Reaction Calculation of Liquid-depth Effect on Radiolytic Hydrogen Generation by using a One-dimensional Model

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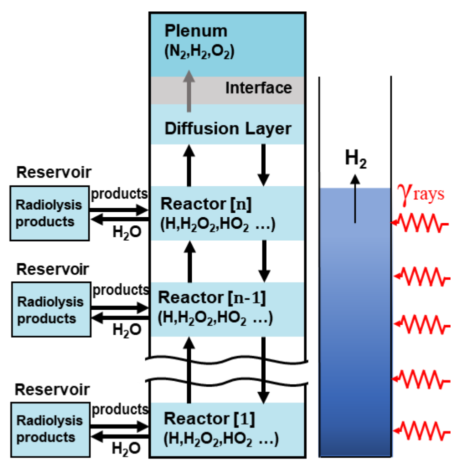
We tried to calculate the liquid-depth effect on hydrogen (H_2) generation by water radiolysis to build a one-dimensional (1D) reaction model in the vertical direction based on the open-source software CANTERA. The division of reaction cells was found to be important in the calculation. As the division number increased, the slope of the increase in the amount of H_2 generated with respect to the absorbed dose became smaller, and was compared with the experimental result.

Keywords: Water Radiolysis, Hydrogen Generation, Liquid Depth Effect, Reaction Calculation, CANTERA.

1. Introduction

H_2 generation by water radiolysis is a serious concern in the 1F severe accident and subsequent decommissioning processes. For the H_2 safety in the storage of wet radioactive materials, not only the experimental but also analytical studies on H_2 generation from water radiolysis are important. Until now, we have conducted those closely related to the 1F by the experiments for the effects of seawater salts, liquid depth and temperature [1], and by the calculations for the effect of liquid flow [2].

In this study, we tried to calculate the liquid-depth effect on the radiolytic H_2 generation, in which the H_2 amount deceases with increasing the depth, to build a 1D reaction model and then elucidate the effect.



(a) Calculation (b) Experiment

Figure 1 Modeling of reaction system based on experimental one (b).

2. Calculation Method

Reaction calculations were performed based on CANTERA [3]. The 1D reaction model was build based on the experimental system [1] for the effect of liquid flow on water radiolysis [2] as shown in Figure 1. The calculation domain was divided into individual reactors (reaction cells) and the number of divisions was set to be variable.

The primary radiolysis products were supplied from each reservoir to the respective reactor, and reversely, H_2O corresponding to the amount of products were discharged in the opposite direction. The products were assumed to move between the reactors at a mass flow rate corresponding to their diffusion coefficients. The gas products were released from a diffusion layer into a plenum through an interface.

3. Results and Discussion

Figure 2 shows the calculated result of H_2 generation from radiolysis of pure water at 8 cm height by low LET (linear energy transfer) radiations such as Co-60 γ-ray. The experimental result [1] is also shown in Fig. 2.

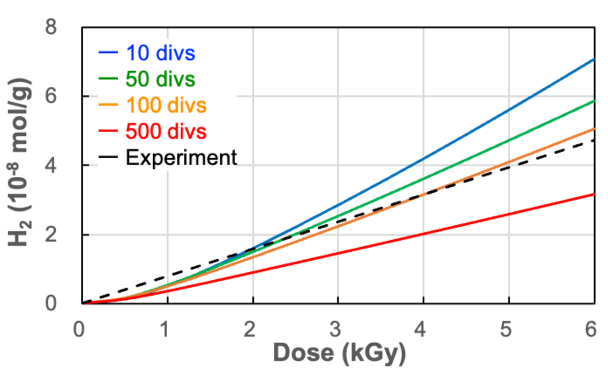


Figure 2 Calculated H_2 generation from radiolysis of pure water at 8 cm height by low-LET radiations.

The calculated result was found to depend on the division number of water involved in the radiolysis. As the division number increased (the height of reaction cell decreased), the slope of the increase in the generated H_2 amount with respect to the absorbed dose by the water became smaller and approached to the experimental result. However, when the number exceeded 100, the calculation results were underestimated under the current experimental and calculation conditions.

References

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