§1. Conceptual Design Studies towards LHD-type DEMO Reactors

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On the basis of a steady progress in the LHD experiment, a lot of achievements have been made in terms of refinement of the database, physics analysis, and engineering R&D for the helical system. This study advances conceptual design activity of the helical DEMO reactor FFHR-d1 by utilizing these achievements and wide-ranged researches including the core plasma physics and the reactor technology through cooperative researches in NIFS. This study also aims at establishing an engineering basis that enables engineering demonstration of the helical DEMO and contributing to a progress in nuclear fusion research by clarifying issues and prospects of each research field.

This study has been conducted under the Fusion Engineering Research Project, launched at the beginning of FY2010. Conceptual design activity of FFHR-d1[1] and related engineering R&D have been conducted by 3 research groups (superconducting magnets, in-vessel components, reactor system design) that consist of 13 task groups with a cooperative research between universities and other institutes. In this fiscal year, we focused on the study of the maintenance method and the operational mode of FFHR-d1. In parallel, several ideas to enhance the safety were proposed.

In the consideration of the construction method, which is regarded as the third round of the conceptual design, discussions were mainly focused on the winding procedure of the helical coils. To secure the soundness of the vacuum vessel, which is an important safety component as a vacuum or tritium boundary, we adopted the construction procedure starting from the innermost component: shielding blankets, vacuum vessel, coil-support structure and superconducting coils. We also began to make the Gantt chart (Fig. 1) to grasp the overall structure of the construction procedure and to ensure its consistency. To shorten the time required to replace the breeding blankets and divertor plates in radiation environment, discussion on the optimization of the module structure and the pipe-cutting location of these components were advanced. To improve the flexibility of the divertor design including the material selection and the control method of the heat and particle loads, the novel divertor concept, which utilizes the built-in divertor structure of the heliotron-type configuration and enables the placement of the divertor module in an area receiving much less radiation by modifying the shape of the coil-support structure and vacuum vessel, was proposed[2] (Fig. 2).

Related to the multi-path design strategy[3] which introduced in the last fiscal year, 1-D integrated physics analysis of the plasma start-up scenario for FFHR-d1B (high magnetic field option proposed by the core plasma task group) was advanced by the design integration task group[4] through the collaboration with the Numerical Simulation Reactor Research Project. In parallel, several new ideas were proposed as part of the design option which aims the at the moderation of the engineering design requirement on the superconducting coil system (FFHR-d1C): homogeneization of the toroidal distribution of the divertor heat flux by modifying the winding law of the helical coils, enlargement of the space for the blankets by introducing sub-helical coils which locate outside of the main helical coils and produce inverse currents against the main coils, and so on. We make a continuous effort on the establishment of a more attractive design concept by the multi-path design strategy including these new ideas.

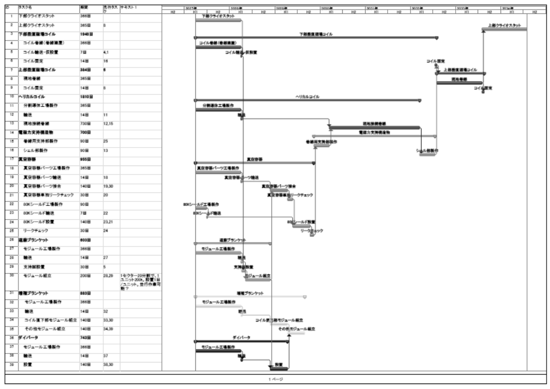

Fig. 1. Gantt chart of the construction procedure.

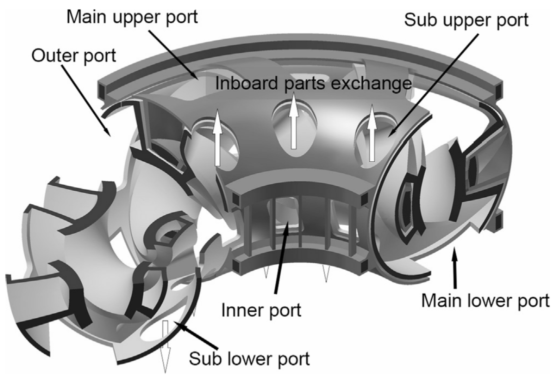

Fig. 2. Schematic of the novel divertor concept (reprint from the Fig. 8 of Ref. [2]

1) Sagara, A. et al.: Fusion Eng. Des. **87** (2012) 594.
2) Tamura, H. et al.: Fusion Eng. Des., in press (2015).
3) Sagara, A. et al.: Fusion Eng. Des. **89** (2014) 2114.
4) Goto, T. et al: Proc. of 25th IAEA FEC, FIP/P7-16, to be published in Nucl. Fusion (2015).