§1. Effect of Oxygen Concentration on Hydrogen Combustion by Pt-Al_2O_3 Catalyst for a Vacuum Exhaust Gas Processing System

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The study of fusion energy is making progress over the past few decades. Then the operational gas of fusion test devices changes from hydrogen gas to deuterium gas or deuterium/tritium gases in order to obtain high performance plasma. Under the deuterium plasma operation, a small amount of tritium is generated in the vacuum vessel. The tritium will be exhausted with operational gas from the fusion test device via the vacuum pumping system. Because tritium is a radioactive isotope of hydrogen, it has to be managed safely in accordance with laws and regulations. As one of the tritium processing techniques for vacuum exhaust gas from fusion test device, the combination of catalytic oxidation reactors and water vapor absorber is the candidate methods. However, the vacuum exhaust gas does not contain oxygen gas. Then, hydrogen gas cannot be oxidized in the catalytic oxidation reactors without oxygen gas. On the other hands, the hydrogen has a large heat of combustion and is accompanied with a danger of explosion when the hydrogen concentration in air is more than 4%. Therefore, it is necessary for hydrogen combustion to dilute the hydrogen concentration less than 1% by dry air for safety combustion and adjust oxygen gas concentration. In this report, for the purpose of treatment of hydrogen gas in the vacuum exhaust gas by the technique of catalytic oxidation and water vapor absorb, the effects of oxygen concentration on hydrogen combustion by a commercially available platinum catalyst are evaluated.

The test sample of platinum catalyst, DASH520, is purchased from N.E. CHEMCAT Co. Ltd. The substrate of catalyst is Al_2O_3 and has a spherical shape with a 2 to 3 mm diameter. The density of precious metal on the catalyst was about 4 g/L. It has been evaluated the hydrogen oxidation performance in air.[1)] The volume and weight of catalyst sample in the reactor bed is ϕ15 mm x 13mm and 2.0 g. A schematic diagram of atmospheric pressure fixed bed flow type reactor is shown in Fig.1. The gaseous of both hydrogen and oxygen is diluted with dry air or nitrogen gas. The gas concentrations were adjusted approximately 0.1% of hydrogen and 4.7%, 10%, 21% of oxygen. The flow rate of mixture gas was approximately 1000 sccm measured by a file flow meter. The electric furnace was controlled by a programmable temperature controller with a thermocouple on the heater and heated up in stepwise to over 150^{o}C. Process gases were sampled at the inlet and outlet of the catalyst bed and their concentrations were analyzed by a gas chromatograph. The conversion rate, C[%], is defined by following equation:

$$C = \frac{C_{in} - C_{out}}{C_{in}} \times 100, \qquad (1)$$

where C_{in} is the hydrogen gas concentration at the inlet of the catalyst bed, and C_{out} is the hydrogen gas concentration at the outlet.

Figure 2 shows the effects of oxygen concentration on the hydrogen conversion rate at room temperature. The degradation in the catalytic activity is observed for the increase of oxygen gas concentration. The oxygen adsorption onto the catalysis surface would increase with oxygen partial pressure. Thus, the inhibition effect by oxygen molecule might arise from the adsorption on the catalysis surface. In the vacuum exhaust gas processing system which requires the dilution of hydrogen and the adjustment of oxygen concentration, it is found that oxygen gas is not necessarily a high concentration. From the viewpoint of the safety hydrogen combustion, hydrogen concentration should be diluted less than 4% and sufficient oxygen would be supplied to satisfy the oxygen requirement for the hydrogen combustion.

1) Uda. T., Fusion Sci. Technol., **48**, (2004), 480.

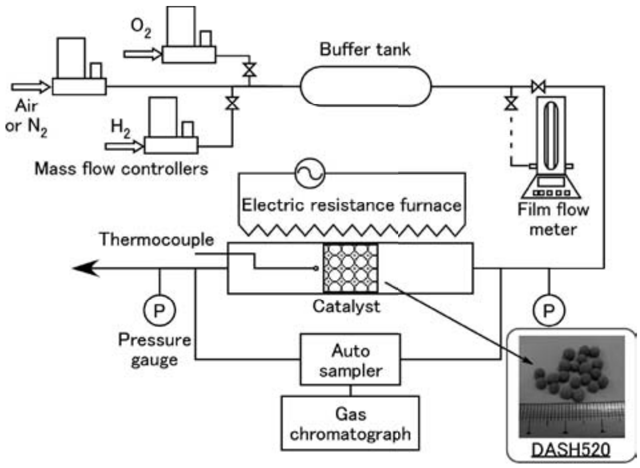

Fig. 1. A schematic diagram of atmospheric pressure fixed bed flow type reactor

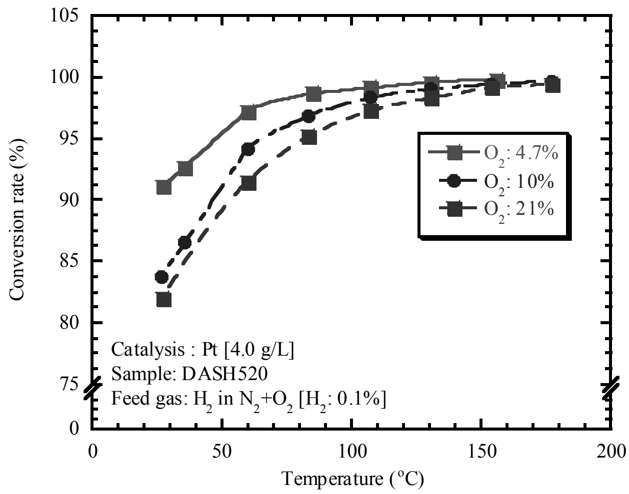

Fig. 2. The effects of oxygen concentration on the hydrogen conversion rate at about room temperature.