§13. Modular Coil Design for Quasi-axisymmetric Stellarator

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Preliminary design of modular coil system for the NIFS quasi-axisymmetric stellarator has been made. The basic algorithm of finding the coil shape for a given plasma structure is similar to the one developed in Garching for designing coils of Wendelstein VII-X. But more advanced techniques have been added to the computer code after the coil system for W VII-X was finally determined.

The calculation step starts by selecting the current carrying toroidal surface on which the distribution of surface current density is determined so as to reconstruct the boundary shape of a given plasma configuration. While in the old algorithm, the shape of the current carrying surface (CCS) is externally given, the new code calculates the optimized shape of CCS by itself. Because the weak boundary condition is necessary for the code to run safely, two toroidal surfaces are given externally which bound the area of CCS. This new algorithm makes it possible to find out coil shapes with smaller curvature than before which greatly reduces the difficulty of manufacturing coils.

The second step is to approximate the surface current with the discrete filament currents. The shape of filaments is described by 48 points for each coil. Since there are 5 different shapes of modular coils, 240 variables determine the total coil system. The optimization loop with 240 variables is calculated to satisfy conditions given by the physicists. Typical examples of these external conditions are maximum allowed value of coil curvature, the minimum distance between neighboring coils, the profile of rotational transform, the magnetic well depth, the island width at the rational surfaces. It is important that such physical conditions can be handled in the same way as the engineering conditions. This procedure is a version of the conventional optimization techniques of magnetic field configuration based on coil parameters.

Figure 1 shows the top view of one of modular coil designs for the NIFS quasi-axisymmetric stellarator. The shape of the plasma boundary is also shown to give the total image of the device. The CCS of this design is between two toroidal surfaces which have 35 and 60 cm distance from the plasma surface. The plasma configuration has two toroidal periods and ten coils are designed for one period. The number of coils is determined for the acceptable toroidal ripples caused by the distance of coils. Owing to the symmetry, five coils on the half toroidal period are the same as other five coils on another half period.

Figure 2 gives the side view of the system. It is advantageous for the design of heating system that an opening of coil distribution is found on the side of the torus. A tangential beam injection might be possible without modifying the original coil shape for the access of a beam injector.

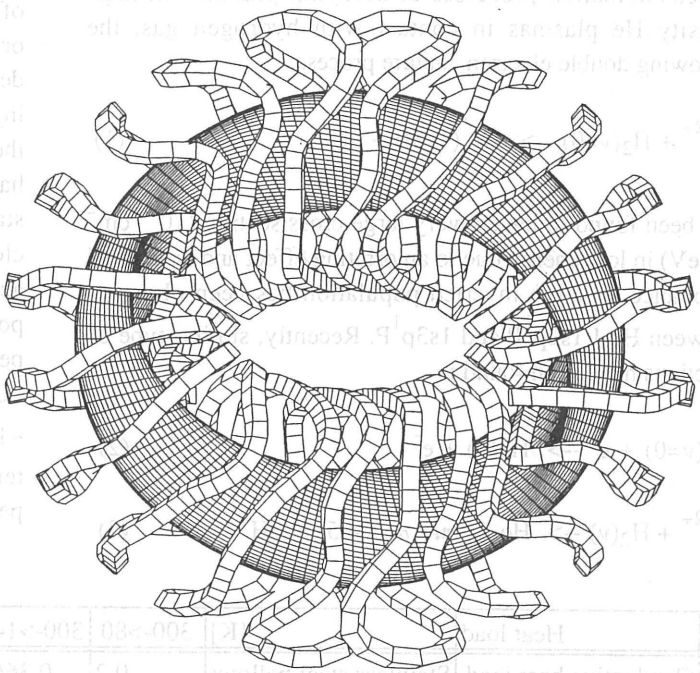

Fig. 1. Top view of modular coils.

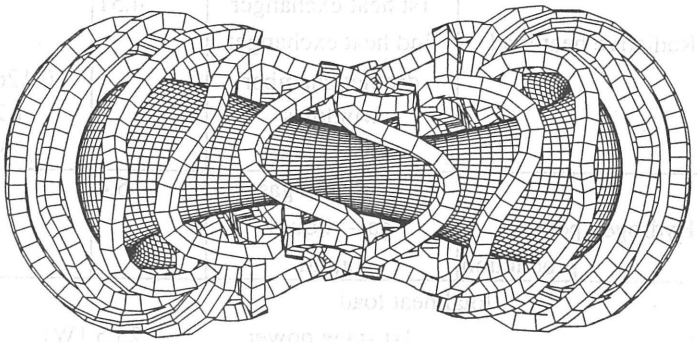

Fig. 2. Side view of modular coils.