§2. System Design of the Helical Fusion Reactor FFHR-d1

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i) Modification of the shape of in-vessel components

After the decision of the primary design parameters of FFHR-d1[1], the detailed design of core plasma is in progress by the core plasma task group in collaboration with the Numerical Experiment Research Project[2] and high aspect ratio configuration with helical pitch parameter $\gamma_c = 1.2$ was selected as a standard configuration for FFHR-d1. Because core plasma with a higher aspect ratio has a smaller minor radius, the volume of vacuum vessel and blankets can be reduced if the shape of them is specialized in this configuration. Thus we reconsidered the shape of vacuum vessel and blankets based on the result of magnetic field line tracing calculation. Here we considered the shape of blankets at the inboard side not to interfere the vacuum magnetic field structure with strongly inner shifted configuration ($R_{ax}/R_c = 3.5/3.9$) in preparation for the abrupt drop of plasma pressure. The modified poloidal cross-sectional view of FFHR-d1 is shown in Fig. 1.

ii) Consideration of plasma operation control scenario

Plasma operation control scenario has a big impact on the system design of a fusion reactor because it determines the required design and operation conditions of not only peripheral equipment (e.g., diagnostics, fueling, heating system, etc.) but also power plant equipment (e.g., heat transport, power generation system, etc.). In last fiscal year, a quasi-1D calculation code to solve temporal evolution of radial profiles of electron density and temperature was developed in collaboration with the core plasma, the fueling and the operation control task groups [3]. In this fiscal year, the code was modified to reflect the pellet ablation profile predicted by the neutral gas shielding (NGS) model. Using the modified code, plasma operation control scenario of FFHR-d1 was examined. Here experimental data with a peaked density profile with inward-shifted, high aspect ratio configuration ($R_{ax}/R_c = 3.55/3.9, \gamma_c = 1.2$) was used and fueling by a pellet containing 10^{23} particles with an injection velocity of 1.5 km/s, which can be achieved without special technological development, was assumed.

It was found that the minimum density and fusion power which enable self-ignition state strongly depends on magnetic field strength. Here we adopted $B_{ax} = 6.0$ T, with which the minimum fusion power of 3 GW can be achieved. As shown in Fig. 2 and 3, baseline plasma operation control scenario with smooth ignition-access and steady-state sustainment was established using a feedback control of the line-averaged electron density[4].

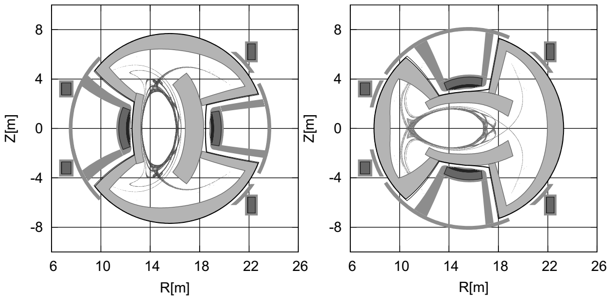

Fig. 1: Poloidal cross-sectional view of FFHR-d1.

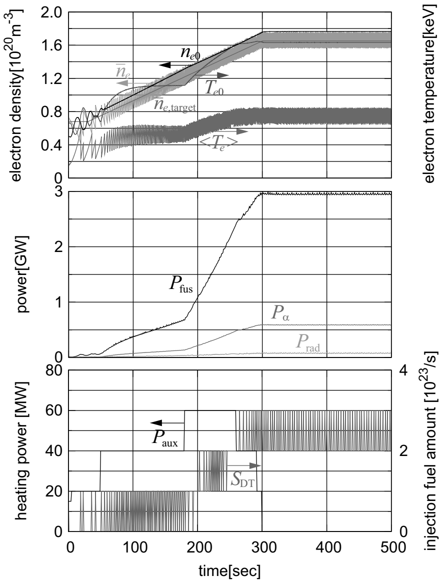

Fig. 2: Time evolution of the plasma and external control parameters of the baseline scenario.

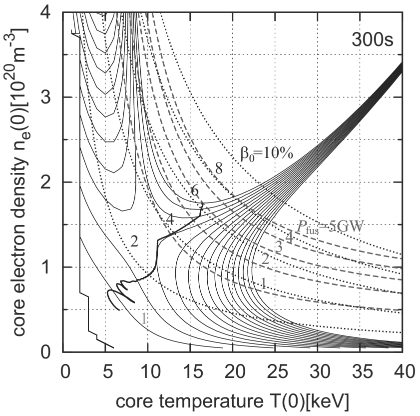

Fig. 3: Trajectory of the central electron density and temperature on Popcon plot.

1) Goto, T. et al.: Plasma Fusion Res. **7** (2012) 2405084.

2) Miyazawa, J. et al.: Nucl. Fusion **54** (2014) 043010.

3) Goto, T. et al.: Annual Report of NIFS April 2012-March 2013, 264 (2013).

4) Goto, T. et al.: Fusion Eng. Des. (2014), in press.