

§25. Design Support and Sophistication of Trapping and Recovery System for Low-concentration Gaseous Tritium

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It is planned to conduct deuterium plasma experiments in National Institute for Fusion Science (NIFS). In these experiments, D-D fusion reactions take place and tritium is produced, and thus the release of tritium to the environment has to be minimized. Thus, there is a necessity that the tritium recovery system with large-scale and higher integrity is developed and constructed. For this purpose, it is required to obtain and accumulate updated database for chemical engineering design by testing most recently commercial and available catalysts and adsorbents in experiments. In this work, we selected an adsorbent and examined its adsorption characteristics for water vapor.

The experiments were performed under the steady state condition. The catalysts were packed in a reactor made of quartz. The argon gas containing hydrogen (about 300-800 ppm) and oxygen (20%) was introduced to the reactor. Experiments were also performed using wet process gases which contained water vapor (about 300-1000 Pa) in order to study the influence of coexistent water vapor on the catalytic activity for oxidation of hydrogen. The authors studied adsorption behavior of water vapor on the DASH520 catalyst and MS5A adsorbent, as well.

The mass transfer capacitances for oxidation of hydrogen of DASH520 was quantified and the adsorption isotherms of water vapor on the DASH520 catalyst and MS5A adsorbent were correlated using a sort of multi-site Langmuir-Freundlich equation. Experimental results on the catalytic oxidation of hydrogen in wet gases reveal that coexistence of water vapor severely inhibits the catalytic oxidation of hydrogen. It was found that the mass transfer coefficient for catalytic oxidation in wet gases is expressed as a function of the amount of water adsorbed on the catalyst substrate.

In D-D experiments in NIFS, (a) detritiation of vacuum vessel purge gas and (b) plasma exhaust gases is required. Numerical simulation was performed for both cases. Figure 1 shows changes in the concentration of molecular from of tritium in the outlet stream of the catalyst bed for the case (a). With regard to the temperature of inlet gas, three cases (30 °C, 100 °C and 200 °C) were tested. I can see that catalytic activity is considerably decreased in the cases where the inlet gas temperatures are 30 °C and 100 °C. This is because that water vapor contained in the process gas inhibits catalytic activity with increase in the amount of water adsorbed on the catalyst substrate. However, this effect could be considerably avoided if the inlet gas

temperature is raised to 200 °C as shown in the figure. Subsequent numerical simulation for condenser and polymer membrane-type dehumidifier was performed in the case where the inlet gas temperature is raised to 200 °C. Figure 2 shows changes in amounts of bulk water and concentration of tritiated water in drain tank. The amount of bulk water increases almost linearly with lapse time. The concentration of tritiated water increases in the same trend.

In conclusion, catalytic oxidation rate of hydrogen and water adsorption characteristics are investigated for commercial catalyst and adsorbent. Based on the experimental results, simulation models were constructed for catalyst bed, adsorption bed and polymer-type membrane dehumidifier. Test process simulations were carried out on the basis of the detritiation systems designed in NIFS.

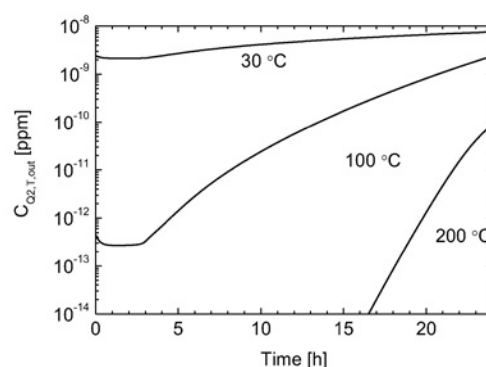


Fig. 1 Change in concentration T_2 in outlet stream of Pt/alumina catalyst bed

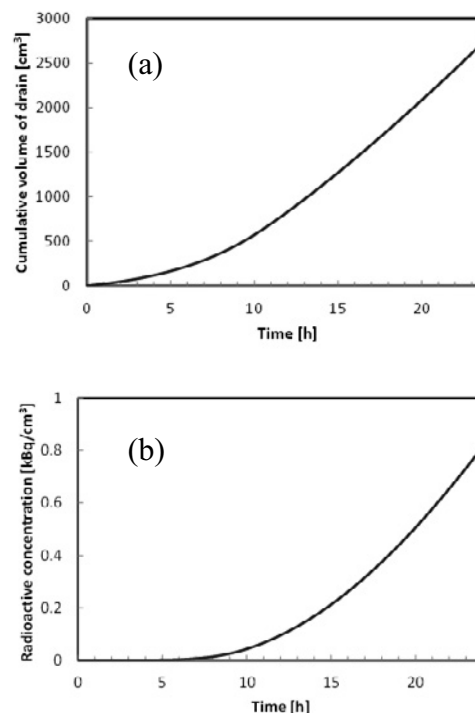


Fig. 2 Change in (a) amount of bulk water and (b) concentration of tritium in drain tank