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Test facility for vapor adsorption using molecular sieve in helium coolant purification system

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1. Introduction

Nuclear fusion reactor has own tritium breeding system. HCS (Helium cooling system) removes the heat from the Tokamak and the tritium breeding system by circulating high pressure helium. Since the breeding zone is established at high temperature and high pressure, and has thin steal wall for effective heat transfer, a small amount of tritium can be permeated to HCS from the tritium breeding zone. Since it can be exposed to external environment, it should be removed for safety requirements in the system. The coolant purification system (CPS) will play a role to capture the tritium in HCS. 1 % of helium flow is bypassed in CPS from HCS and is purified through several steps. In the system, a molecular sieve bed (MSB) will capture the oxidized tritium Q_2O, through physical adsorption. To develop and confirm the MSB design and its function, the test facility is designed by KAERI and NFRI. Tests will be performed to compare absorption rate and saturation characteristics according to diameter, length, and flow rate. Through the research, it is expected that a more reliable CPS design could experimentally be derived

2. Methods and Results

2.1. Coolant purification system

CPS consists of oxide bed [1, 2], adsorption bed [3], impurity bed [4]. CPS captures tritium and gas impurities through several steps. In the first step of purification, hydrogen isotopes are oxidized and converted to Q_2O using metal oxide (CuO) under 250 ~ 300 ° C to increase the size of the molecule. Secondly, Q_2O is physically adsorbed using zeolite molecular sieves. They are crystalline with plentiful pores of precisely defined diameter. [2] Q_2O with large size and polarity is adsorbed while on the other helium passes through the sieve. MSB has a high adsorption efficiency of 99% or more and is high efficiency at room

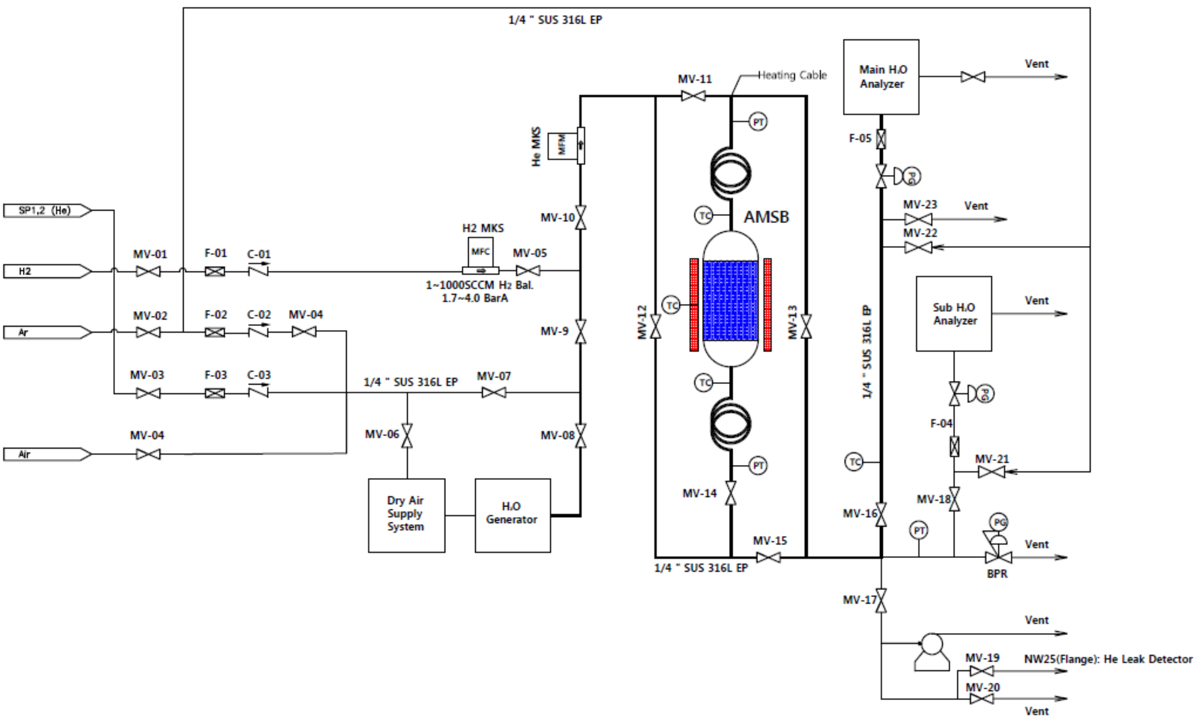

Fig 1 Schematic diagram of MSB test facility

temperature. Another characteristic is that MSB can be reused by changing pressure and temperature. The capacity of vapor adsorption varies depending on the temperature and pressure. So, if two MSBs are connected in parallel, continuous operation is possible.

2.2 test facility for MSB characteristics

The test facility has been constructed for the experimental verification of the adsorption under a very low concentration of Q_2O. Fig 1 shows the schematic diagram of MSB test facility. The low pressure experiment is planned through scaling down, in contrast to CPS condition of 8 MPa, due to the lack of helium supply and low concentration of Q_2O. Tests were performed under room temperature and 2 bar, but the partial pressure of hydrogen is maintained at 0.4 Pa.

The facility can be divided into two parts. The first part is gas supply system shown in Fig 2. After helium passes the demoisturizer system, it carries a vapor from 1 to 40 ppm using regulators and mass flow controllers. The concentration of vapor is measured with a gas analyzer. This analyzer is CRDS type and has 1ppb accuracy in the range of 0 ~ 450ppm.

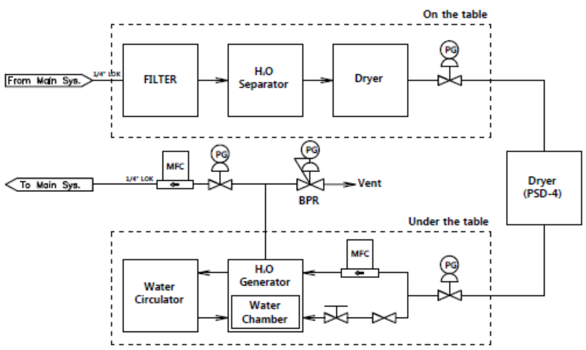

Fig 2. Flow diagram of demoisturizer system and vapor supply system. The system consists gas dryer and vapor generator with mass flow rate controller

The vapor generator was newly produced for low flow rate and high accuracy by KRISS in Korea. The principle that the amount of water evaporated through the diffusion tube changes at specific temperature and gas flow rate is used. Three micro tubes with different diameter between 0.1mm and 1mm are connected to a small water chamber in order to control the target evaporation rate. Vapor can be stably supplied by the generator for tens of hours as indicated in fig 3. Concentration of vapor was controlled with valves ranging from 1 ppm to few hundreds of ppm.

The second part is the test section including the MSB module and a heater for desorption process. Nine different MSB modules were manufactured with different diameters and lengths - 16, 20 and 24 mm and 24, 64 and 128 mm, respectively. Tests will be performed at a linear velocity ranging from 5 to 25 m/min.

3. Conclusion and further works

In order to verify the adsorption characteristics under a very low concentration of Q_2O, the test facility has been constructed. The MSB modules with various

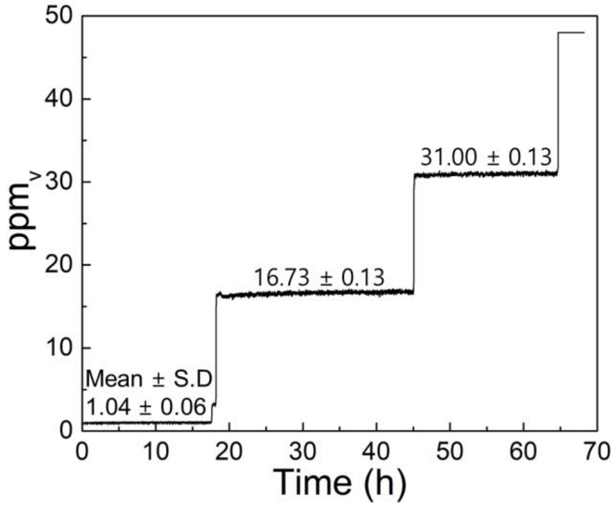

Fig 3. Stable vapor supply with 0.1mm evaporation tube. Concentration of vapor was controlled with valves. Helium flow rate was 5 slpm

geometry will be compared. Through the research, it is expected that more reliable MSB will be experimentally determined.

ACKNOWLEDGMENTS

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