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ヘリカル型核融合炉 FFHR-d1 磁場配位の工学的最適化に関する検討進展
Progress on the Engineering Optimization of the Magnetic Configuration for the Helical Fusion Reactor FFHR-d1

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Conceptual design studies of the LHD-type helical fusion reactor FFHR-d1 are progressing by employing a multi-path strategy for configuration optimization in order to secure the design foundation. The FFHR-d1A is defined as the base option for promoting the 3D engineering design [1], having the major and minor radius of the helical coils of 15.6 m and 3.744 m, respectively. The helical pitch parameter γ_c is thus 1.20 in this case. The "blanket space", Δ_{cp}, the distance between the innermost layer of the helical coil windings and the ergodic layer outside the last closed flux surface (LCFS) is very tight, 950 mm, at the inboard side of the torus. A pair of sub-helical coils, NITA (Newly Installed Twist Adjustment) coils, can be situated at about two times the minor radius of the main helical coils having a minor radius of 3.9 m with γ_c of 1.25 as a slightly modified configuration. An oppositely directed current of ~5% of the main helical coil current in the NITA coils is effective to enlarge Δ_{cp} to ~1100 mm.

The ferromagnetic effect brought by the Reduced Activation Ferritic/Martensitic (RAFM) material, such as F82H, used in the structure of the blankets may distort the magnetic field. This effect has been newly analyzed for the heliotron configuration of FFHR-d1 by combining the finite element method (FEM) code ANSYS and the magnetic field-line tracing code HSD. Slight expansion of magnetic surfaces is seen with the relative permeability of 1.3. The present analysis is considered to be an overestimation and the blanket model is reexamined. It is also proposed that the NITA coils can be used to reduce the magnetic surfaces if necessary, as is shown in Fig. 1.

It has been also found that the correction coils (LID coils) are effective to mitigate the non-uniform divertor flux of magnetic field lines, as is shown in Fig. 2. The present calculation does not include the collision effect of plasma particles, which may further flatten the distribution. The new calculation is now under way.

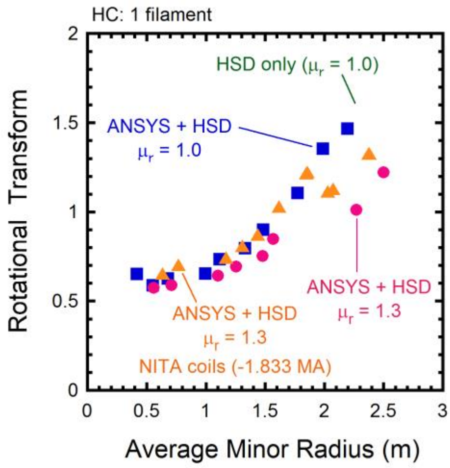

Fig. 1. Changes of the rotational transform by ferromagnetic effect and by inclusion of NITA coils.

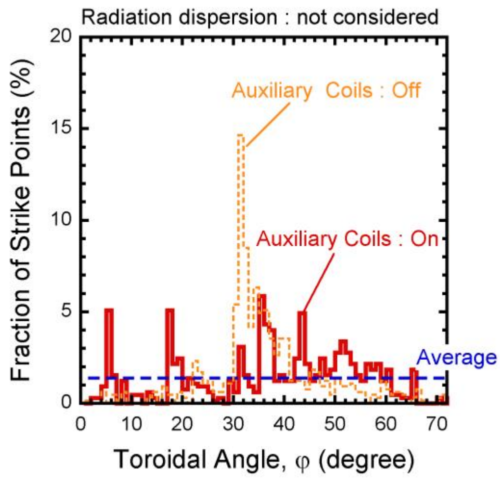

Fig. 2. Fraction of the number of strike points of magnetic field-lines coming to the divertor regions plotted as a function of the toroidal angle with and without using the LID coils at 6 MA current.

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