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Completion of IFMIF/EVEDA Li Test Loop construction and commissioning

IFMIF/EVEDAリチウム試験ループの完成

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The EVEDA Li test loop (ELTL) successfully completed its construction and commissioning in the IFMIF/EVEDA project as one of the ITER-BA. Design for the ELTL had been done from Mar. 2009 to Dec. 2009 in large part, and then the construction was started on Nov. 2009 in the O-arai site of the Japan Atomic Energy Agency and completed on the middle of Nov. 2010. In the commissioning conducted subsequently, the following tests were performed: 1) Li ingots installation into the ELTL, 2) Li charging and draining operation, 3) Li circulation tests. In a final phase of the circulation test, stable liquid Li flow at a velocity of 5 m/s was successfully achieved.

1. Introduction

The International Fusion Materials Irradiation Facility (IFMIF) is aimed at producing an intense high energy neutron flux generated by a deuteron (D^+) - lithium (Li) nuclear reaction. In the current concept of the IFMIF, two 40 MeV D^+ beams whose total current is 250 mA are injected into a beam target called Li target which is a liquid Li stream flowing at a nominal speed of 15 m/s (operation range: 10-20 m/s).

Engineering Validation and Engineering Design Activities (EVEDA) for the IFMIF is being in progress under the Broader Approach Activities (BA). In the EVEDA, as a major activity of R&Ds on the IFMIF Li target facility[1], the EVEDA Li test loop (ELTL) simulated the actual IFMIF Li target facility was constructed and is scheduled to operate for two years for the purpose of collecting indispensable data for construction of the IFMIF Li target facility and of completing an IFMIF engineering design. This paper presents the design of the ELTL as well as the construction and the commissioning completed on March. 2011.

2. Design of the IFMIF/EVEDA Li test loop

The ELTL was designed to have major components necessary to produce the Li target for the design phase since Mar. 2009 to Dec. 2009. The ELTL consists of two major Li loops which are the main loop and the purification loop, as shown in a piping and instrumentations diagram (P&ID) of the ELTL in Fig. 1.

The main loop consists of the main circulation piping, a quench tank, an electro-magnetic pump (EMP), an electro-magnetic flow meter (EMF), a forced-air type cooler (air cooler), a dump tank and valves. The tanks connect to Ar gas cylinders and turbo-molecular vacuum pumps to control pressure and vacuum of 10^{-3} Pa near a free-surface of Li flow. In the main loop, the maximum flow rate is 3000 L/min to produce a Li flow whose velocity, thickness and width are up to 20 m/s, 25 mm and 100 mm respectively in the target assembly (TA). The performances with regard to the velocity and the thickness are the same as that envisaged in the IFMIF, while the width is 1/3. In the TA placed at the top of the platform, the Li flow is formed by a double contraction nozzle along a concave back plate (BP) as shown in Fig. 2. The nozzle is derived from the potential flow theory to form a stable jet up to 20 m/s. Static pressure inside the Li target is enhanced due to centrifugal force by flowing along the concaved BP, and therefore boiling of the Li target by the D^+ beam's heat is not occurred in IFMIF.

The purification loop is connected to the main loop at the upstream and downstream of the main EMP. And the impurity monitoring loop is branched at the downstream of the impurity traps in the purification loop. The purification loop includes a cold trap aiming to remove mainly oxygen, and two mechanical interfaces to install two hot traps aiming to remove nitrogen and hydrogen (hydrogen isotopes in IFMIF) respectively.

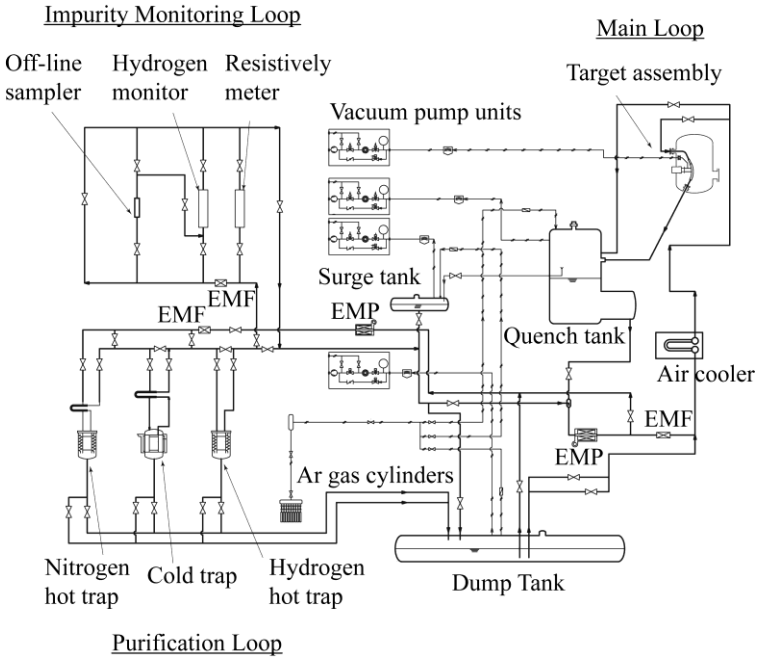

Fig.1. P&ID of ELTL

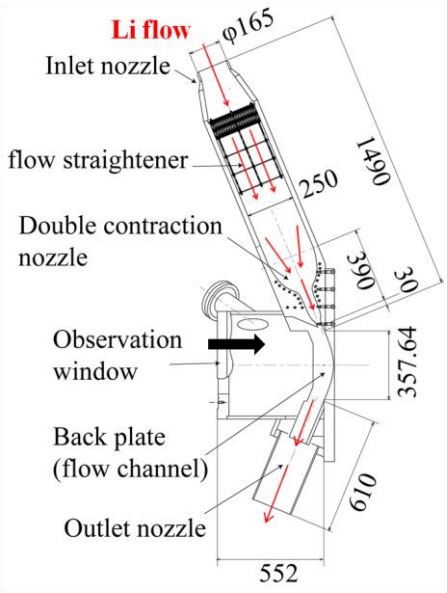

Fig. 2 Target assembly (unit: mm)

These two hot traps are designed and fabricated in collaboration with Japanese universities (the two traps are not installed yet at this moment). The impurity monitoring loop includes a Li sampler to analyze impurity concentration off-line, and interfaces to two on-line monitors developed in the collaboration.

3. Construction and commissioning of the IFMIF/EVEDA Li test loop

The ELTL had been constructed for two years since 2009, and have completed the commissioning (performance tests) on March 2011 in the O-arai Research and Development Center in the JAEA. Fig. 3 shows a photograph of the ELTL.

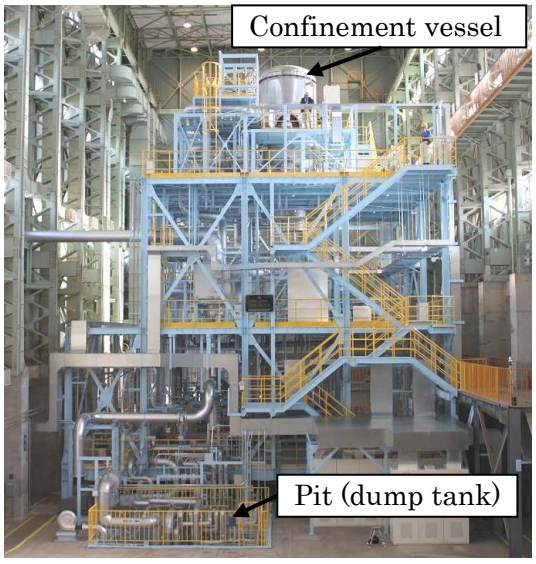

Fig.3. Front view of the ELTL

The loop consists of three floors and a pit in which the dump tank is placed. The target assembly is installed in an air-tight vessel (confinement vessel) on the 3rd floor, and the height of the ELTL is approximately 20 m from the ground level.

In the commissioning conducted after completing the construction, the following tests were performed: 1) Li ingots installation into the ELTL, 2) Li charging and draining operation, 3) Li circulation tests. In the Li circulation tests, the performance of each equipment of the ELTL was aimed to be checked, and was confirmed to satisfy pre-defined specifications. In a final phase of the circulation tests, in the target assembly, stable liquid Li flow at a velocity of 5 m/s was successfully achieved in a pressure condition of 0.12 MPa of Ar gas (Fig. 3).

4. Summary

The EVEDA Li test loop as a major Japanese activity on the Li target system in the IFMIF/EVEDA had been designed and constructed in the O-arai site of the JAEA since Mar. 2009. The construction and subsequent commissioning was completed on March 2011. The Li target at a velocity of 5 m/s was successfully achieved in the commissioning.

Reference

[1] H. Nakamura, P. Agostini, K. Ara, S. Fukada, K. Furuya, et al., “Status of engineering design of liquid lithium target in IFMIF-EVEDA”, Fus. Eng. Des. 84, 2-6, June 2009, 252-258