§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, 3-D design examination of in-vessel components was advanced from the viewpoint of safety and RAMI (reliability, availability, maintainability and inspectability). As a result, 3-D design of FFHR-d1 including the shape of ports and module structure of blankets was modified.

After an intensive study on physics analysis of the core plasma based on direct extrapolation of the LHD experimental results by the core plasma task group in collaboration with the Numerical Experiment Research Project, a high aspect ratio configuration, which can suppress Shaflanov shift, was adopted as a basic configuration of FFHR-d1[2]. The design integration task group modified 3-D shape of the in-vessel components based on this new configuration: reduction in the volume and simplification of the shape of the in-vessel components. In-vessel components task group conducted stress analysis of coil support structure, resulting in enlargement of the size of the ports and reduction in the volume of the support structure[3] (Fig. 1).

In parallel with the 3-D design as the second round of the design activities, iterative work from the first round has been advanced for the core plasma design, ignition start-up analyses, and fueling scenario. As a consequence, a multi-path strategy for FFHR-d1 has been introduced[4] (Fig. 2). Here FFHR-d1A is the above-mentioned basic design configuration with a modified Aspect ratio. The core plasma task group proposed a new design option with the magnetic (B) field enhanced by 20% to ensure MHD stability (FFHR-d1B in Fig. 2). The superconducting magnet task group proposed another flexible design with configuration optimization of vertical field coils having the engineering merit of minimizing the total stored magnetic energy (FFHR-d1C in Fig. 2). Furthermore, to maintain design flexibility for FFHR, a sub-ignition version, FFHR-c1, has been allocated as "before-demo, compact, and component-test", and FFHR-z1 as an ideal design. We will advance the establishment of a more attractive design concept with this multi-path strategy.

Responding to the starting up of the joint core team (all-Japan organization towards research and development for DEMO establishment), we also started a new, solution-focused activity with the Fusion Reactor Design Group of Japan Atomic Energy Agency (JAEA) to enhance collaboration. We will accelerate the consideration on maintenance and safety issues through peer reviews of mutual design activities.

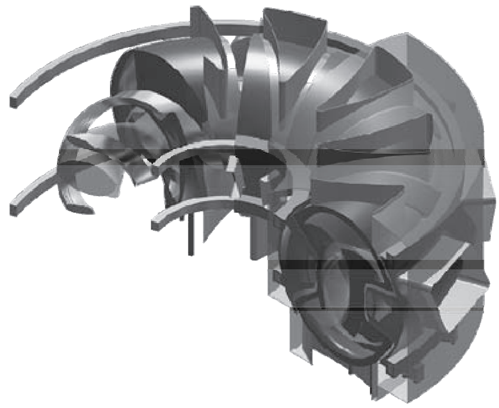

Fig. 1. 3-D design of FFHR-d1.

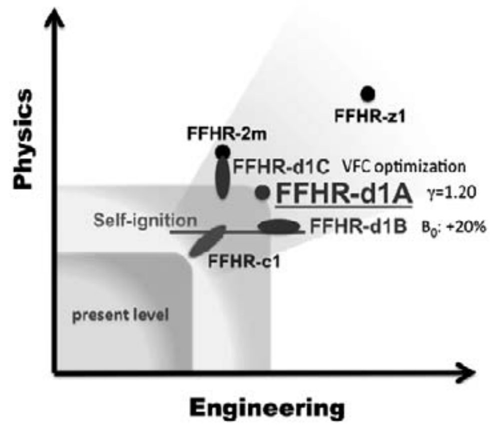

Fig. 2. Mapping of the multi-path strategy on FFHR.

1) Sagara, A. et al.: Fusion Eng. Des. **87** (2012) 594.
2) Miyazawa, J. et al: Nucl. Fusion **54** (2014) 043010.
3) Tamura, H. et al.: Fusion Eng. Des. (2014), in press.
4) Sagara, A. et al.: Fusion Eng. Des. (2014), in press.