Current Design of the Flange Type Hydrogen Permeation Sensor in Liquid Breeder

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1. Introduction

Tritium concentration measurement in liquid breeder is essential in order to study various tritium breeding technologies for development of fusion energy. There is, however, no commercial sensor for measuring tritium concentration in liquid breeder.

In 2004, A. Ciampichetti et al. [1] proposed a hollow capsule shape permeation sensor and they theoretically and experimentally evaluated the performance of the sensor made of Nb membrane at test condition of 500 ℃. However, the evaluation result showed the measured hydrogen permeation flux in the sensor much lower than the predicted one and they concluded that, the result is due to the formation of an oxide layer on the sensor membrane surface [1]. Three years later, A. Ciampichetti et al. [2] observed that a hollow capsule shape permeation sensor has too long response time to measure hydrogen concentration in liquid breeder. However, they suggested optimizing the sensor geometry with the reduction of the ratio 'total sensor volume/permeation surface' to overcome the low hydrogen permeating flux. Fig. 1 shows the optimized permeation sensor designs: an annulus type, cylinder with filling type, ultra-thin membrane type.

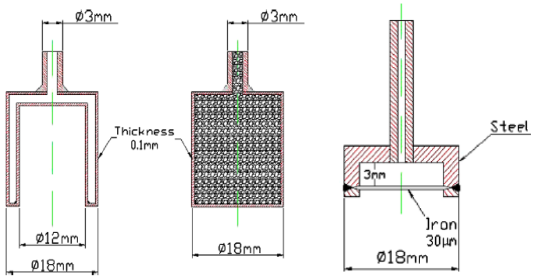

Fig. 1. The optimized permeation sensor [Ciampichetti et al., 2007, ref. 2]

In present paper, current design of the modified flange type permeation sensor is introduced and the sensor evaluation test plan is described.

2. Modified Flange Type Permeation Sensor

Lee et al. [3-6] considered previous researchers works and observations and then proposed the flange type permeation sensor with porous inner-structure to improve the 'sensor volume/surface' ratio and to avoid membrane oxidation due to welding process [3-4]. However, the flange type sensor had a problem with leak during verification test.

Fig. 2. The flange type permeation sensor with porous structure [Lee et al., 2013, ref. 4]

The previous flange type sensor adopted with CF (ConFlat) flange use a copper gasket and knife-edge flange to achieve an ultrahigh vacuum seal. In present application, however, it is difficult to sealing a knife-edge flange and a thin-membrane sheet especially various temperature operation environments (RT - 300℃). To solve these problems, C-ring spring metal gasket is adopted and modified the flanges as shown in figure 3.

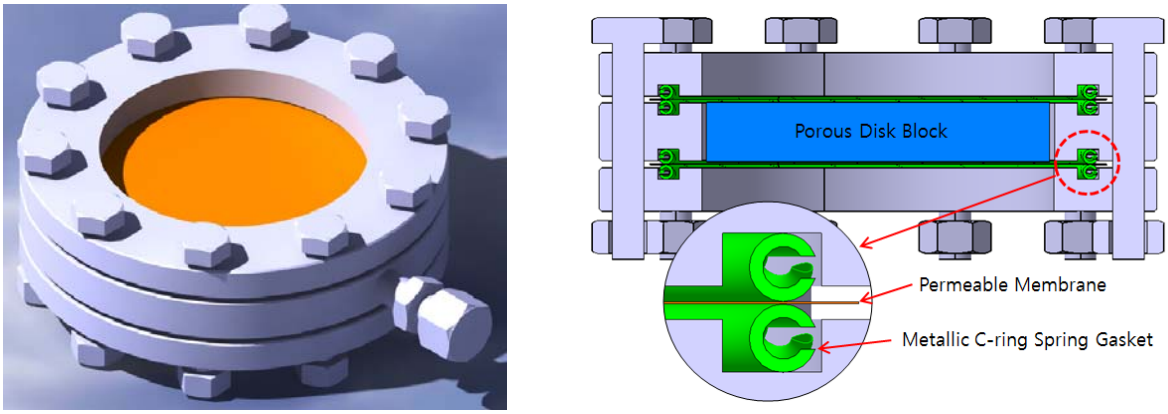

Fig. 3. The modified flange type permeation sensor design using Metallic C-ring Spring Gasket

3. Verification and Performance Test Plan

The modified permeation sensor will be evaluated its soundness (seal tightness) and performance (response time) in the vacuum test chamber under high temperature (~ 300℃) gas environment conditions [fig. 2, ref 3]. The evaluation test will be performed with 0.1, 0.2 mm thickness of pure iron, niobium, and tantalum membranes by end of 2015.

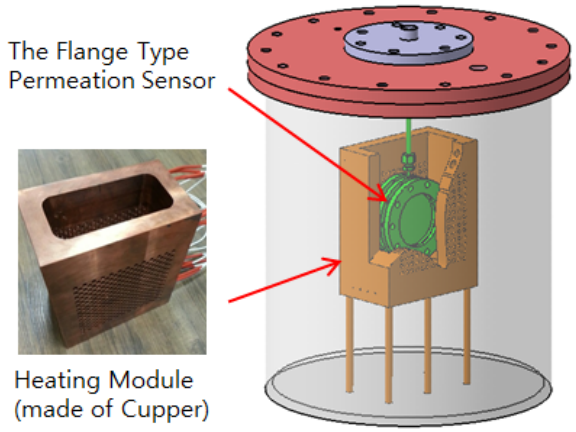

Fig. 2. Photograph and 3-D modeling of the vacuum test chamber and the heating module [ref. 3]

2. Conclusions

For development of the liquid breeding technologies in nuclear fusion, the permeation sensor to measure tritium concentration in liquid metal breeder has been developed. Lee et al. [3-6] proposed a flange type permeation sensor to dramatically reduce the ratio sensor ‘inside volume/permeation surface’ and to remove membrane welding during sensor manufacture process. However, the flange type sensor has problem with sealing.

In present study, the modified flange sensor design with a metallic C-ring spring gasket is introduced. The modified sensor will be verified and evaluated under high temperature conditions by end of 2015.

REFERENCES

[1] A. Ciampichetti et al., Materials selection and design of a hydrogen measurement device in Pb-17Li, J. of Nuclear Materials 329-333, pp.1332-1336, 2004.
[2] A. Ciampichetti et al., performance of a hydrogen sensor in Pb-16Li, J. of Nuclear Materials 367-370, pp.1090-1095, 2007.
[3] E. H. Lee et al., Development of a permeation sensor made of vacuum flanges to measure hydrogen isotopes in liquid metal breeder, Tran. of Korean Nuclear Society Autumn Meeting, Gyeongju, Korea, 2013.
[4] E. H. Lee et al., Development of a flange type hydrogen permeation sensor for liquid breeders, Tran. of 25th Symposium of Fusion Engineering, San Francisco, CA, USA, 2013.
[5] E. H. Lee et al., 수소 동위 원소 침투 장치, Patent in Rep. of Korea, No. of Patent: 10-1293482, 2013
[6] E. H. Lee et al., 플렌지형 수소동위원소 침투 장치, Patent in Rep. of Korea, No. of Patent: 10-1406868, 2014