Evaluation of Leakage from PCHE in Helium Cooling System

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1. Introduction

The utilization of PCHE(Printed Circuit Heat Exchanger) has continuously been increasing in the nuclear power industry[1-4]. PCHE, fabricated by using chemical etching and diffusion bonding method, consists of thousands of channels in a small volume[5]. Therefore, it has huge advantages in structural integrity and heat transfer. In addition, PCHE is applied to nuclear fusion reactor. HCS(Helium Cooling System) in ITER TBM (Test Blanket Module) [6,7] is one of the examples. Since the installation space of ITER TBM is very limited and the stability has been verified, PCHE is the optimal heat exchanger. The HCS removes the heat from the TBM by thecirculating helium. In the process, small amount of tritium is permeated. The possibility of tritium permeation through the steel plated should be validated in the environment that allows the inflow of radioactive materials. In addition, the minimum thickness of the plate to maximize the heat transfer is less than 1 mm. In this study, helium is used to experimentally verify the chronic leak between plates in PCHE.

2. Methods and Results

2.1. PCHE for chronic leak test

In this section, the geometry of PCHE for the tests is explained. The picture of the PCHE is shown in Fig. 1. The material is stainless steel 316L and dimension is 200 mm (L) * 50 mm (W) * 43mm (H). The heat exchanger consists of 40 steel plates etched with 1 mm semi-circle channels and two thick plate to protect both ends. In previous PCHE, there are several types of channels: straight type[8], zigzag type[9,10], S-foil[11,12], 3-D design[13] and so on.

A number of previous researches, which compare the heat transfer aspects of these models, have been conducted.[14, 15] Among them, the PCHE was built as a zigzag shape because it has high heat transfer efficiency and relatively small internal pressure drop. The first and second sides were both built with the internal header. The channels of each plate are in the cross direction and in zigzag shape with a slope of 15 degrees.

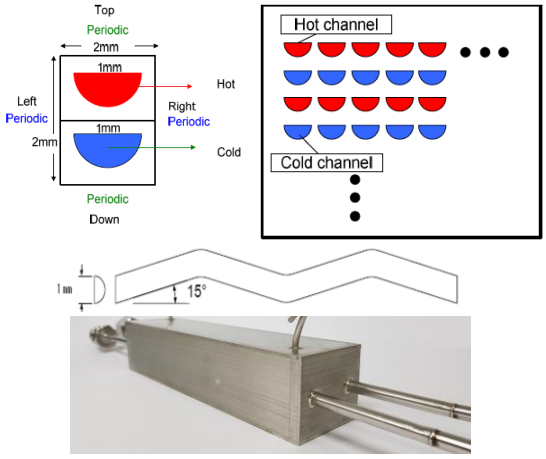

Fig. 1. Geometry of PCHE channels for chronic leak test

2.2 Test condition

The experimental conditions on each side were implemented in which chronic leaks are easy to occur. To determine the permeation of the helium from the primary side, the primary side was filled with 99.9999% purity helium and the secondary side will be kept at 10^{-9} mbar of vacuum. The Helium leak detector uses the ASM142 model of the Pfeiffer vacuum company. Fig 2 shows the data acquisition systems of helium leak detector.

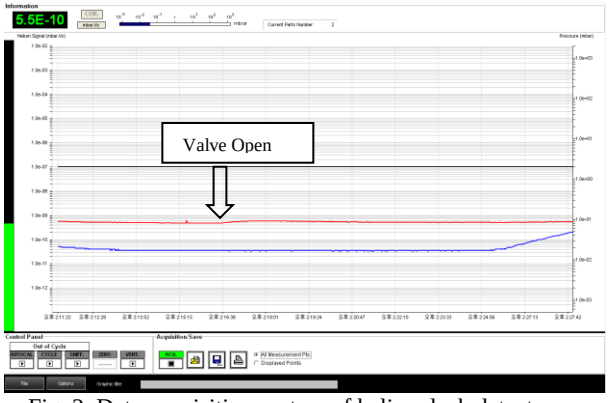

Fig. 2. Data acquisition system of helium leak detector

2.3 Pre-test and result

A pre-test was conducted, to determine if there's any part of the PCHE not bonded during diffusion bonding process, prior to measuring the permeation between the channels. The PCHE was placed in a helium

environment and the internal pressure of each side was maintained at 10^{-10} mbar, and the flow of helium from the outside was examined. Data was measured by leak detector's own software

As a result, the vacuum was well maintained and the vacuum level remained stable. The results are shown in the following table 1.

Table. 1. Vacuum PCHE for chronic leak test

Pressure[mbar]	Base pressure	Test pressure
Primary side	$5.1*10^{-10}$	$5.9*10^{-10}$
Secondary side	$9.5*10^{-10}$	$1.1*10^{-9}$

3. Conclusion and further works

PCHE is applied to HCS in ITER TBM. The possibility of tritium permeation through the steel plated should be validated in the environment that allows the inflow of radioactive materials to apply in Korean TBM. Before the chronic leak test, the pre-test was performed to check micro leak on the PCHE wall. As a result, the vacuum was well maintained. The chronic leak test is conducted in the environment with the initial 1 bar to a maximum of 40 bar. After pressurization, the helium permeated from the primary side is measured over time. The temperature conditions of both sides are set at room temperature. This experiment is currently under preparation and is planned to be proceeded.

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