Preliminary Test for the Design of the In-Bed Calorimetry of the ITER SDS Bed

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1. Introduction

In the International Thermalnuclear Experimental Reactor (ITER) storage and delivery system (SDS), SDS beds recover, store and supply DT fuel gases [1, 2]. One of the major roles of the SDS bed is a in-situ measurement of the tritium inventory by using tritium decay heat (0.32 W/g). In-bed calorimetric measurement method has been developed by T.Hayashi et al [3,4] by using a 1/10 scale ZrCo bed of the SDS bed. Objective of the present study is the development of a in-bed calorimetry design for a full scale SDS bed containing 70g tritium. This paper presents the results of the preliminary experimental tests performed by using a dummy SDS bed.

2. Experimental Setup

Fig.1 shows a three-3dimensional view of the internal structure of the dummy SDS bed. This bed is composed of primary and secondary vessels, which form pressure and tritium confinement boundaries. The primary vessel contains a large cylindrical filter, a cartridge heater, an inner helical He gas flow pipe, and a dummy powder (sand; particle size ~㎛) of ZrCo is loaded in the 7mm gap between the filter cylinder and the primary vessel. Outer helical He gas flow pipe is brazed on the grooved surface of the primary vessel. High vacuum zone between the primary and secondary vessels contains six thermal reflectors for a reduction of the radiation, convection and conduction heat loss from the primary vessel to the secondary vessel.

Fig.2 shows a schematic flow diagram of the test apparatus composed of two He gas circulation loops. Each loop comprises a gas transfer pump, a mass flow controller, a He gas inlet heater and so on. Thermocouples are placed in the He gas inlet and outlet nozzles of the SDS dummy bed to measure the temperature increase resulting from the decay heat simulating the heat. Table 1 lists the major design parameters of the dummy SDS bed.

Table 1: Mechanical design parameters of dummy SDS bed

Maximum design temperature [℃]	600
Maximum design pressure [MPa]	0.5 (internal)
Minimum design pressure [MPa]	Full vacuum
Number of Thermal reflector (SS316L)	6
Maximum Cartridge heater Power [kW]	1.5
Primary vessel (SS316L) [m]	Outer diameter: 0.196 Inner diameter: 0.19 Length: 0.37
Secondary vessel (SS316L) [m]	Outer diameter: 0.23 Inner diameter: 0.22 Length: 0.37
Filter cylinder (SS16L) [m]	Outer diameter: 0.176 Pore size < 0.5 ㎛
Inner helical He gas flow pipe (Cu) [mm]	Outer diameter: 9.5 Inner diameter: 7.6 Length: 6700
Outer helical He gas flow pipe (Cu) [mm]	Outer diameter: 3.1 Inner diameter: 1.8 Length: 6900

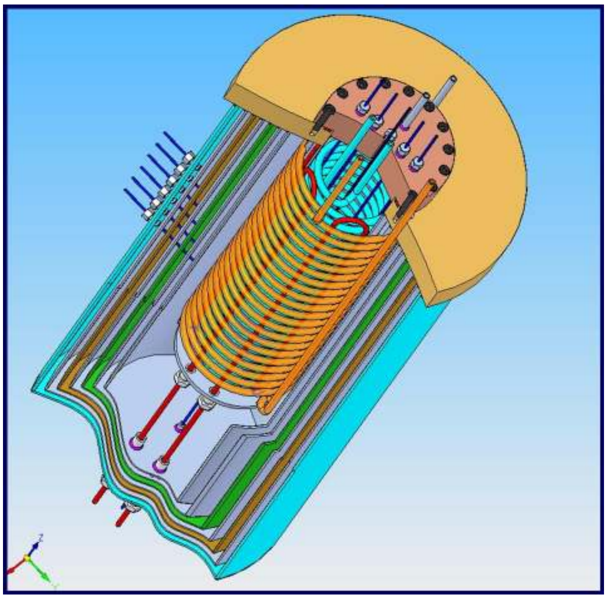

Fig.1. Three-dimensional view of the test bed

3. Results and Discussion

Preliminary measurement of a in-bed calorimetry was performed under a high vacuum ($< 10^{-4}$Pa in the high vacuum zone) with a constant He flow rate (5 L/min). He gas was filled in to the primary vessel to simulate a T_2 gas pressure equilibrated with the SDS bed temperature during a storage. Three heater input powers (50, 25 and 16W) was applied to simulate the decay heat of tritium (150g-T, 75g-T, 50g-T).

Table 2 and Fig.3 show the test results.

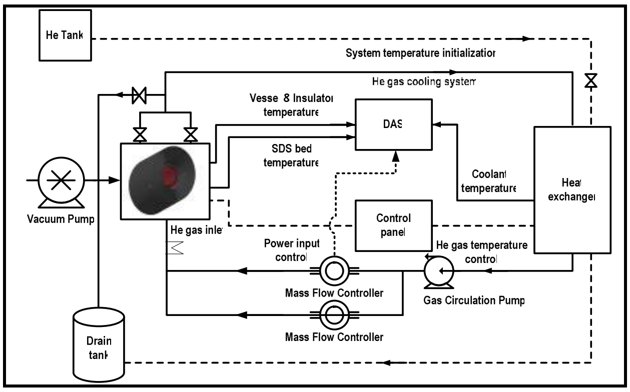

Fig.2. Schematic diagram of test loop

Table 2: Test result summary

Input Power [W]	He gas flow pipe		Inlet temp. [℃]	Temp. rise [℃]
	Location	flow rate [L/min]		
50	Inner	5	19.3	1.1
	Outer	5	19.3	1.6
25	Inner	5	18.1	0.9
	Outer	5	18.1	1.5
16	Inner	5	18.5	1.05
	Outer	5	18.4	1.9

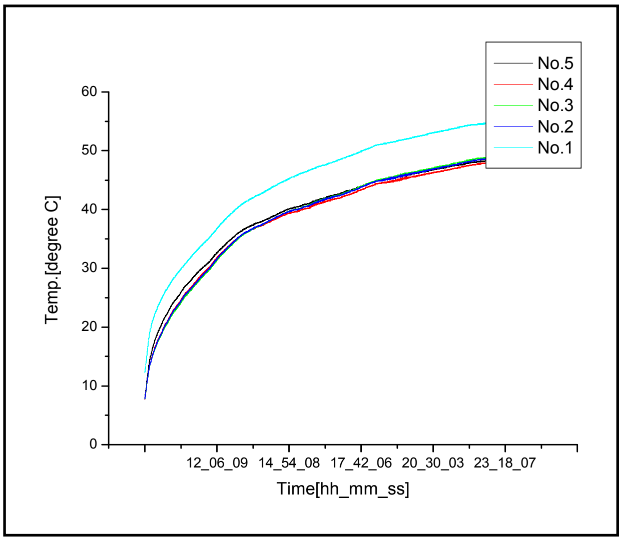

Fig.3. Inlet and outlet temperature profiles

4. Conclusions

From these preliminary tests, the following findings were obtained;

ⅰ. Outside of the primary vessel must be completely surrounded by thermal reflectors and a high vacuum zone to minimize a heat loss.

ⅱ. He back-fill pressure in the primary vessel has to be adjusted properly to simulate a equilibrium DT gas pressure in the SDS tritium storage bed.

ⅲ. Large contact surface area between the He gas flow pipes in the SDS bed and the primary vessel and filter cylinder have to be ensured to enhance the decay heat transfer to the in-bed calorimetry He loops.

iv. To obtain a satisfactory result, we are planning to fabricate a new test bed with careful design study and heat analysis of SDS bed during storage of 70g tritium.

Acknowledgements

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