Meanwhile, the engineering constraints are also taken into account, which are the minimum interval between adjacent coils and the maximum curvature. This optimization process is accomplished by the NESCOIL code.
The Mercier stability, ballooning stability and neoclassical transport were also calculated to evaluate the property of the CFQS configuration. The MHD equilibrium of the configuration is almost stable up to beta = 1%. The neoclassical transport in the CFQS is expected to be less than that in 1/v regime in the W7-X.

Country or International Organization

China, People's Republic of

Paper Number

EX/P5-23

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Session Classification: P5 Posters