§1. Studies on Permeation Behavior of Tritium in Cooling Piping Material

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i) Introduction

Stainless Steels (SS-304, 316 etc) are expected to be used as various component materials like cooling pipe in fusion reactors due to their good mechanical properties and corrosion resistance. Elucidations of tritium behaviors in stainless steel, especially, the clarification of the permeation behavior of tritium in the stainless steel is important from the viewpoint of the tritium safety for DD discharge experiment in LHD. In this study, the tritium permeation behavior in various temperature regions assumed with an actual device in stainless steel was evaluated at low temperature region. As the fundamental experiment, permeation experiment was carried out using the deuterium.

ii) Experimental

The SS-316 samples with the thickness of 0.1 mm^t were used. Deuterium permeation experiment was carried out by the permeation analysis system that was designed and established in Shizuoka University. To remove the surface oxide layer, the sample was pre-heated at 673 K before experiment under the vacuum. Thereafter, the samples were heated at 373-673 K, and deuterium was introduced into the chamber in the pressure of 10 Pa and permeated deuterium was integrated for 6 h in the exposure time. Thereafter, permeated deuterium was measured by QMS.

iii) Results and discussion

Figure 1 shows the amount of permeated deuterium in various deuterium chemical forms at the temperature up to 673 K.

It was found that the major chemical form of deuterium was gas form like HD and D_2. In addition, water form of HDO or D_2O was hardly released. It was thought that this result is an effect of removing the surface oxide layer. Therefore, it was considered that the deuterium released as HDO or D_2O would be released by recombination with residual oxygen in the oxide film which was not removed by pre-treatment. The present experimental results indicate that permeation behavior of tritium below 373 K would be able to estimate by this experimental setup according to the result of temperature dependence experiment. At high temperature region, it was found that the amount of HD or D_2 increased, indicating that the reduction of oxygen concentration on the sample surface induced that gas (HD or D_2) desorption. Moreover, results of this experiment were well fitted to the Arrhenius plot. As a result, activation energy of permeated deuterium was 0.30±0.01 eV. It is considered that this value can be used to permeation experiment of the tritium in the future. As the next stage, exposure pressure dependence experiment will be carried out based on the findings of this study and the permeation behavior of tritium will be clarified. Additionally, the hydrogen isotope adsorption/desorption behavior on the surface of the oxide layer will be revealed by the FT-IR measurement.

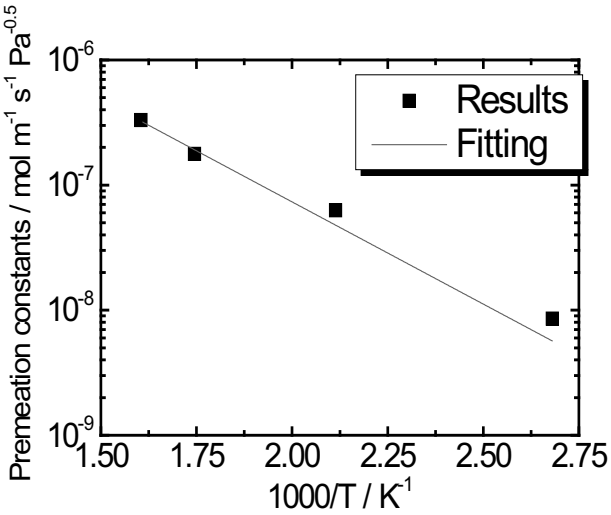

Fig.1 Chemical forms of permeated deuterium

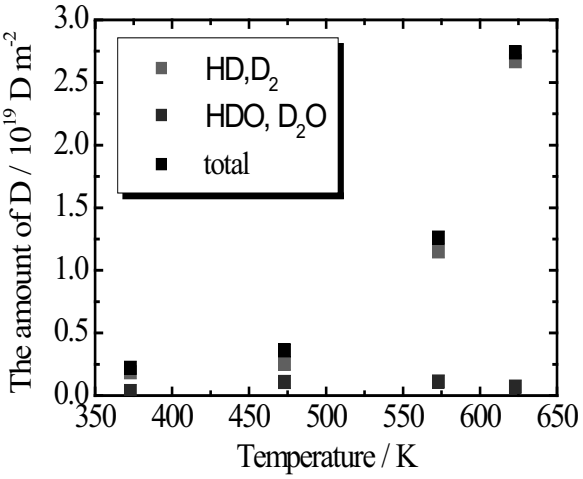

Fig.2 Arrhenius plot to the permeation constant at temperature dependence experiment