SIV-3

BAにおけるトカマク型原型炉設計の概要
Overview of Tokamak Demo Designs in Broader Approach Activity

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1. Introduction

The first phase of Demo design study in the Broader Approach (BA) activity of International Fusion Energy Research Centre (IFERC), which was called as Phase-1, was started in June 2007. The study in Phase-1 was implemented by the leaderships of M. Araki (the first IFERC-Project Leader), D. Maisonnier of EFDA (Project manager of EU) and K. Tobita of JAEA (Project manager of Japan). The main activity in Phase-1 was based on workshops in order to exchange technical design issues and to identify “common elements” for Japan – EU joint design works in the succeeding period after Phase-1.

DEMO Design Activities (DDA) started a joint work stage, Phase-2, after the DDA unit of the Project Team (PT) was organized in January 2011, under the leader ship of a new IFERC Project Leader, N. Nakajima.

In the new framework, the activities have been jointly conducted by the union of the DDA unit of IFERC, EU Home Team (EU-HT) and Japan Home team (JA-HT). The Leader of DDA unit is K. Okano from CRIEPI, Japan. The EU-HT is conducted by a new project manager (PM) G. Federici, and the PM of JA-HT is K. Tobita, continuously.

In Phase-2, DEMO Design Workshops have been replaced by Technical Coordination Meetings (TCMs), where specific technical and programmatic issues for DEMO design are discussed by experts from EU and Japan.

The first TCM (TCM-1) was held in Kashiwa-Campus, near Tokyo on 19-20 January 2011, in the form of a joint DEMO Design and R&D Workshop, and included in addition of design topics also a status report on the progress on DEMO material R&D activities in the frame of the BA. The second TCM (TCM-2) was held in Garching on 24-25 May and the third (TCM-3) is held in Kashiwa on 1-3 November.

2. Joint Works in DDA

The joint works in Phase-2 have been defined as follows;

<u>Phase-2a</u> (Jan 2011-Dec 2012):
Consolidation of knowledge, to define a sound common basis for DEMO design, and to provide input to parallel and future R&D needed for DEMO,

<u>Phase-2b</u> (Jan 2013-Dec 2014):
Detailed studies on key design issues, options and DEMO parameters, and

<u>Phase-2c</u> (Jan 2015-May 2017):
Development of pre-conceptual design options for DEMO.

The present period is the Phase-2a which will be succeeded by the Phase 2b after the next January.

3. Status of Design study

There is progress in system code benchmark regarding pulsed operation. The benchmark on pulsed operation was carried out. The poloidal flux supply from the poloidal coil system or the central solenoid given the JA and EU systems codes (TPC code of JAEA and PROCESS code of CCFE) was validated using a Japanese MHD equilibrium code TOSCA, which revealed a problem of evaluating the poloidal flux supply in each code. After the modification, complete agreement between the codes was confirmed regarding the poloidal flux supply [1].

Using these codes, there has been significant progress to quantify key physics & technology necessary for a case of somewhat conservative design options, called DEMO-1 [2], which will make easier to start the DEMO construction in the early 2030s.

Two cases for steady state (SS) design options which have been proposed by JA-HT are also considered in the activity. The design policy for these SS variations is slightly different from the previous Japanese example of DEMO designs which were designed with thermal output around 3GW. Both of the new SS variations are planned with 2GW thermal output with the major radius about 7m. These options are called DEMO-2 and DEMO-3. The change of output has been done mainly because of a aspect for safety-design. The DEMO-2 and DEMO-3 are also planned to install a Central Solenoid (CS) enough to achieve V*Sec ~ LpIp, which make possible to ramp-up the plasma current up to the full specification value by the CS swing [3].

Priorities of issues in Design and R&D have been identified. They include a work on blanket technology including tritium extraction and control technology, remote maintenance, magnets design and conductor optimization. Finding a reliable solution for the heat exhaust of DEMO is a main priority.

The study on conventional radiative divertors includes some extension of the range of conditions using the simplified integrated and specific models, allowing a model development on a more complete description of power exhaust to use it in the systems code, and some improvement of the design databases for the extrapolation of key parameters under suitable conditions.

The extended divertor leg concept [4], which is a fully detached divertor concept based on an extended divertor leg to reduce the divertor heat load to a tolerable level, has been numerically studied.

Advanced divertor configurations and alternative new concepts such as “super-X” and “snow-flake” are also assessed in light of the feasibility of the magnetic configuration [5,6].

Novel material as a solution of Plasma Facing Components (PFC), e.g., liquid metals, has been investigated. This work includes,

i) to review the rationale for liquid metals as PFCs and to determine the implications on the plasma operation and performance,

ii) to provide knowledge needed PFC components development with liquid metals,

iii) to investigate the problem of Tritium inventory as an important issue on liquid target,

iv) to identify the candidate liquid metals and review recent experimental results, and, in parallel,

v) to investigate the design integration and engineering aspects of using liquid metals in a DEMO divertor.

Radiation environments and decay heat of in-vessel components are assessed to consider remote maintenance equipment and cooling methods during the maintenance of DEMO[7]. The temporal evolution of the decay heat from the blanket and the divertor after stopping the operation was evaluated to help with considering the cooling system during transport of the blanket sectors and divertor sectors.

The technological target-ranges relevant to super conductors and in-vessel components have been compiled towards a unified list of the technologies through the face-to-face discussion between the JA and EU experts.

4. Status of Safety Study

The Safety Research in the DEMO Design Activities (hereafter DDA Safety Research) has been conducted since April 2012. The goal is to analyze accidental sequences, to develop possible design projections for preventing and mitigating serious accidents, and eventually to compile the safety design guidelines.

The DDA Safety Research will be conducted in two stages:

Stage 1 (April 2012 – March 2013);
“Preparation stage”

Stage 2; (April 2013 – March 2017);
“Assessment stage”

The main coverage of the present Stage-1 is:

i) Definition of safety requirements,
ii) Definition of source terms,
iii) Identification of reference events, and
iv) Preparation of computer codes.

The works are being conducted in collaboration with an EU safety expert to preliminary investigate i), ii) and iii) and to review previous fusion safety works (including the ITER documents).

References

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