

FORMATION AND REMOVAL OF DIOXINS IN THE INDUSTRIAL WASTE INCINERATOR

Dong Jun Koh, Kyong-Tae Kim, Min-Kyun Kim, Byoung-Eog Kim and Rae-Woong Chang

Air Pollution Research Team, Environment and Energy Research Center, Research Institute of Industrial Science and Technology, P.O.Box 135, Pohang 790-330, Korea

Introduction

Since the discovery of the dioxin emissions from the municipal solid waste incinerators, considerable efforts have been made to study the formation and removal of dioxins during the incineration¹⁻³. Investigations revealed that the concentrations of dioxins in the stack of the incinerators mostly exceed those measured in the furnace⁴. Dioxins can be formed in the downstream of the furnace as the flue gas is cooled. This formation occurs in the temperature range of 200 to 500°C by reactions between components such as oxygen, water, hydrochloric acid gas and products of incomplete combustion^{4,5}. Waste heat recovery boilers operate with several seconds of gas residence time within this temperature range of dioxin formation. Gas cleaning system such as electrostatic precipitators may also operate within this temperature range.

The main objective of this work is to study the formation and removal of dioxins in the downstream of the industrial solid waste incinerator. We report the results of the analysis of dioxin emissions in the electrostatic precipitator, activated carbon injection system, heat exchanger and catalytic reactor for the removal of dioxins. The tests were performed in an industrial solid waste incinerator which treats the mixed wastes of plastics, oil-contaminated cloths, wooden materials and wasted oils.

Materials and Methods

Process descriptions

The tests were performed in the fluidized bed type industrial waste incinerator. The capacity of the incinerator is 46 ton/day. A schematic diagram of the incinerator is shown in Fig.1. The gas treatment system consists of a heat exchanger, a waste heat recovery boiler, a dry reactor for the injection of activated carbon, an electrostatic precipitator and a catalytic reactor for the removal of dioxins.

Sampling and analysis

The sampling and analysis were carried out according to the Korea standard methods. The quantitative and qualitative analyses of dioxins were made by a High Resolution GC/MS. For convenience, the analysis results on the dioxin concentration are expressed by the toxic equivalent.

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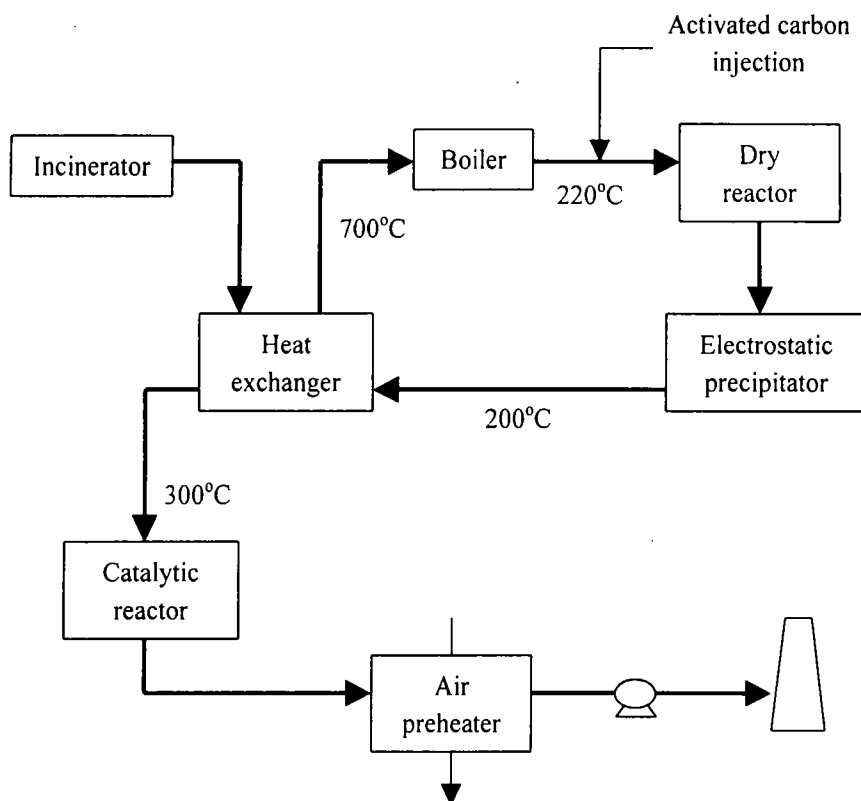


Fig. 1. Schematic diagram of the industrial waste incinerator.

Results and Discussion

Formation and removal of dioxins after combustion

Table 1 shows the dioxin removal characteristics in the electrostatic precipitator by the injection of activated carbon. Without injection of activated carbon, the concentration of dioxins after the electrostatic precipitator is higher than that measured after the boiler. This indicates that dioxins are produced even in the dry reactor and electrostatic precipitator which are operated at low temperature range of $200\sim 220^{\circ}\text{C}$.

With the activated carbon injection of $50\text{mg}/\text{Nm}^3$, the concentration of dioxins also increased after the electrostatic precipitator. However, the increase in the injection amounts of the activated carbon decreased the concentration of dioxins after the electrostatic precipitator. This result indicates that the dioxin formation reaction such as de Novo synthesis and the removal of dioxins by the adsorption on the activated carbon competitively occur in the dry reactor and electrostatic precipitator.

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Table 1. Dioxin removal by the injection of activated carbon.

Injection amounts of activated carbon (mg/Nm ³)	Concentration of dioxins (ngTEQ/Nm ³)	
	After boiler	After electrostatic precipitator
0	8.98	12.01
50	3.06	3.79
200	6.29	0.82
	3.32	0.52
	-	0.41
	-	0.32
	-	0.38
-	0.35	0.35

The formation of dioxins also occurred in the heat exchanger. Table 2 shows the concentration of dioxins before and after the heat exchanger. The flue gas after the electrostatic precipitator is preheated to 300°C by the heat exchanger for the oxidation reaction in the catalytic reactor. This temperature range of 200~300°C is also the temperature range of de Novo synthesis.

Table 2. Formation of dioxins in the heat exchanger.

Concentration of dioxins (ngTEQ/Nm ³)	
After electrostatic precipitator	After heat exchanger
0.52	1.29

In the catalytic reactor for the removal of dioxins, the removal efficiency was about 60 ~ 70%. This low removal efficiency of the catalyst may be due to the formation of dioxins in the catalytic reactor. Furthermore, the temperature increase to 300°C for the catalytic reaction led to the formation of dioxins in the heat exchanger. Therefore, lowering the reaction temperature seems to be more effective for the dioxin emission control.

Formation and removal of dioxins in the catalytic reactor

For the investigation of the catalytic removal efficiency in the low reaction temperature, the flue gas containing dioxins was introduced into the small catalytic reactor. The reaction temperature was then adjusted to 250°C by electric heater and the flow rate of the flue gas was about 8Nm³/hr. The space velocity was fixed to 2,400 hr⁻¹ and the gas linear velocity was changed as in Table 3. The results show that the increase in the linear velocity enhances the

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dioxin removal efficiency. In the low linear velocity, the concentration of dioxins increased after the catalytic reaction. It seems to be due to the formation of dioxins by the de Novo synthesis.

Table 3. Effect of gas linear velocity on the dioxin formation in the catalytic reactor.

Linear velocity (m/sec)	Concentration of dioxins (ngTEQ/Nm ³)		Efficiency (%)
	Before reactor	After reactor	
0.135	0.35	0.71	-
0.26	0.38	0.19	50
0.45	0.64	0.09	86

References

1. Acharya P., DeCicco S. G., and Novak R. G. (1991) *J. Air Waste Manage. Assoc.*, 41, 1605.
2. Olie, K., Vermuelen P. L., and Hutzinger O. (1977) *Chemosphere*, 6, 455.
3. Fangmark I., Stromberg B., Berge N., and Rappe C. (1994), *Environ. Sci. Technol.*, 28, 624
4. Kilgroe J. D. (1996) *J. Hazardous Materials*, 47, 163.
5. Griffith J. G., and Pitts D. M. (1995), *Pollution Engineering*, Nov., 50.