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FUNDAMENTAL STUDY ON MIXED BEHAVIOR OF H_2 AND VAPOR IN A STORAGE CONTAINER WITH A NEWLY DEVELOPED CATALYST

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Abstract: On the decommissioning of Fukushima Dai-ichi nuclear power plant, fuel debris is packed to radioactive waste long-term storage containers. When the fuel debris includes water, since hydrogen (H_2) and oxygen are produced by radiolysis of water, H_2 concentration in the container increases. Passive Autocatalytic Recombiners (PARs) which is high performance on H_2 treatment are developed to reduce the H_2 concentration. The present study was conducted to confirm the effectiveness of H_2 concentration reduction by the presently developed PARs. From the results, it was found that the current PAR can effectively reduce the H_2 concentration.

Keywords: *Hydrogen, PAR, Storage container, Reduction of concentration, Development.*

1. INTRODUCTION

In the decommissioning of nuclear power plants, fuel debris picked up ftom the bottom of the reactor vessel is inserted in a radioactive waste long-term storage container and stored. In the process, since hydrogen gas is produced by radiolysis of water [1], it is important to ensure the safety of the waste storage container to reduce the concentration of H_2 gas, and to keep below the explosion limit. So, we are developing new PARs to reduce H_2 concentration in the storage containers. The currently developed PARs have features of compact and high H_2 treatment performance in comparison with the conventional ones. Therefore, the present study was begun to confirm that the storage container with the currently developed PARs is effective to reduce the H_2 concentration. This paper describes the results of the experiments on the reduction of H_2 concentration and the preliminary numerical simulations.

2. EXPERIMENTS

2. 1. PARs and experimental conditions

In order to verify the effectiveness of PAR, the present experiments were carried out. Two types of PAR were used: One is the alumina-made PAR which consists of alumina particle with a diameter of 5-20 mm and includes platinum of 0.5-1wt%; and, the other one is the ceramic-made PAR which is base on the ceramic round plate with a diameter of 70 mm and thickness of 10 mm and includes platinum, paladium and rhodium of of 0.045wt%. The outline of an experimental container is shown in Fig. 1. The major experimental conditions were as follows: hydrogen gas flow rate, 50-200 cc/min; H_2 injection time, 50-200 min; initial temperature and pressure of the experimental continer, 40 degree Celsius and atomosphere pressure; and, there are no simulated debris inside the container. The H_2 concentration and humidity are measured by two sensors as shown in Fig. 1. After H_2 gas injection was stopped, the experimental container was maintained more than two hours to record every data of H_2 concentration, relative fumidity, pressure, fluid temperature and wall temperature.

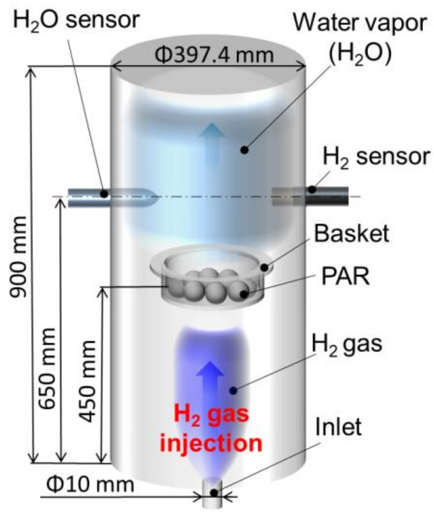

Fig. 1 Internal configuration of an experimental container

2. 2. Experimental results and discussion

Figure 2 shows time variations of H_2 concentration at the ceramic-made PAR condition. There are the results of three cases on H_2 flow rate; 50 cc/min x 200 min, 100 cc/min x 100 min, 200 cc/min x 50 min. Here, three solid lines show H_2 concentrations and three dashed lines show the relative humidities. In every case, H_2 concentration increased as soon as the H_2 gas is injected, and it decreased immediately after the H_2 gas injection stopped. Moreover, the humidity increased very quick with the H_2 gas injection.

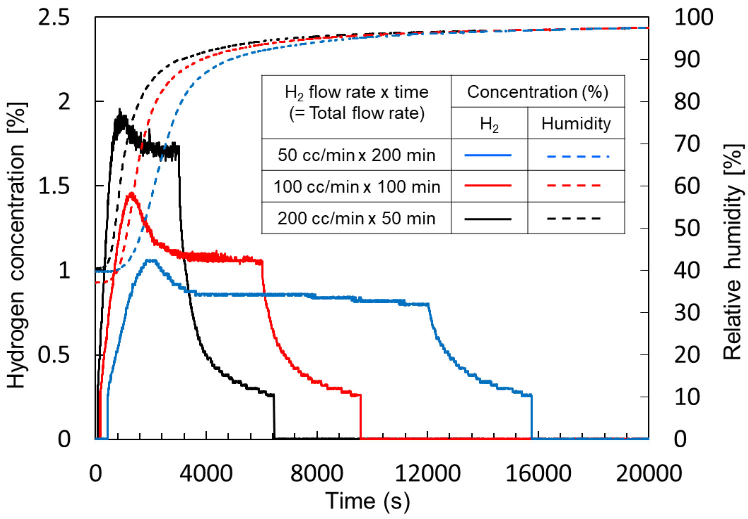

Fig. 2 Time variations of H_2 concentration at the ceramic-made PAR condition

3. NUMERICAL ANALYSIS

The preliminary numerical analyses were to evaluate the experimental results and confirm the hydrogen behavior in the experimental container. The analytical conditions are as follows: three-dimensional cylindrical coordinate with the iniform mesh division was applied; Arrhenius equation was used to calculate the reaction rates [2] of H_2 and O_2; The continer inside is initially filled with air of 40 degree Celsius and atomosphere pressure; and, H_2 is injected from the container bottom. In the analysis the ANSIS-Fluent was used as a solver.

Figure 3 shows the predicted H_2 and H_2O mass fractions at 5, 10 and 30 s after the H_2 gas was injected. H_2 rises straightly and contacts with the PAR. Vapor (i.e., H_2O) is produced as soon as H_2 contacts with the PAR and then vapor stagnates gradually with time in the upper area of the PAR as a mixture with air.

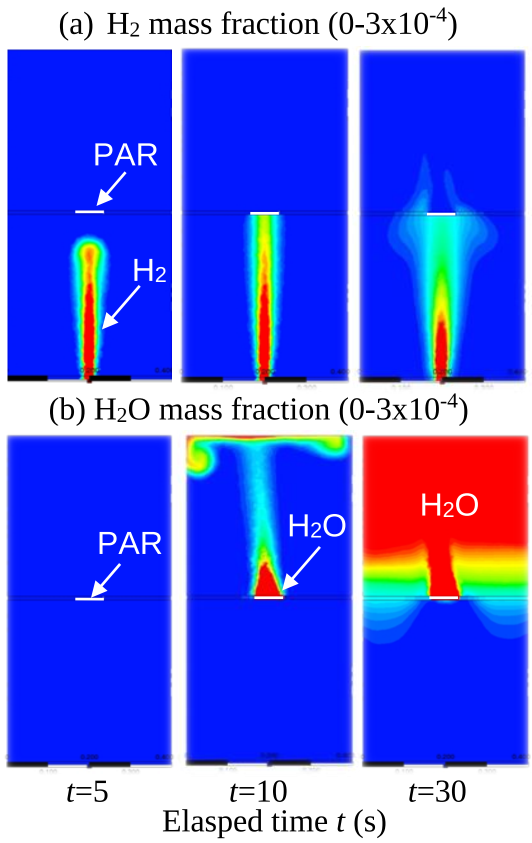

Fig. 3 Predicted H_2 and H_2O mass fractions after 5, 10 and 30 s from the calculation

3. CONCLUSION

From the present study, tthe effectiveness of the newly developed PARs was confirmed by the demonstration experiments and the H_2 and H_2O behavior in the container was predicted by analyzeing the chemical reaction of H_2 and O_2. In the near future the comparison of experimental and numerical results on the mixed behavior of air, H_2 and vapor will be performed.

4. REFERENCES

1. A.O. Allen, *The Radiation Chemistry of Water and Aqueous Solutions*, Van Nostrand, N.Y. (1961).

2. C. K. Westbrook, F. L. Dryer, Simplified reaction mechanisms for the oxidation of hydrocarbon fuels in flames, *Combustion science and technology*, 27(1-2), 31-43 (1981).