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Status of development of the tritium permeation sensor for liquid breeder and performance test plan

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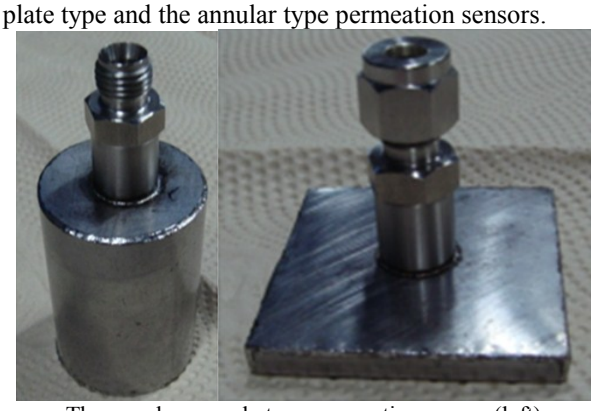
1. Introduction

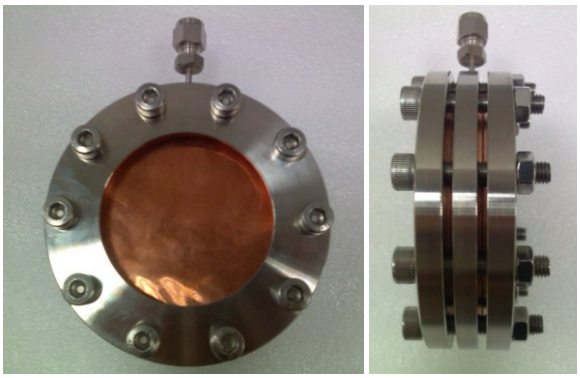
Tritium, used as fuel for DT reaction in fusion reactor, will be supplied from CANDU type nuclear power plants for ITER project. However, tritium self-sustainment is essentially required to operate commercial fusion power plants. Liquid lithium or lithium eutectic breeder blankets have been studied during past decades in order to develop tritium breeding technology in the fusion reactor [1-5]. For the development of the breeding technology, one of the key issues is how to measure tritium concentration in the liquid metal. Various kind of permeation sensors have been proposed in the world [6-7]; however the response time of the sensors still take too long to measure tritium (or hydrogen isotopes) simultaneously, so it is difficult to study tritium breeding related researches (such as tritium generation, extraction and permeation etc.). In Korea, several types of the permeation sensors were proposed to solve the response time problem and were tested to evaluate the performance of the permeation sensors [7]. In present study, status of development of the permeation sensors is briefly introduced and the performance test plan is described.

2. Design of the Flange Type Permeation Sensor

In Korea, the plate type and the annular type permeation sensor filled with porous structure were proposed based on the annular type permeation sensor developed in EU [8]. The proposed permeation sensors were designed thinner membrane and larger permeation surface per unit volume than the annular type permeation sensor to improve the response time and were filled with the porous structure to endure the hydraulic pressure of the liquid (metal) breeders. However, manufacturing the permeation sensors with thin membrane was difficult because it was hard to be welded between the thin membranes each other and welding heat cause surface oxidation, disturbed hydrogen permeation, on the membrane. In 2012, the flange type permeation sensor, overcome the manufacturing difficulty and the oxidation problem, were proposed [9]. This permeation sensor could be made of even thinner membrane (~ 0.1 mm) than any other permeation sensor. Figure 1 shows pictures of the plate type and the annular type permeation sensors.



The annular capsule type permeation sensor (left)
The plate type permeation sensor (right)



The flange type premeation sensor (present)

Fig. 1. Photographs of the hydrogen permeation sensors [9]

3. Verification and Performance Test Plan

The flange type permeation sensor has been tested to evaluate its soundness (seal tightness) and performance (response time) in the vacuum test chamber [10]. From the previous tests, the sensor was verified its seal tightness; on the other hand, hydrogen permeation was not observed because the evaluation tests were performed under room temperature. The test chamber has been modified with heating module made of cupper block in side of the test chamber in order to evaluate response time of the permeation sensor under high

temperature (~ 500℃) conditions, which is corresponded with the operational temperature of liquid breeders. The evaluation test under high temperature conditions will be performed by end of 2013 and then the flange type permeation sensor will be tested in liquid PbLi eutectic, mainly considered as the liquid breeder for fusion reactor in the near future.

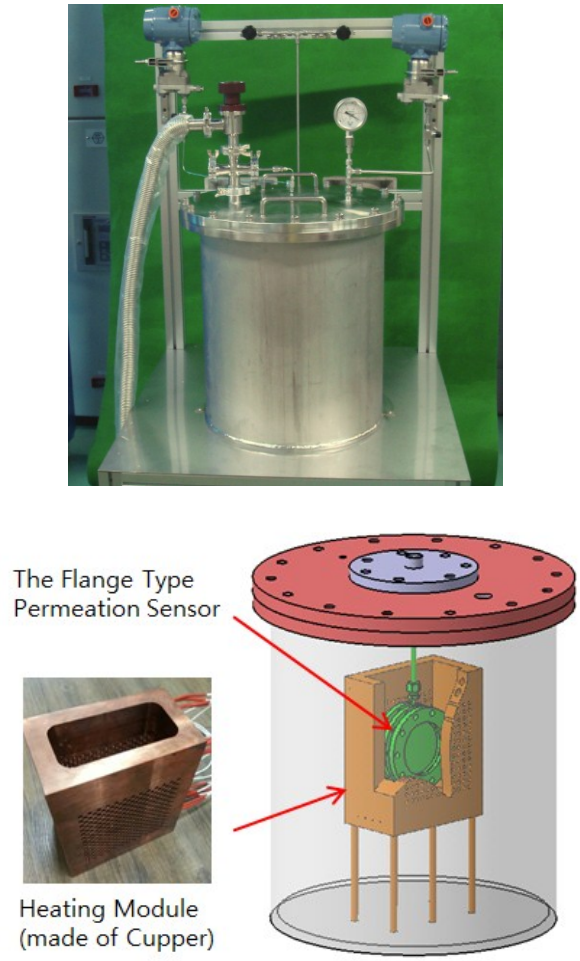


Fig. 2. Photograph and 3-D modeling of the test chamber and heating module

4. Conclusion and Further Works

In Korea, the flange type permeation sensor was proposed to improve the response time and manufacturing convenience of the sensor. The permeation sensor was tested to proof its advantages than other permeation sensors in the vacuum test chamber; however, evaluation of the sensor response was failed because of no heating module in the test chamber for high temperature test. The test chamber has been upgraded with heating module to evaluate the response time of the flange type permeation sensor under high temperature of liquid breeders operation conditions. The evaluation test will be performed by end of 2013 and verification test in the liquid PbLi eutectic will be prepared in the near future.

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