Progress in the experimental evaluation of reduction bed in coolant purification system using Research Apparatus for Vapor Adsorption and Desorption (RAVAD)

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1. Introduction

In fusion power plants, the coolant purification system (CPS) removes tritium or impurities in helium as a coolant [1]. In particular, hydrogen isotopes (Q_2) are not easy to remove due to their small molecular size, but if they are oxidized to water molecules (Q_2O) through an oxide bed, they can be easily adsorbed by a molecular sieve bed (MSB) at room temperature. The reducing bed plays a role in reducing it back to Q_2 and sending it to the Tritium Accountancy System (TAS) to determine the amount of tritium. We previously constructed a Research Apparatus for Vapor Adsorption and Desorption (RAVAD), to verify the performance of MSB adsorbing Q_2O. The goal of this study is to verify the performance of the reducing bed by utilizing RAVAD.

2. Test facility and methods

RAVAD was designed to experimentally verify the adsorption-desorption properties of MSBs. Before the feasibility test at high pressure, scaled-down tests are performed at 5 bar or less, which is lower than the actual operating conditions [2]. Various carrier gas supply systems and vapor generators were connected to the apparatus to verify the characteristics of the MSB, and to evaluate the effect of the geometry of the MSB, the test section was designed to be interchangeable, and various MSBs were modularized to perform the experiments [3].

Two MSBs are installed in the CPS to perform the adsorption-desorption operation crosswise using the characteristics of pressure-temperature swing adsorption. While the adsorption process is operated in a low temperature and high-pressure environment, the desorption process separates the Q_2O adsorbed on the MSBs by circulating helium at high temperature and low pressure. The mixed gas passes through a reducing bed made of Zr-Mn-Fe alloy before being sent to the TAS, and Q_2O is converted to Q_2. Since it is only passed through once in a short period of time, it is necessary to ensure that enough chemical reactions occur in the reducing bed.

The environment is very similar to the operating environment of RAVAD, which is a high-temperature, low-pressure carrier gas containing moisture that passes through the reducing bed once. RAVAD can create an operating environment of up to 400 ℃ or more for MSB desorption experiments. Although RAVAD does not have a hydrogen concentration meter, the reduction rate can be checked by comparing the water concentration before and after the reducing bed. We are currently designing a reducing bed for testing and plan to conduct experiments soon.

3. Conclusion and further works

The CPS is composed of various columns that have their own roles. For the experimental verification of each column, RAVAD was built, and the experiments to confirm the adsorption and desorption characteristics of MSB using it have been completed. The next step is to expand the experimental device for oxide bed verification. In addition, we will utilize the advantages of RAVAD to verify the operating characteristics of the reducing bed. The experimental results of RAVAD will be very useful for the future construction of a high-pressure helium experimental device and are expected to design a reliable CPS.

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