CATALYTIC DESTRUCTION OF PCDDS IN FLUE GAS FROM MUNICIPAL SOLID WASTE

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ABSTRACT

We have tried to apply catalytic destruction technology to reduce PCDDs and PCDFs concentration levels in the flue gas from municipal solid waste incinerators. A high temperature, at least 1000°C, is required to decompose PCDDs and PCDFs, by the usual combustion, in a short period. However, from the point of view of saving energy, it is better to finally clean up the exhaust gas at a low temperature, because the temperature of flue gas from the incinerator is comparatively low, 250 to 300 degrees centigrade, after leaving the waste heat boiler and air pollution control unit.
We had already confirmed the possibility of removing PCDDs by catalytic destruction. Now, we have conducted pilot plant experiments in which exhaust gas of max. 1900 Nm³/H was induced from the outlet of the electrostatic precipitator of a municipal solid waste incinerator.
As a result, the destruction ratio of PCDDs and PCDFs of at least 99 % was attained, at a temperature less than 300°C, depending upon SV (space velocity) and the form of the catalyst.

KEYWORDS

PCDDs; PCDDs destruction; Catalytic destruction; municipal solid waste incineration; flue gas

EXPERIMENTS AND CONSIDERATIONS

Catalyst

In this research, catalysts, mainly Pt supported on a carrier based on Si and Ti, were used. They had a honeycomb form and corrugate form, and four types were compared. The geometric properties of the catalysts used are shown in Table 1.

Table 1. Geometric properties of Catalyst

	No.1	No.2	No.3	No.4
Cell pitch (mm)	7.0	4.0	3.2	3.7~7.5
Wall thickness (mm)	1.0	1.0	0.5	0.4~0.5
Cell shape	Square	Square	Square	Corrugate
Hydraulic Diameter (mm)	6.0	3.0	2.7	—
Geometric Surface Area (m²/m³)	470	640	910	860

Pilot Plant Experiments

The experimental equipment mainly consist of a reactor containing the catalyst, a heat exchanger for keeping the exhaust gas temperature constant, and a hot air stream generator. Figure 1 depicts the schematic flow diagram of the pilot plant.
The temperature of the gas induced from the incinerator was controlled by exchanging heat between the hot air stream from the generator and the induced gas. The amount of induced gas to the equipment was max. 1900 Nm^3/H.
The dimensions of the reactor were 550 mm square in diameter and ca. 3000 mm in height. Four catalyst units of 450 mm square and 400 mm long were equipped in it.

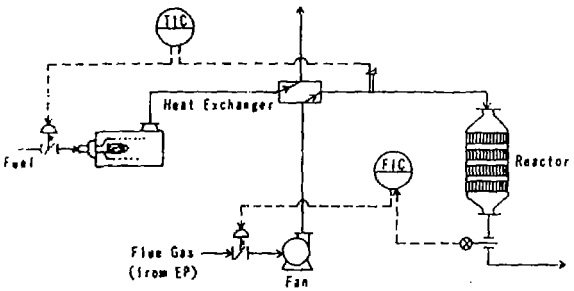

Fig.1. Schematic flow diagram of the pilot plant

Destruction of PCDDs and PCDFs

The destruction of PCDDs against reaction temperature is shown in Figure 2. That of PCDFs is shown in Figure 3.
The destruction ratios are different, depending on the geometric surface area, if SV is the same. Thus, a higher geometric surface area gives a higher destruction ratio. This tendency can be seen in both PCDDs and PCDFs.

SV (space velocity) is defined by the following equation.

$$SV = \frac{\text{Gas Flow } (Nm^3/H)}{\text{Reactor Volume } (m^3)}$$

Even at 250°C, it can be seen that Catalyst Nos. 2, 3, and 4 show sufficiently high destruction ratios.
The curve designated by No. 2 + No. 3 show the result of using two No. 2 units in the first half and two No. 3 units in the last half of gas processing.

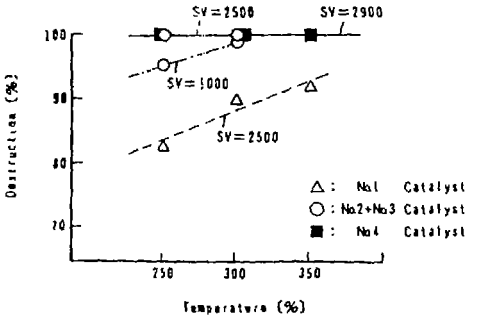

Fig.2. PCDDs destruction ratio against temperature

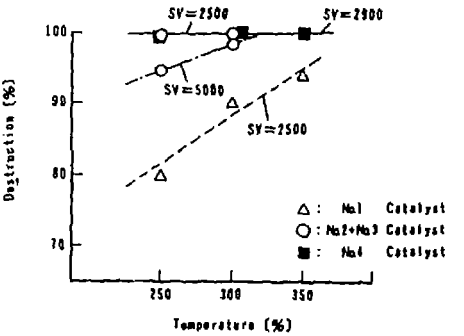

Fig.3. PCDFs destruction ratio against temperature

Effect of Surface Area

Cell geometry and total geometric surface area are very important factors in catalytic destruction.
Figure 4 shows the destruction of PCDDs against AV. AV is defined by the following equation.

$$AV = \frac{\text{Actual Gas flow rate } [m^3/H]}{\text{Total surface area of catalyst } [m^2]}$$

As apparent from the figure, the destruction ratio decreases linearily as AV increases. It can be expressed by the following equation.

$$\eta = K_1 \ AV + K_2$$

where $K_1 = -4.190$, $K_2 = 128.57$ at 250°C

$K_1 = -1.926$, $K_2 = 116.21$ at 300°C

$K_1 = -1.526$, $K_2 = 111.24$ at 350°C

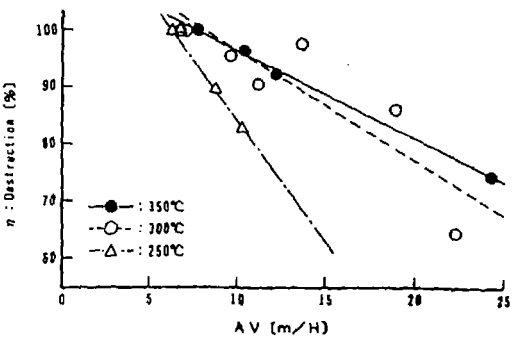

Fig.4. PCDDs destruction ratio against AV

Destruction of PCDDs homologues

The destructions of each PCDDs homologue is shown in Figure 5.
It can be seen that in the area of the higher destruction ratio, the ratios are at the same level between homologues. In the area of the lower ratio, the ratio for T4CDD is low, so that it lowers somewhat the TCDD equivalents (TEQ) destruction ratio as a result.
Here, the international TCDD equivalents factor (ITEF) was used as the equivalents factor.

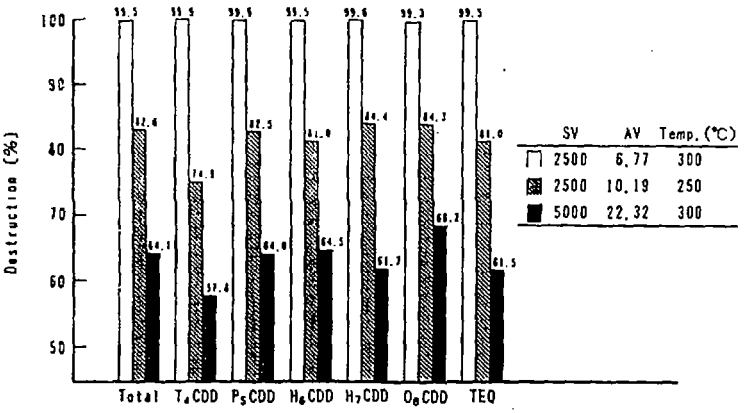

Fig.5. Destruction of PCDDs homologue

CONCLUSIONS

We had conducted pilot plant experiments to confirm the reduction of PCDDs and PCDFs using a catalytic method between 250 and 350 degrees centigrade.
From the experiments it was found that a sufficiently high destruction ratio can be attained even at a temperature 300°C or less. It was also found that destruction ratios of 90% or more, 99% or more at the maximum, can be realized by selecting the proper AV. The destructuion ratio (n) and AV have the close correlation which is defined by the following equation.

$$n = K1 \quad AV + K2$$

This destruction method can be practised by equipping a catalyst reactor inside the exhaust gas duct and it is simple and highly effective.
The destruction ratio's true concentration was about the same as the destruction ratio of TEQ (TCDD equivalents).

REFERENCES

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2)Patent JP, 62-126493, Method for Treating Exhaust Gas from Incinerator.
3)Patent JP, 1-144667, Method for Treating Exhaust Gas.
4)Patent JP, 1-146250, Method for Treating Waste Product.