§4. Design of Split-Type Helical Coils for FFHR-2S

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The conceptual design studies on the LHD-type fusion reactor (FFHR) have been conducted both on physics and engineering issues, and the recent design activities are summarized in [1]. In these studies, the coil pitch parameter, γ, defined by $(m/l)(a_c/R_c)$ for continuous helical coils (having the toroidal pitch number m, poloidal pole number l, average minor radius a_c and major radius R_c), has been chosen to be lower than 1.25 adopted for the present LHD. This choice is for the purpose of reducing the electromagnetic hoop-force on the helical coils while ensuring larger blanket space between the core plasma and the helical coils. The latest standard configuration, FFHR-2m1, has $\gamma = 1.15$ with $m = 10$, $l = 2$, $a_c = 3.22$ m and $R_c = 14$ m.

One of the difficult issues with this configuration is the still observed interference between the ergodic layers and blankets (thickness: ~1.1 m) especially at the inboard side of the torus, as is shown in Fig. 1(a). In order to reduce the heat flux on the blankets, the "helical x-point divertor" concept is proposed [2]. On the other hand, we have also been seeking for another approach of ensuring much clearer blanket space by modifying the coil configuration while keeping the major radius below 16-17 m. One example of such modified configurations is to split the helical coils in the poloidal cross-section. As was found in the previous study [3], the symmetry of magnetic surfaces around the magnetic axis can be improved, without shifting the magnetic axis inward, by increasing the current density at the inboard side of the helical coils while decreasing at the outboard side. Modulation of the current density can be practically obtained by splitting the helical coils.

However, it was also found that the divertor traces could not be easily removed from the blanket at the inboard side by simply splitting the helical coils while maintaining the original pitch parameter. In order to overcome this difficulty, we recently found that a drastically larger gap can be obtained by reducing the pitch parameter together with splitting the helical coils. One of the examples of such configurations is shown in Fig. 1(b) with $\gamma = 1.0$. The major radius is a bit increased to be 16.1 m, while the same minor radius of 3.22 m is kept. We should note that such a low pitch parameter has never been examined so far, as it is well known that one is already in the so-called forbidden zone for generating magnetic surfaces with a $l = 2$ heliotron configuration [4]. On the other hand, it should also be stressed that by having a smaller γ, the helical coils are expected to experience less electromagnetic forces, which is one of the fundamental benefits of FFHR.

For the new configuration, named FFHR-2S, various physics properties of the magnetic field should be investigated, such as the drift orbits of high-energy particles and MHD stability. At the same time, the optimization of the coil configuration should be done also from the engineering viewpoint. For example, the blankets located at the x-points can be moved farther in order to avoid direct touching of divertor traces, however, the supporting structure should be designed in good coordination with helical coils and poloidal coils.

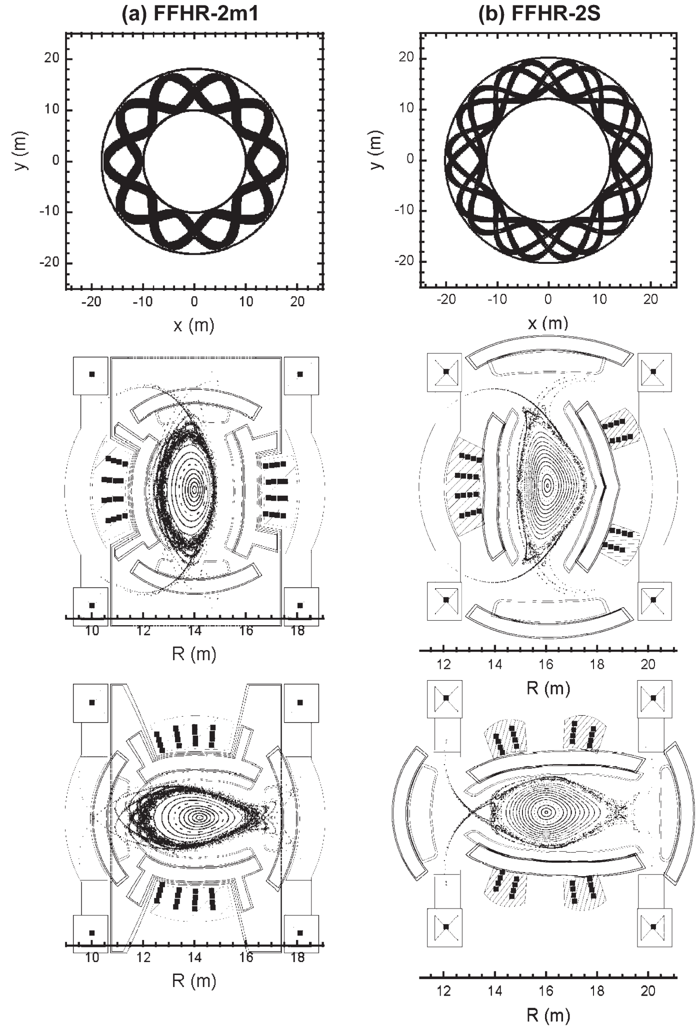

Fig. 1 Plan views of the coils, and magnetic surfaces at two cross-sections for (a) FFHR-2m1 and (b) FFHR-2S.

References

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