§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 for 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 for 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. In this fiscal year, the detailed design of core plasma and in-vessel components were advanced on the basis of primary design parameters set on FY2011. As a result, 3-D CAD design of FFHR-d1 including cryostat was proposed.

The core plasma task group performed the detailed examination of core plasma design on the basis of the extrapolation of LHD experimental data[2] in cooperation with the NIFS Numerical Experiment Research Project. It was found that simultaneous achievement of avoidance of density limit, MHD stability, suppression of neo-classical transport and confinement of high-energy particles could be possible by a combination of the adoption of the high aspect ratio configuration and vertical field control. This result will be fed back to the LHD experiment.

The basic 3-D shape of in-vessel components was set using the result of a field line tracing calculation by the design integration task group. On the basis of this 3-D basic shape, the blanket task group performed 3-D neutronics calculation using an MCNP code. The result indicated that neutron flux around divertor region can be suppressed by an order of magnitude[3] (Fig. 1). This is a great advantage of LHD-type helical system and leads to a flexible selection in the divertor design. It also enhances reactor safety in terms of the suppression of decay heat. The in-vessel component task group performed the detailed design of the supporting structure and 3-D CAD design including ports, cryostat and cold support legs (Fig. 2).

In addition to these achievements, clarification of the investigation and development issues for the DEMO reactor is in progress. In particular, the consideration of the shape of heating ports, primary consideration of diagnostic system and conceptual design of power supply system which includes the consideration of effectiveness and safety were advanced by the heating system task group, the diagnostic system task group and the power supply system task group, respectively thorough the discussion with outside collaborator at academic meetings or collaborative research meetings.

(a)

(b)

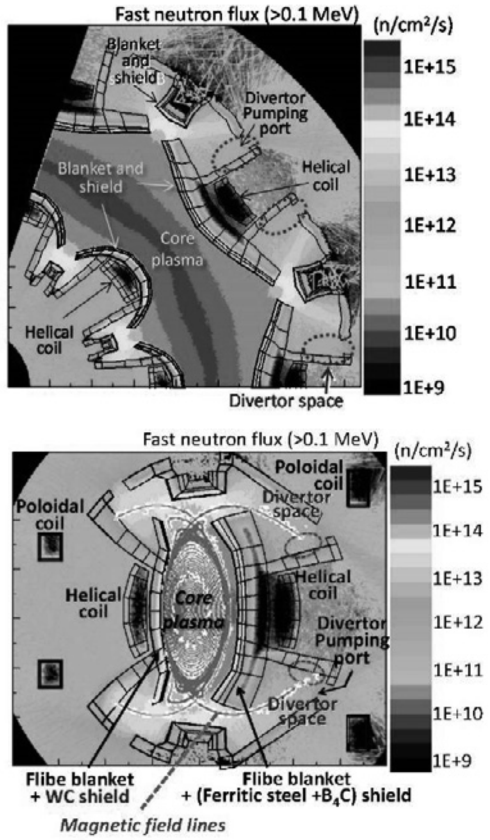

Fig. 1. Distribution of fast (>0.1MeV) neutrons of FFHR-d1 on (a) equatorial plane and (b) vertically-elongated poloidal cross-section.

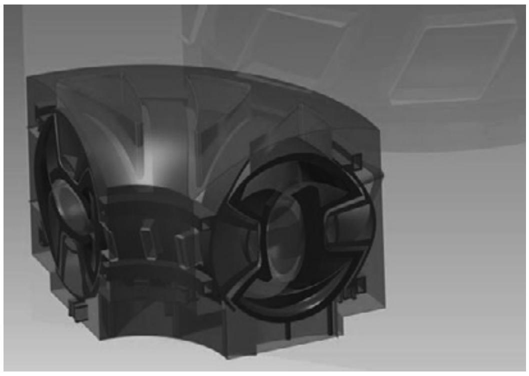

Fig. 2. 3-D CAD drawing of FFHR-d1

1) Sagara, A. et al.: Fusion Eng. Des. **87** (2012) 594.
2) Miyazawa, J. et al.: Nucl. Fusion **52** (2012) 123007.
3) Tanaka, T. et al.: Proc. of 24th IAEA Fusion Energy Conference, San Diego, CA, USA, Oct. 8-13, 2012, FTP/P7-36.