Recent MSW Fluidized Bed Incineration Plant and Dioxin measurement data

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1. Introduction

In 1990, the Japanese Ministry of Health and Welfare published "The Guidelines for the Prevention of Dioxin Generation," a document defining the direction of measures to reduce dioxin emissions from MSW incineration plants. It also summarized the government's effective policy directives for controlling the formation of dioxin compounds. The Guidelines point to the necessity of ensuring the complete combustion of unburned gas as the condition for controlling dioxin generation. It further lays down the process control standards in terms of such vital control parameters as combustion temperature, residence time of combustion gas, and oxygen concentration.

We designed the fluidized bed MSW incineration plant to meet the Guidelines. In addition, the original combustion control system is used in the plant. As a result, it has been possible to achieve steady combustion operation, with dioxin concentration levels substantially below the values to be attained in the Guidelines. This report presents details of the MSW incineration system.

2. Determination of the Furnace Structure

The incineration furnace is of the Twin-Interchanging Fluidized-bed type (TIF) and its design was started with a series of computer simulations of combustion. Their purpose was to determine the furnace structure, with the design objectives being to ensure effective agitation and mixing of the combustion gas to achieve adequate combustion in a minimum volume.

The following example shows the type of problems that were investigated. Fig. 1 presents the incinerator models for computor simulations. The waste charged into the furnace bed is gasified with partial combustion taking place and secondary combustion occurring in the free-board zone of the furnace. Model A has a baffle plate installed in the boiler inlet zone and boiler B has apertures in the baffle plate. Fig. 2 gives a concentration analysis of the unburned gas from among the simulation results. In model A, the combustion gas is agitated and mixed through the baffle plate so that complete combustion is reached before the gas enters the boiler's second pass. In contrast, it can be seen that the combustion gas in model B is blown and scattered up from the center of the furnace without reaching complete combustion so that the unburned gas flows to the second boiler pass. The results of the simulation indicate that model A with its baffle plate structure is effective in achieving agitation and mixing of the combustion gas.

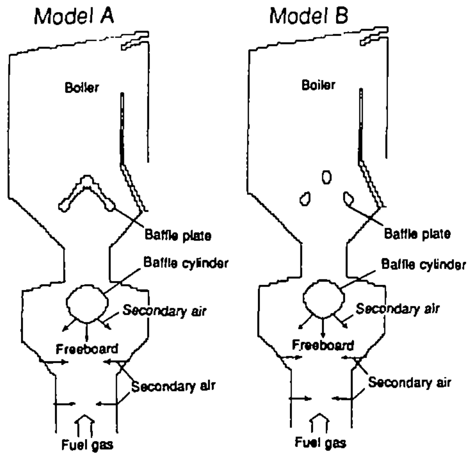

Fig.1 Two-dimensional incinerator models

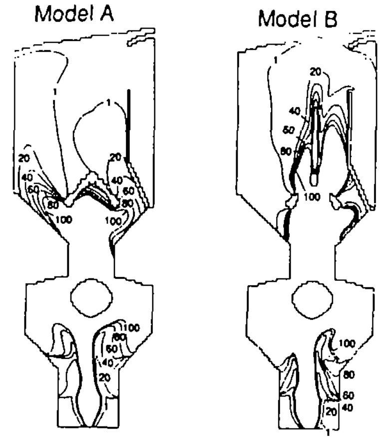

Fig.2 Contours of unburned fuel gas(1-100ppm)

Fig. 3 is a vertical section view of the furnace designed to achieve complete combustion in a minimum volume. The seconoary air is injecied to generate a whirling flow of the combustion gas in the free-board zone and produce a mixing and agitation effect. Fig. 4 shows the method by which the secondary air is injected.

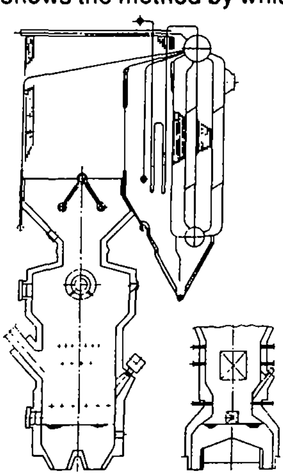

Fig.3 Furnace

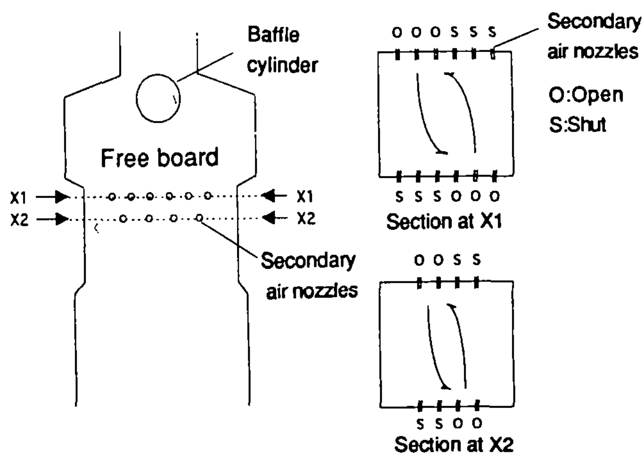

Fig.4 Secondary air injected with whirl

The furnace is designed so that after the combustion gasses have cleared the free-board zone, they are effectively agitated as a result of the baffle cylinder and throat section shape to achieve complete combustion in the furnace due to the baffle plate at the bottom of the boiler. *The residence time of the combustion gas is 3.0 seconds, a value significantly* greater than the residence time of 2.0 seconds specified in the Guideline.

3. Optimum Combustion Control

Combustion control is used to control the waste supply rate, secondary air supply rate and the fluidizing air bypass damper, with the "brightness" of the furnace interior (referred to below as the "flame sensor output") as the main detection criterion. To achieve more appropriate combustion control, the flame sensor output has been used as the value providing the fastest indication of the combustion conditions in the furnace. The following is an outline of the combustion control system.

1) Waste Supply Rate Control

The Waste supply rate control system controls the rotational speed of the Waste supply feeder so as to time the charging of the waste in an appropriate manner to suit the furnace combustion conditions. This waste charge rate control is coupled with another control system for simultaneously maintaining the boiler drum pressure at a constant level. Fig.5 is a flow schematic of the waste supply rate control system.

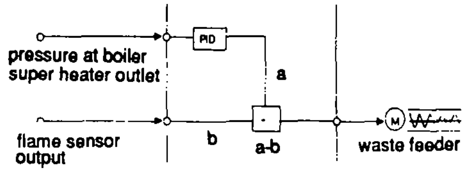

Fig.5 Waste feed rate control

2) Secondary Air Rate Control

The secondary air rate control system is designed so as to inject the proper amount of secondary air required for complete combustion in accordance with the combustion conditions in the furnace. The control system controls the secondar air supply rate on the basis of the oxygen concentration and flame sensor output so as to permit steady operation while maintaining the oxygen concentration in the furnace as constant as possible. Fig. 6 is a flow schematic of the secondary air supply rate control system.

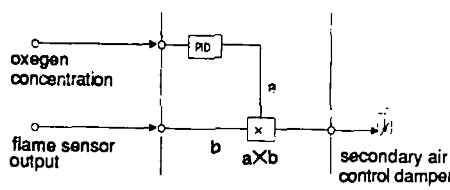

Fig.6 Secondary air control

3) Fluidizing Air Rate Control

The fluidizing air rate control system controls the speed of waste combustion in the furnace. In the past, it was sometime not possible to achieve complete combustion in a fluidized bed incineration furnace when the rate (velocity) of gasification of the waste was too fast and the changes in combustion rate were too large. This control system has been developed to solve these problems. In the presence of excessive combustion, the waste charging rate is reduced by the previously described waste supply rate control system and simultaneously with this, the fluidizing air bypass damper opens to reduce the fluidizing air supply rate, which results in a slow down in the rate of gasification of the waste in the furnace bed. This evens out the combustion rate and leads to a satisfactory complete combustion in the free-board zone. Fig. 7 is a flow *schematic* of the fluidizing air rate control system.

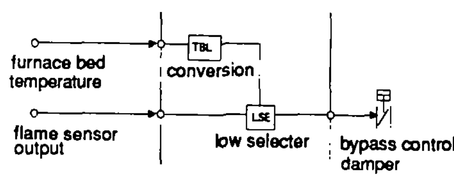

Fig.7 Fluidizing air rate control

Fig. 8 shows the oxygen and carbon monoxide (CO) concentration chart associated with furnace operation using this control system and compares it with a similar chart relating to furnace operation without this control system.

It is clear that the CO concentration peak is absent in furnace operation with this control system and that a favorable steady combustion regime is established.

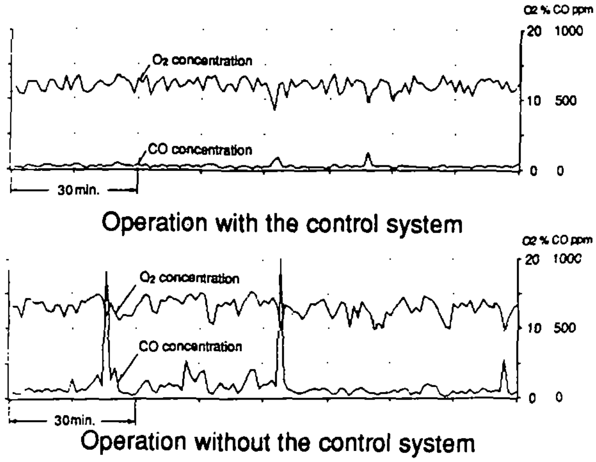

Fig.8 Operation chart

4. Measurement Results

Fig. 9 is a flow schematic of the MSW incineration process in a fluidized bed incineration plant. The exhaust gas leaving the combustion furnace is cooled in the waste heat boiler and subjected to a reaction with slaked lime ($Ca(OH)_2$) slurry in the spray tower along with removal of hydrogen chloride gas. After dust removal in the bag house,the gas is emitted to the air from the stack. The waste gas was measured over two days using a total of four measurements. The sampling positions were chosen at the boiler outlet and the stack. The measurements at the boiler outlet were performed only on two of the total of four occasions.

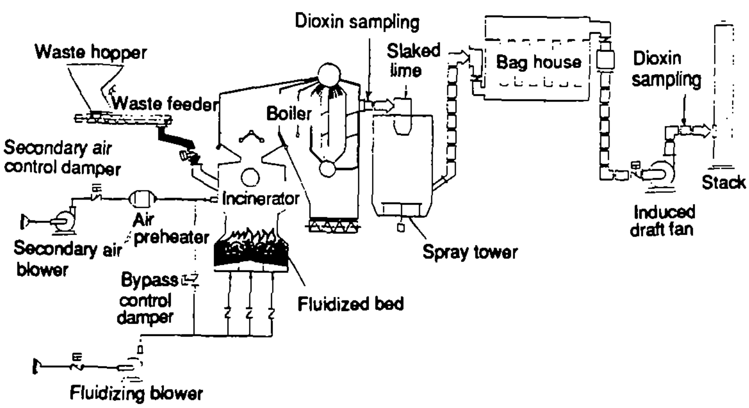

Fig.9 Flow schematic of the incineration process

Table 1 presents the operating conditions at the time of measurement and the measurement results in conjunction with the data specified in the Guideline.

Table1 Result of measurements

	Guidelines (Newly constructed fully continuous with boiler)	Measurement data			
Line		A	A	B	B
Furnace bed temperature		620	620	620	610
Incineration temperature	800℃ or more	850	850	860	860
Boiler outlet temperature		250	250	245	250
bag house Temperature	200℃ or less	150	150	150	150
Retention time in furnace	2 sec or more	3.0 sec			
Oxygen concentration	6% or more	12.7	12.7	12.8	12.4
Dust content at bag house outlet	20mg/Nm3 or less	< 1mg/Nm3			
HCl concentration		0	0	2	0
CO concentrarion	50ppm or less	30~40	30~40	20~30	10~20
Concentration of dioxins at boiler outlet			3.0		4.4
Concentration of dioxins at bag house outlet	0.5ng/Nm3(TEQ) Expected value	0.072	0.11	<0.05	<0.05

For either of the lines, the measurement data for the dioxin levels in the waste gas at the stack are very favorable as they are significantly below the suggested Guideline value of 0.5ng/Nm^3 I-TEQ. The boiler outlet values were measured as 3.0ng/Nm^3 I-TEQ (line A) and 4.4ng/Nm^3 I-TEQ (line B). These values are substantially lower than those recorded with conventional systems. The reasons why the dioxin concentration was so low at the boiler outlet can be attributed to the following circumstances.

1) A sufficient temperature, residence time of the combustion gas and stirring effect is ensured for the combustion process in the furnace so that there is little emission of unburned portions.
2) Appropriate combustion control entails extremely minor variations in the oxygen concentration and effectively reduces the generation of CO, with the overall result of maintaining stable operation of the incineration plant.

5. Summary

Reduction in dioxin emissions associated with MSW incineration plants has been achieved as a result of the following factors.

1) Use of a furnace structure capable of intensifying the mixing/agitation of the combustion gas and of ensuring an adequate residence time and the injection of secondary air as an effective means in intensifying the mixing/agitation of the combustion gas.
2) Stable operation as a result of appropriate combustion control.

6. References

1) Japanese Ministry of Health and Welfare,The guidelines for the prevention of dioxin generation,1990
2) Naito T,Nakajima Y,Sato K,Furuya H,Yoshida H,Hirota I, Improvement in Combustion by Fluidized-bed Incineration system, Ebara technical report 152,1991:29-34