§18. Tritium Balance in a DT Fusion Reactor

Katayama, K., Nishikawa, M., Matsuda, S., Fukada, S. (Kyushu Univ.),
Masuzaki, S.

Tritium consumed in the plasma vessel of a DT fusion reactor must be supplied from the breeding blanket system through the main fueling system to maintain the self-sustainable DT nuclear burning. The tritium balance in a DT fusion reactor has been discussed by Nishikawa[1-3] by comparing the amount of tritium consumed in the fueling cycle including the vacuum vessel with the amount of tritium supplied from the blanket system taking the effect of tritium trapped to re-deposition layer of the plasma facing material, the effect of permeation loss through wall of the vacuum vessel and the effect of tritium decay in inventory into account. The evaluation of tritium permeation loss in the blanket system is an important issue. It has been known that water vapor is released from solid breeder materials by the desorption of adsorbed water and the water formation reaction between the oxygen in the breeder and the hydrogen in the purge gas. However, tritium permeation behavior through ferritic/martensitic steel F82H on which oxide layer is formed has not been understood to date. In the present work, hydrogen permeation experiments by using F82H tubes with and without oxide layer were carried out.

Hydrogen permeation experiments were conducted by the co-current double tube method. The schematic diagram of experimental apparatus is shown in Fig.1. F82H tubes, which were supplied from Japan Atomic Energy Agency (JAEA), were used as a sample tube. The sample tube is concentrically placed in a quartz tube, 22.0 mm in inner diameter. Ar gas was introduced in the inner channel and 10% H_2/Ar gas was introduced in the outer channel. Hydrogen concentration in the outlet gas of the inner channel of the sample tube was measured by a gas chromatograph. Two kinds of F82H tubes were used in this experiment. One is the F82H tube which had been exposed in the atmosphere for about one year after the hydrogen permeation experiment with water vapor. The presence of oxide layer on the surface was confirmed by SEM observation. The other is the F82H tube which is fresh.

Fig.2 shows hydrogen permeability for each sample and indicates that the influence of oxide layer on hydrogen permeation is negligible. This means that the permeability obtained in dry hydrogen gas condition can be applied for consideration of tritium balance in a fusion reactor. The value is close to the Serra's data[4]. The permeation experiment at 800 ^oC was carried out and then it was performed at lower temperatures. The obtained permeability was considerably smaller than that obtained before 800 ^oC-heating as shown in Fig.3. This is caused by phase transformation. It is speculated that a portion of ferritic/martensitic structure transformed to austenite structure. When the temperature of F82H reaches 800 ^oC in a severe accident including loss of coolant, tritium permeation will be suppressed by the phase transformation.

1) Nishikawa, M., et al., Fusion Nucl. Des., **85** (2010) 987.
2) Nishikawa, M., Fusion Sci. Tech, **57** (2010) 120.
3) Nishikawa, M., Fusion Sci. Tech, **60** (2011) 1071.
4) Serra, E., et al., Mater. Sci. Tech., **14** (1998) 573.

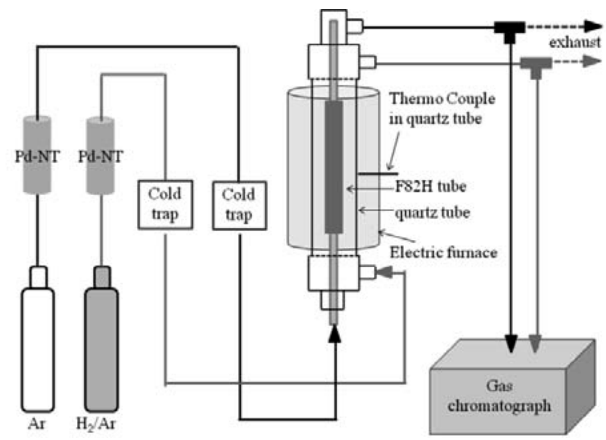

Fig.1 The schematic diagram of the experimental apparatus.

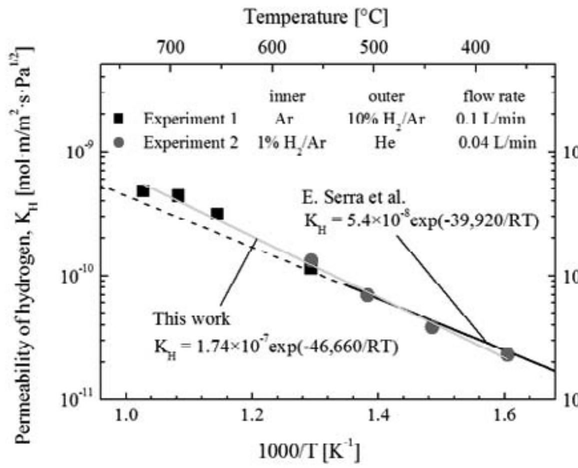

Fig.2 The permeability of hydrogen through F82H with (■) and without (●) oxide layer.

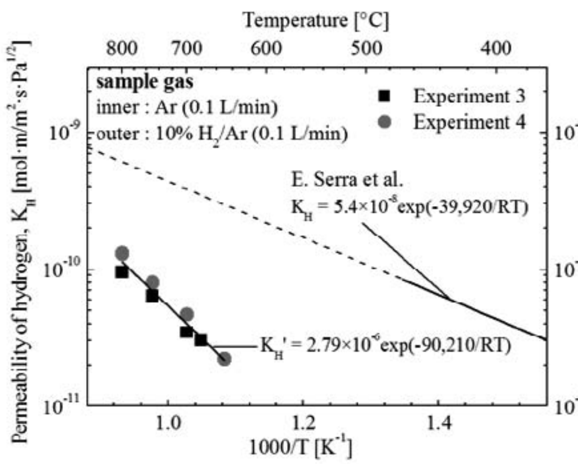

Fig.3 Hydrogen permeability after 800^oC-heating.