DEVELOPMENT OF DIOXIN CONTROL TYPE SMALL SIZED INCINERATOR WITH NEW COMBUSTION SYSTEM

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Introduction

Since hazardous chemicals such as dioxins do not arise, the enlargement of the incinerator advances. In the meantime, by December 2002 execution of the incinerator exhaust gas regulation method, the wavy closure of the small incinerator which local government and industrial waste traders manage happened successively, and an equivalent confusion seemed to occur to the waste treatment industry. In this study, a new combustion that combines steam injection with rotational flow was devised, and it aimed at complete combustion in a small incinerator which is dioxin free. It is necessary to clarify the combustion mechanism of the new combustion in order to realize this incinerator development. In this experimental equipment, measurement flanges and an observation window for investigating the combustion situation in the incinerator were incorporated. It seems that it would greatly contribute to a cleaner environment, if this incinerator can be realized.

The discharge of dioxins has become a problem recently, and the "dioxins countermeasures special laws" were enforced in January 2000, and the emission standard will became stricter in December 2002. Especially, small incinerators utilized in industry, educational institutions, government facilities, hospitals and ordinary homes will not satisfy the environmental standard. As a result, incineration processing of waste in such an organization will be stopped, it will be necessary to employ the services of a waste disposal company, at a cost several times that of the in-house incineration cost, and in addition, the economical oppression increases for small and medium enterprise waste treatment.

It is considered that small organic substances such as dioxins arise by the chlorination of incomplete combustion in the burning process, heat recovery, gas cooling process and exhaust gas treatment process. Therefore, "complete burning" is considered the priority in the control of dioxins in incineration processing. Though complete burning technology is common in a large furnace, the technology that burns completely in a small furnace has not yet been established.

Generally, conditions for achieving complete burning are as follows: 1) High combustion gas temperature 2) Residence time of the gas and 3) Turbulence and secondary air inside of the furnace [1]. This is called "3-T". These conditions need to be met in order to reduce unburned hydrocarbon and precursor material in combustion gas. In this study, new combustion which combines steam injection with rotational flow as a method for achieving these conditions is tried, with the aim of realization of complete burning in a small incinerator. Not only could it be used more efficiently by small and medium sized companies, should such an incinerator be realized, but also it would be able to greatly contribute to environmental preservation.

Methods and Materials
Figure 1 is the experimental set-up. This facility is composed of the main body of the small incinerator, exhaust gas quick cooling tower, exhaust gas wash-column (scrubber), heat exchanger and circulating water tank (cooling and cleaning) for smoke prevention. This incinerator is a batch mode type, and the capacity is 45 kg/h. This incinerator has a double cylinder structure, and its height is 468.4 cm. Inner cylinder, external cylinder and inside diameter in the chimney are 30.0 cm, 39.7 cm and 16.0 cm, respectively, and the wall thickness is 6 mm. The flange for measuring temperature and air flow distribution inside of the furnace is established at 13 places in the main body of the furnace. In addition, by facing each other, the observation window for observing the combustion situation inside of the furnace is established at 3 places. This was designed considering Laser Doppler Velocimetry (LDV) measurement for examining flow distribution inside of the furnace for the spectroscopic measurement of the combustion. H5, h8 and h12 shown in the figure

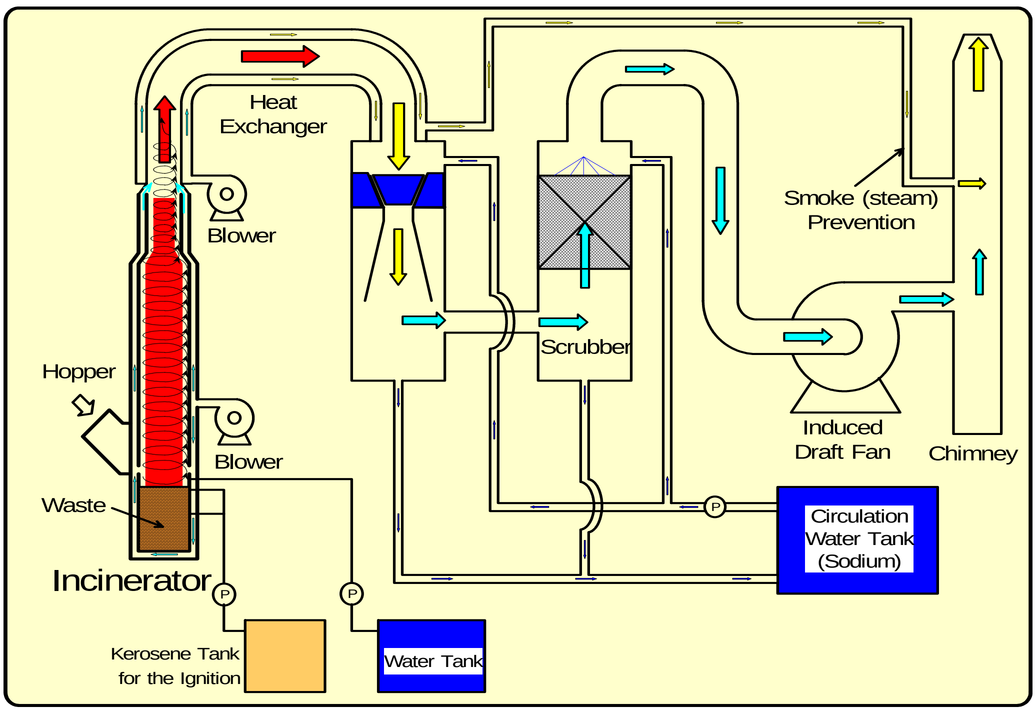

Fig. 1 Experimental set-up.

are numbers of the measurement flange, and heights from the incinerator base are 129.4 cm, 249.4 cm and 410.8 cm, respectively.

First, airflow velocity distribution inside of the furnace was measured by a hot-wire anemometer, and it was confirmed that a swirling flow had been generated. Next, the scrambling between the induced-draft fan of the scrubber and air blower of the furnace main body is confirmed by the manometer, and the inside furnace pressure was confirmed as being adjustable to –4 mm Aq.

It is ignited by the ignition equipment after 300 cc Kerosene is sprayed over the upper part of the refuse to begin with. The airflow rate increases, though the operculum of the hopper is closed after the ignition confirmation, when the inside furnace temperature situation is confirmed. In the case of this experiment, the superscription operation is carried out after thermometry equipment (NR-1000; Keyence), exhaust gas analytical equipment (RI-803A; RIKEN KEIKI GSV-350; testo) operate. The combustion situation is judged from measured values of each measuring device and visual observation.

Results and Discussion

The result of the force calculation that used the equation got as a solution of the combination vortex of Rankine as a solution of the linear vortex of circular cross section is shown in the equation (1).

$$P \square P_{\infty} \square \{(\zeta r)^2/8 \square (\zeta a)^2/4 \square gz\}\rho \quad \text{————} \quad (1)$$

$P\infty$: atmospheric pressure
ζ: vorticity
r: radius
a: inside of furnace radius
gz: gravitational potential
ρ: air density

By using the hot-wire anemometer, circumferential direction velocity distribution inside of the furnace in the case where only the air blower was operated is shown in Fig.4. From this figure, it is proven that the flow velocity inside of the furnace central part is slowed, regardless of the measurement position. It is shown that the rotational flow is being generated on this. Inside of furnace pressure distribution by equation (1) is shown in the same figure.

According to common knowledge, the pressure of the central part is lowered as a result. This means that it does not meet in the furnace wall, when the flame also exists, since the flame suits the central part. It becomes effective in preventing high temperature, since the temperature of the furnace wall is raised only in radiant heat.

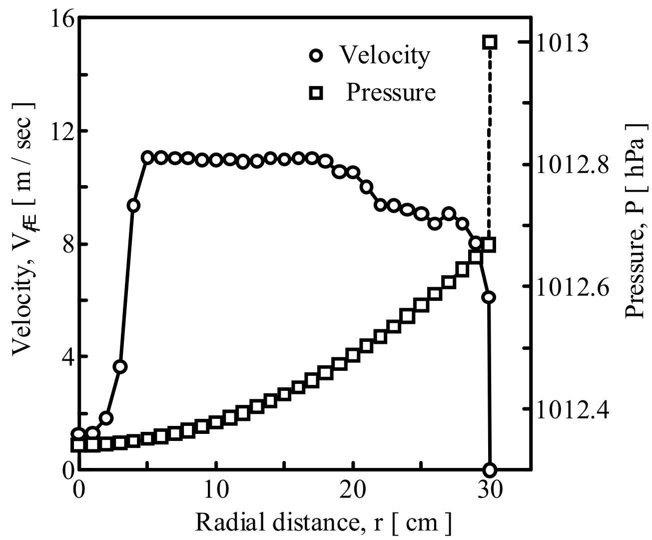

Fig.4 The relationship between velocity and pressure distribution in the incinerator.

From the time hysterisis of the inside furnace central temperature, CO, HC and blast air quantity as the wood burns, the central temperature inside of the furnace reaches over 1000 □ from the ignition in about half the time. By the combustion of the kerosene used in ignition, when the refuse is burnt in the incinerator full cross section, the generation of unburned hydrocarbon (HC) was largest, about 230 ppm. The generation of CO is about 2400 ppm.

And, result of analysis of dioxins in exhaust gas is shown in Table.1. CO and soot were values over the reference value. The concentration of dioxins in exhaust gas was under the reference value.

Table Result of analysis of dioxins and other component in exhaust gas

Item	O_2	CO	NOx	SOx	HCl	Soot	Total-PCDDs
Unit		ppm	ppm	ppm	ppm	mg/m^3N[1)]	$ng\text{-}TEQ/m^3N$
Exhaust gas (1)	13.9	300	180	-	400	320	1.3
Exhaust gas (2)	20.0	549	450	<0.01	3800	200	1.6
Standard	-	100	250	K-factor	700	150	5.0[2)]

1) O_2 equivalent (12)
2) Small incinerator (<2t/h)

A combustion furnace for exactly examining the steam injection effect was produced experimentally, and the mechanism was investigated. Afterwards, spectroscopic measurement and LDV measurements of the flame, etc. were carried out, and the effectiveness of the new combustion of swirling flow and steam in combination was confirmed. Also, dioxins measurement was carried out, and the safety was confirmed. Finally, conditions and specifications for complete burning were decided, after all experiments were finished, and thus product development of a small incinerator can be carried out.

Conclusions

By using wood in the small incinerator for the demonstration, the incineration experiment was carried out. The results are as follows:

1) Rotational flow is being generated inside of the furnace.
2) The inside of furnace central temperature can be maintained at about 1100□.
3) The steam injection effect for the combustion exists.
4) The concentration of dioxins in exhaust gas was under the reference value.

Acknowledgements

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