§7. Comparison of the Oxidation Characteristics of Metal Honeycomb Catalyst with Difference Sizes

Tanaka, M., Uda, T.

Tritium removal system for the processing of exhaust gas from LHD under the deuterium plasma experiment is oxidation of tritiated hydrogen and hydrocarbon to water by packed type catalytic oxidation reactors, followed by adsorption process on a molecular sieve bed. The maximum flow rate for the processing of exhaust gas is 300 m^3/h. To process the exhaust gas with high throughput, we have proposed the honeycomb catalyst which has low pressure drop and high reaction rate. In the previous reports, we have evaluated the oxidation performance of various types of catalyst under various conditions. As the results, it was found that the honeycomb catalyst had same or higher oxidation performance than a conventional particle type catalyst. For the next stage of development, we intended to develop the larger honeycomb catalyst system with an internal heating for practical application.

The test sample of metal honeycomb catalyst is purchased from Tanaka Kikinzoku Kogyo K.K. Specific dimensions of the honeycomb is 56 mm in diameter and 50 mm in length. The support material of honeycomb was 20Cr-5Al-Fe with wash coat. The honeycomb cell density was 400 CPSI (cell per square inch). Palladium precious metal was impregnated by use of solution of it on the surface of honeycomb. The density of precious metal on the honeycomb was 4 g/L.

To examine the oxidizing catalyst, the sample gas is blended with hydrogen and methane gases and an air gas. The gas components were adjusted approximately 0.1% of hydrogen and methane in dry air. The temperature was measured by a thermocouple on the central axis of the front and the rear of catalyst. The heater was controlled by a programmable temperature controller with a thermocouple on the heater. The temperature was kept at a constant value for 2.5 h at each step. The catalyst could be heated up to about 400 ◦C. The mixture gas flow rate was 70 NL/min. The specific gas flow rate: Sv was around 9.5 s^{-1} (4300 h^{-1}). Process gases were sampled at the inlet and outlet of the catalyst bed and their concentrations were analyzed by a gas chromatograph.

From the experimental data of oxidizing efficiencies, decontamination factor K is shown as a function of temperature and the packing volume of the catalyst bed for the tritiated gas treatment system can be calculated using the following equation:

$$K = \frac{C_{in}}{C_{out}} = \exp\left(\frac{k \times V_{cat}}{Q}\right) \quad (1)$$

where K is the decontamination factor at oxidation (DF), C_{in} is gas concentration at inlet of catalyst bed, C_{out} is gas concentration at outlet of catalyst bed, k is the reaction rate constant (1/s), V_{cat} is the volume of catalyst (m^3), and Q is the volume flow rate (m^3/s). Then, the activation energy E_a is calculated by the Arrhenius equation:

$$k = A \exp\left(\frac{-E_a}{RT}\right) \quad (2)$$

where, A is pre-exponential factor, R is gas constant, T is temperature.

Figure 1 shows the comparison of the Arrhenius plots of oxidization performance between small- and large-size catalysts. Although the estimated activation energy was almost the same in spite of the catalyst size, the reaction rate constant k of large size catalyst is smaller than that of small size catalyst. In the experimental system for small size catalyst, the catalyst was set up in an electric furnace and had the uniform temperature distribution. On the other hand, in this experimental system for large size catalyst, the radial temperature distribution was non-uniform because of the internal heating method and an insufficient thermal insulation. Therefore, the large size catalyst would have apparently small reaction rate constant. An external heating system around the catalyst will be installed for the improvement of temperature distribution.

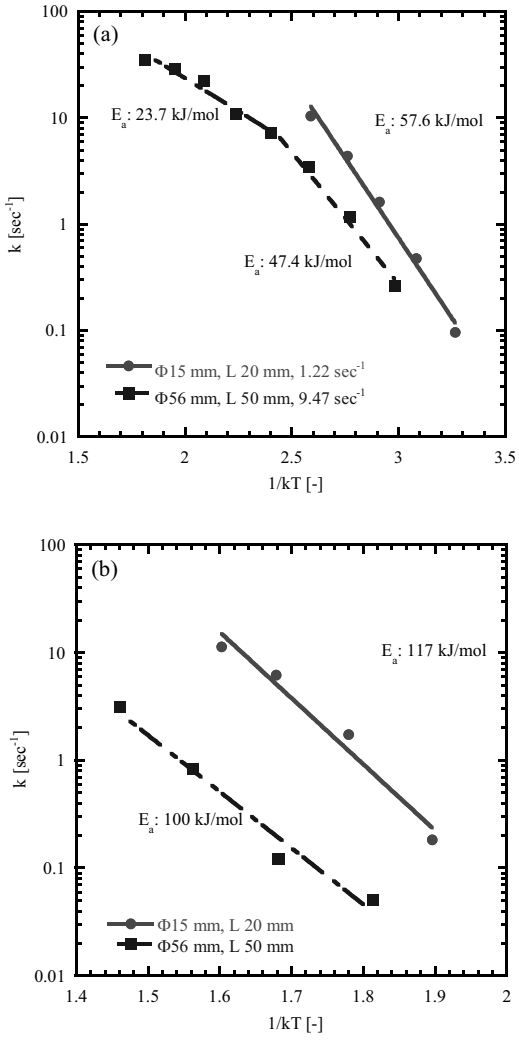

Fig. 1. Comparison of the Arrhenius plots of the oxidation performance between small- and large- size catalysts: (a). Hydrogen gas, (b). Methane gas