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Nuclear Fusion Fuel Cycle Research Perspectives

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1. Introduction

As a part of the International Thermonuclear Experimental Reactor (ITER) Project, we at the Korea Atomic Energy Research Institute (KAERI) and our National Fusion Research Institute (NFRI) colleagues are investigating nuclear fusion fuel cycle hardware including a nuclear fusion fuel Storage and Delivery System (SDS). To have a better knowledge of the nuclear fusion fuel cycle, we present our research efforts not only on SDS but also on the Fuel Supply System (FS), Tokamak Exhaust Processing System (TEP), Isotope Separation System (ISS), and Detritiation System (DS).

2. Nuclear Fusion Fuel Cycle

In this section, we present our research efforts not only on SDS but also on the Fuel Supply System (FS), Tokamak Exhaust Processing System (TEP), Isotope Separation System (ISS), and Detritiation System (DS).

2.1 Nuclear Fusion Fuel Cycle

Fig. 1 shows an example of the nuclear fusion fuel cycle [1].

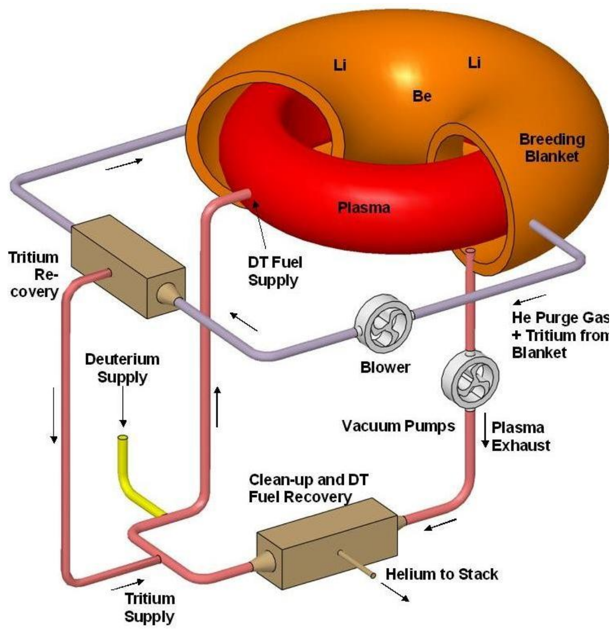

Fig. 1. Nuclear fusion fuel cycle [1]

2.2 Fuel Supply System

Powerful pumps are used to inject gaseous fusion fuels into the vacuum chamber. Produced from a tritium breeding system, or imported or stored, deuterium and tritium are introduced into the vacuum chamber where only a small percentage of the fuel is consumed. A pellet injector is mainly a highly efficient ice maker. An extruder punches out several millimeter-sized deuterium-tritium ice pellets quickly and cold enough to penetrate deep into the plasma core. The frozen pellets are injected through a guide tube located in the inner wall of the vacuum vessel and another guide tube for outer wall injection. In addition, pellet injection is the principal tool used to control plasma density [1].

2.3 Storage and Delivery System

We have been studying SDS, especially depleted uranium (DU) hydride beds. We studied the hydriding and dehydriding performances of a small DU bed [2]. Fig. 2 shows the bed performance test rig. Metal hydride beds were installed onto the bed performance test rig, which is composed of a DU bed and a ZrCo bed of the same morphology. The rig is used for a measurement of the hydrogen recovery and delivery rates. A hydrogen delivery scroll pump is connected to the manifold piping. The amount of hydrogen used for the initial activation, and the hydriding and dehydriding runs, is measured based on the hydrogen pressure in the measuring tank. A control and data acquisition system (DAS) was provided. Fig. 3 shows the bed hydriding performance.

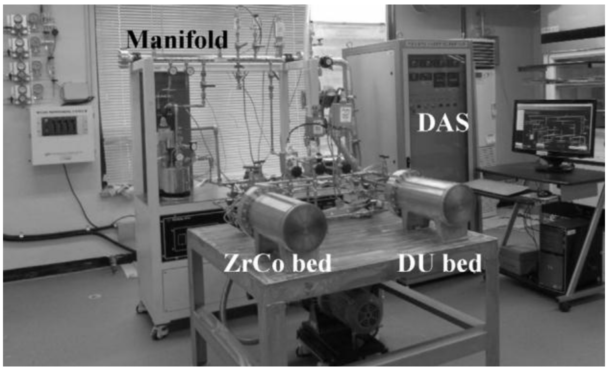

Fig. 2. Bed performance test rig [2]

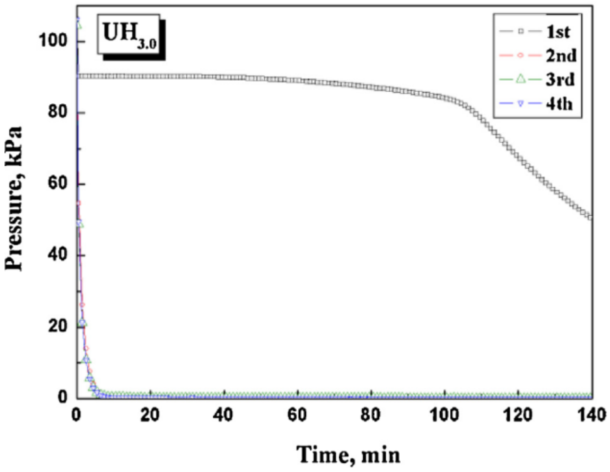

Fig. 3. Bed hydriding performance [2]

2.4 Tokamak Exhaust Processing System

Fig. 4 shows a TEP flow sheet. TEP purifies Tokamak exhaust gases.

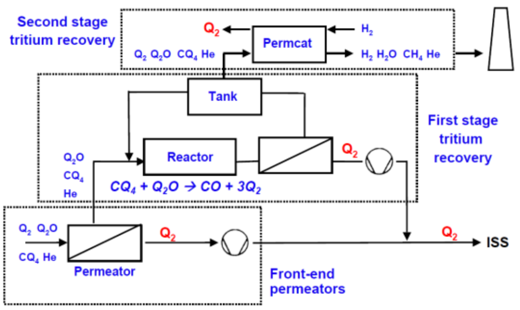

Fig. 4. TEP flow sheet [3].

2.5 Isotope Separation System

Fig. 5 shows an ISS flow sheet. ISS concentrates tritium gas.

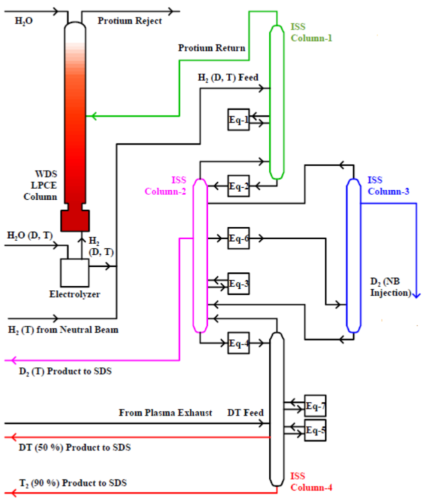

Fig. 5. ISS flow sheet [4].

2.6 Detritiation System

Our detritiation process is composed of an oxidation process for tritiated hydrogen gas, an oxidation process for tritiated organic waste, an adsorption process for tritiated water vapor, and a combined catalytic and chemical exchange process with an optional gas chromatographic isotope separation process, as shown in Fig. 6.

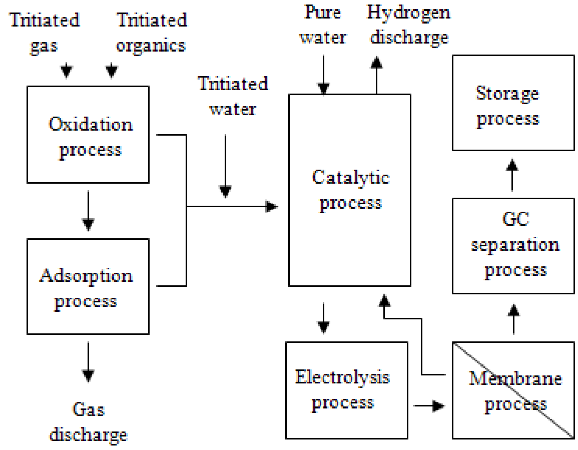

Fig. 6. Detritiation flow sheet [5].

3. Concluding Remarks

To have better knowledge of the nuclear fusion fuel cycle, we presented our research efforts not only on SDS but also on the Fuel Supply System (FS), Tokamak Exhaust Processing System (TEP), Isotope Separation System (ISS), and Detritiation System (DS). Our efforts to enhance the tritium confinement will be continued for the development of cleaner nuclear fusion power plants.

ACKNOWLEDGMENTS

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