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

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

This study has been advanced under a new research project, fusion engineering research project, launched at the beginning of this fiscal year. A conceptual design activity for FFHR-d1 and related engineering R&D have started by 3 research groups (superconducting magnets, in-vessel components, reactor system design) that consist of 13 task groups.

The design integration task group has conducted design window analyses for FFHR-d1 using a system design code.[1] A design with a smaller size and higher magnetic field strength compared with a reference design (FFHR-2m2[2])), which aims at a commercially-competitive power plant, is being considered (see Fig. 1).

The core plasma task group has proposed a new method for extrapolating the plasma parameters obtained in the LHD experiments to a reactor condition, direct profile extrapolation (DPE) method, to enhance a reliability of the core plasma design.[3]

The superconducting magnet group has proceeded an upgrade design for the existing high-field testing device, low-temperature structural analysis, and so on.

To reduce the size of a reactor, the blanket task group has carried out an optimization study for a thickness of the shielding layer under neutronics calculations by selecting advanced shielding materials (e.g., WC) and an adequate placement of materials (see Fig. 2). This group also has carried out an optimization study for the internal structure of the blanket system by coupling neutronics calculations with thermo-fluid and structural analyses.

The tritium task group has established particle balance model that can deal with an entire plant system[4] (see Fig. 3). This model revealed that fueling efficiency has a great influence on particle balance. In relation to this, the fueling task group has started a development of a calculation model for a steady-state fuel supply and an evaluation using the model.

Other task groups (heating system, diagnostics, power supply system, etc.) have started a consideration for development issues.

Some new ideas that utilize advantages of helical systems (e.g., a consideration of heating scenario for a high-density operation[5]), a new divertor sweeping scheme using HTS coils[6]) to reduce particle and heat loads on divertor plates) have also been proposed.

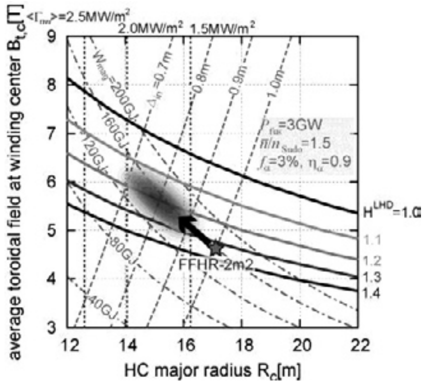

Fig. 1. Design window analysis for FFHR-d1.

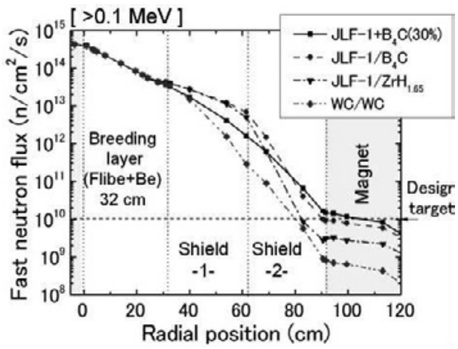

Fig. 2. Result of the neutronics calculation .

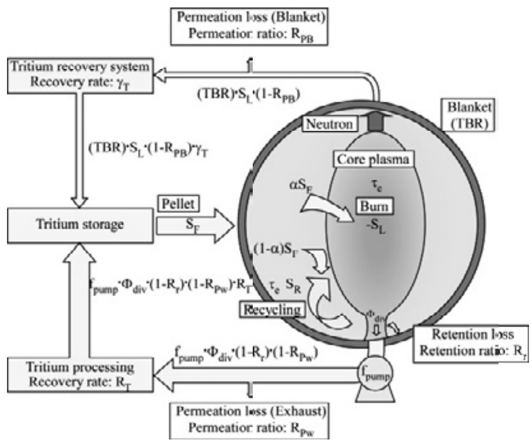

Fig. 3. Schematic view of the tritium balance model.

1) Goto, T. et al.: Proc. of ITC20, Toki, Japan, Dec. 7-10, 2010, O-23, to be published in PFR (2011).
2) Sagara, A. et al.: Fusion Eng. Des. **83** (2008) 1690.
3) Miyazawa, J. et al.: Proc. of ITC20, Toki, Japan, Dec. 7-10, 2010, P2-63, to be published in Fusion Eng. Des.
4) Sagara, A. et al: Plenary Talk at 19th TOFE, Las Vegas, USA, 2010, Fusion Sci. Technol. **60** (2011) 3.
5) Mitarai, O. et al: Proc. of 23rd IAEA Fusion Energy Conference, Daejeon, Korea, Oct. 11-16, 2010, FTP/P6-19.
6) Yanagi, N. et al: Proc. of 23rd IAEA Fusion Energy Conference, Daejeon, Korea, Oct. 11-16, 2010, FTP/P6-21, submitted to Nucl. Fusion.