Preliminary Experimental Results for Tritium Accountancy Measurement

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1. Introduction

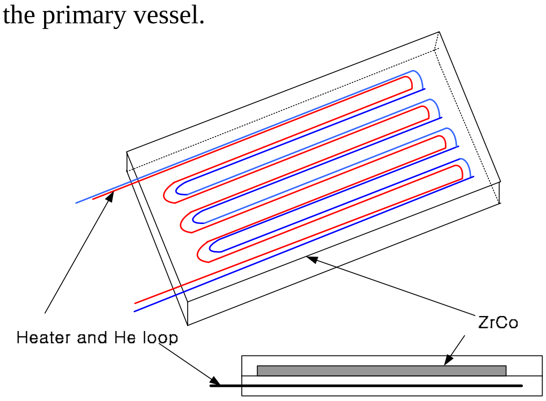
The SDS (storage and delivery system) is one of the major components of ITER fuel cycle. The main function of the SDS is to store the hydrogen isotopes and deliver them to the fuel injection system [1-3].

The tritium inventory of the bed is determined from the decay heat of the tritium without removing the inventory
from bed. The decay heat is measured by the in-bed calorimetry. He through the ZrCo bed and measuring the resultant temperature increase of the He flow. Korea has been various test results for the experimental ZrCo beds. Based on this result, we propose concept of tray type ZrCo bed. ZrCo was reacted with the hydrogen ingressed through SUS filter(120mesh) placed in the tray. The heating coils and the helium loop for the in-bed calorimetry are installed bottom of the tray.

In this paper, we performed thermo analysis on the in-bed calorimetry performance of the bed. Using the software, LABVIEW, the time-dependent temperature distribution of the bed, the temperature difference (Δ T) between the inlet and outlet of the flow through the helium loop.

2. Design concept of tray type bed

The SDS bed is composed of the primary vessel and the secondary vessel. The primary vessel contains the metal hydride (ZrCo) and a Vacuum layer is formed between primary and secondary vessel. The primary vessel measures 140mm in internal diameter and 267mm height. The vacuum layer thickness of 52mm with a single layer of radiation shield is examined in the present work. The structure of the bed is shown in Fig. 1. The tritium is assumed to be uniformly distributed in the primary vessel.



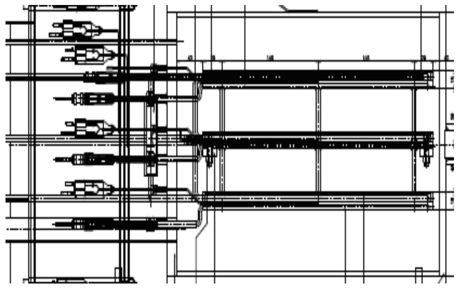


Fig. 1. Schematics of the ITER SDS bed.

The outer wall of the primary container is assumed to be adiabatic assuming that the adiabatic assuming that the radiative heat transfer from the outer wall has negligible
Influence on the time to the steady state; the specific heat of ZrCo and the heat transfer coefficient between ZrCo and He loop dominate the time to the steady state. Fixed mass flow rate and temperature boundary conditions are given to the inlet of the He loop. Relative pressure outlet boundary condition is given to the exit of the He. The pressure of He is 1atm.
In Table 1, the accountancy condition of preliminary experimental.

He gas circulation	Flow rate	3.8, 7.5 SLPM
	Pressure	40kpa
	Inlet temp.	308K
	He purity	99.9999%
Vacuum	Pressure	< 0.1 Pa, continuous evacuation
Decay heat simulation	Tritium(g) Input power	**$H_{0.5}$:** 12.5g (4.1w)
		$H_{1.0}$: 25.0g (8.2w)

Table 1. The accountancy condition

3. Operation condition of the in-bed calorimetry

An error propagation study for the calorimetric measurement of the tritium inventory is carried out for tritium inventories varying form 1 to 70g to determine the operating conditions satisfying the accuracy requirement of ±1g. The calorimetry is performed by measuring the temperature increase and mass flow rate of the helium loop. The error sources are the standard deviations of the mass flow rate and temperature measurements, which are ±1g and ±0.2K, respectively.
The decay heat of tritium recovered by He-loop is

obtain by the follow equation

$$Q = m \cdot Cp \cdot \Delta T \qquad (1)$$

Here, Q is the heat rejected by the He-loop: ΔT is the temperature difference of helium between the inlet and the outlet(T_{out} -T_{in}); m is the mass flow rate of helium; Cp is the specific heat of helium, here assumed as a constant; and the tritium inventory is calculated by;

$$I = \frac{Q}{Q_n} \qquad (2)$$

Where I is the tritium inventory (g); Q_n is the decay heat of tritium per gram .

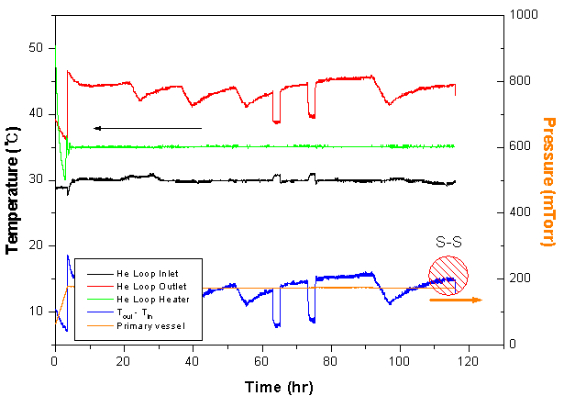
The deviation of measurement of ΔT is:

$$\partial(\Delta T) = = \sqrt{\partial T_{in}^2 + (\partial T_{ex} + \partial T_{SS})^2} \qquad (3)$$

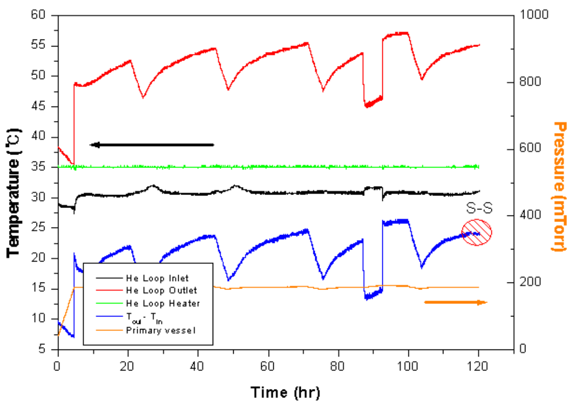
$\partial(\Delta T)$ is the deviation of measurement of ΔT (0.2K); ∂T_{in} is the deviation of He temperature at the inlet; ∂T_{ex} is the deviation of He temperature from the steady state. The inlet temperature is assumed to be constant at 308K [4].

4. Result

The time-dependent temperature change of the bed is monitered during in-bed calorimetry. Fig. 2 shows the change of temperature difference between the helium outlet and inlet (ΔT)of H_x (x= 0.5, 1.0) of tritium inventory of the primary vessel.



(a) $H_{0.5}$



(b) $H_{1.0}$

Fig. 2. Temperature variation during inventory ($H_{0.5}$, $H_{1.0}$) measurement

In this calculation, the temperature at the helium inlet (T_{in}) is fixed at 35℃ and ΔT in steady state (ΔT_{ss}) are 14.5℃($H_{0.5}$ condition) and 15.3℃($H_{1.0}$ condition). So the temperature at the helium outlet (T_{out}) in steady state are 44.8℃($H_{0.5}$ condition) and 55.1($H_{1.0}$ condition).

Acknowledgements

This work is supported by the Ministry of Education, Science and Technology of Republic of Korea under the ITER Project Contract.

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