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NITAコイルを用いたヘリカル型核融合炉ブランケットスペースの革新的増大
NITA Coil — Innovation for Enlarging the Blanket Space in the Helical Fusion Reactor

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Conceptual design studies of the LHD-type helical fusion reactor FFHR-d1 are progressing steadfastly. A multi-path strategy is being pursued for securing the design foundation, which presently specifies FFHR-d1A as the base option for promoting the 3D engineering design [1]. In d1A, a pair of helical coils (major radius: 15.6 m) has the helical pitch parameter γ_c of 1.20, which was changed from the previous value of 1.25 for the original d1 [2]. Due to the γ_c decrease, the "blanket space" Δ_{cp} at the inboard side of the torus is enlarged from 890 mm to 950 mm. Here Δ_{cp} is defined as the distance between the innermost layer of the helical coil windings and the ergodic layer outside the last closed flux surface (LCFS). In order to further improve the structural integrity and to lower the neutron flux, it is preferable to further enlarge Δ_{cp}.
Four methods have been investigated so far for enlarging Δ_{cp}, however, some of them were difficult to realize practically and others were not sufficient. An innovative method was proposed in 2014 to shed a new light on this issue. The idea is to vary the current density within the helical coil by subdividing the coil windings into multiple blocks [3]. This method was, however, determined to be again infeasible since the current density in the helical coil was too high. Then, a modified version of the similar concept was proposed, in which a pair of sub-helical coils, presently named NITA (Newly Installed Twist Adjustment) coils, is employed at about two times the minor radius of the main helical coils [4]. An oppositely directed current of ~5% of the main helical coil current is applied to NITA coils and this combination effectively lowers γ_c to be ~1.15. As the main helical coils have the original minor radius of FFHR-d1, Δ_{cp} can be resultantly enlarged to ~1100 mm. The minor radius of LCFS is still comparable to that of FFHR-d1A, which is a contrast to choosing a smaller γ_c for the main helical coils. Presently, the electromagnetic stress analysis is being carried out to examine the effect of inclusion of NITA coils.

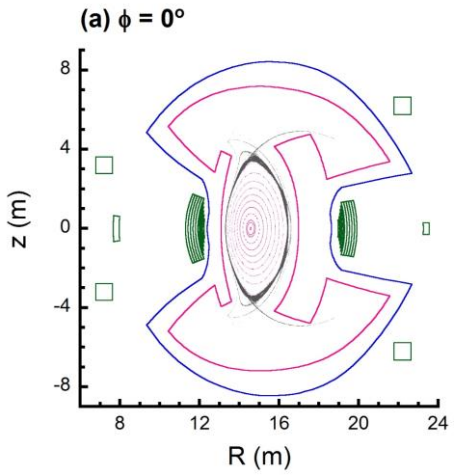

Fig. 1. Cross-sectional image of the vacuum magnetic surfaces in the FFHR-d1-TW configuration with NITA coils having -5% current of the main helical coils.

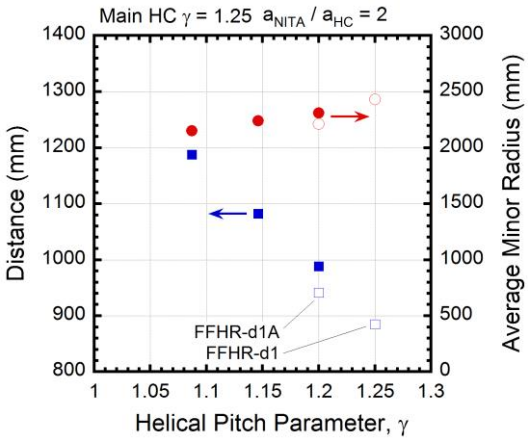

Fig. 3. Dependence of the blanket space and average minor radius obtained in the FFHR-d1-TW configuration as a function of the effective helical pitch parameter.

[1] A. Sagara, H. Tamura, T. Tanaka, et al., Fusion Eng. Des. 89 (2014) 2114.
[2] H. Tamura, T. Goto, T. Tanaka, et al., Fusion Eng. Des. 89 (2014) 2336.
[3] T. Watanabe, N. Yanagi, A. Sagara, Plasma Fusion Res. 9 (2014) 3403089.
[4] T. Watanabe, private communication.