

Municipal Solid Waste and Persistent Organic Pollutants Treatment Systems

Dr. Masamitsu TAKAHASHI, KOBELCO ECO-SOLUTIONS CO., LTD.

Dioxins and polychlorinated biphenyls (PCBs) are typical persistent organic pollutants, which affect public health by accumulating and concentrating in human bodies. The Japanese government has enforced laws concerning special measures against these substances.

KOBELCO ECO-SOLUTIONS' technologies include fluidized-bed gasification plus swirl-flow melting, and plasma ash melting to decompose dioxins in municipal solid waste. The fluidized-bed gasification and swirl-flow melting system can gasify solid waste and melt fly ash in one process, reducing dioxin content to less than 1 μ g-TEQ/t-refuse. The plasma ash melting system melts ash discharged from incinerators.

PCBs are dechlorinated by a sodium dispersion (SP) method. PCB-contaminated sludge and sediments can be treated by reductive heating and an SP (RH-SP) method. PCB-contaminated wastes are decomposed by a plasma melting system. All these systems have displayed excellent results in pilot-scale experiments and have been authorized as appropriate technologies to manage these pollutants.

Introduction

Environmental concerns increased dramatically in the 1990s. A typical example is the concern for dioxins. In Japan, dioxins became an issue when it was reported that dioxins were detected in fly ash from municipal solid waste incinerators in 1983. High temperature treatment (melting) technologies were introduced to the field of refuse treatment in 1990s, which created a major change in treatment processes and legislation. In 2000, the "Law for Special Measures for Handling Dioxin" was enacted and the regulations were tightened against emissions of dioxins not only from incinerators, but also from other facilities.

PCBs (polychlorinated Biphenyls) were banned, or regulated in production, use, export and import by the Stockholm convention in 2001. PCBs are highly toxic, persistent and bioaccumulative Persistent Organic Pollutants (POPs), similar to dioxins. Japan also ratified the convention in 2001 and enacted the "Law Concerning Special Measures Against PCB Waste" and committed to abolish PCBs domestically within 15 years.

In response to the needs for treating those POPs, KOBELCO ECO-SOLUTIONS CO., LTD. developed

and commercialized technologies to treat waste containing persistent substances. This article introduces those technologies.

1. Ash melting technology

Approximately 90% of dioxins discharged from a municipal solid waste incinerator is contained in fly ash. We developed a fluidized-bed gasification and swirl-flow melting technology and a plasma ash melting technology to render fly ash harmless by melting.

1.1 Fluidized bed gasification and swirl-flow melting technology

Our fluidized bed gasification and swirl-flow melting technology¹⁾ was developed to cover fully the situation from pyrolysis gasification to fly ash melting. Since October 2000 we have completed six facilities and are constructing five more facilities. **Table 1** shows our achievements.

Figure 1 shows a schematic drawing of a fluidized bed gasification and swirl-flow melting system. The system consists of a fluidized bed gasification furnace and a swirl-flow melting furnace, both of which are vertical cylindrical types.

Solid wastes are first pulverized and continuously fed into the fluidized bed gasification furnace in constant quantities.

Air, supplied from the bottom of the gasification furnace to form a fluidized bed of sand, partially burns, pyrolytically decomposes and gasifies the solid waste. Resulting combustible materials and ash are transferred to the back-end, swirl-flow melting furnace in the form of flammable pyrolysis gas, unburned carbon and ash. Incombustibles in the waste, such as metals, are continuously discharged along with the sand, out from the exit pipe in the center of the dispersion plate placed at the furnace bottom, and sieved to be separated. The discharged sand is fed back to the furnace.

The unburned carbon and fly ash generated in the gasification furnace is blown with pyrolysis gas into the swirl-flow melting furnace in the tangential direction. An amount of air, required for complete burning, is supplied here. The combustion relies mainly on gas combustion having high combustion

Table 1 Commercial plants of gasification and melting system

Delivery places	Location	Capacity of facility	Power generation	Completion
Chubu-kamikita area-wide service association	Kamikita county, Aomori prefecture	60 t/d (30 t/d × 2 units)	-	October, 2000
Aki regional sanitary facility management association	Aki county, Hiroshima prefecture	130 t/d (65 t/d × 2 units)	1,300 kW	November, 2002
Kazuno area-wide administrative association	Kazuno city, Akita pref.	60 t/d (30 t/d × 2 units)	-	November, 2002
Ishinomaki area-wide administrative association	Ishinomaki city, Miyagi pref.	230 t/d (115 t/d × 2 units)	2,600 kW	March, 2003
Nakatsugawa/Keihoku environmental facilities association	Nakatsugawa city, Gifu pref.	98 t/d (49 t/d × 2 units)	900 kW	March, 2004
Oono/Katsuyama area-wide administrative association	Oono city, Fukui pref.	84 t/d (42 t/d × 2 units)	-	March, 2006
Nemuro-Hokubu waste management area-wide association	Bekikai cho, Hokkaido	62 t/d (31 t/d × 2 units)		Under construction
Sashima environmental management association	Bando city, Ibaraki pref.	206 t/d (103 t/d × 2 units)	3,000 kW	Under construction
Sagamihara city	Sagamihara city, Kanagawa pref.	525 t/d (175 t/d × 3 units)	10,000 kW	Under construction
Iwade city	Iwade city, Wakayama pref.	60 t/d (30 t/d × 2 units)		Under construction
Kawagoe city	Kawagoe city, Saitama pref.	264 t/d (132 t/d × 2 units)	4,000 kW	Under construction

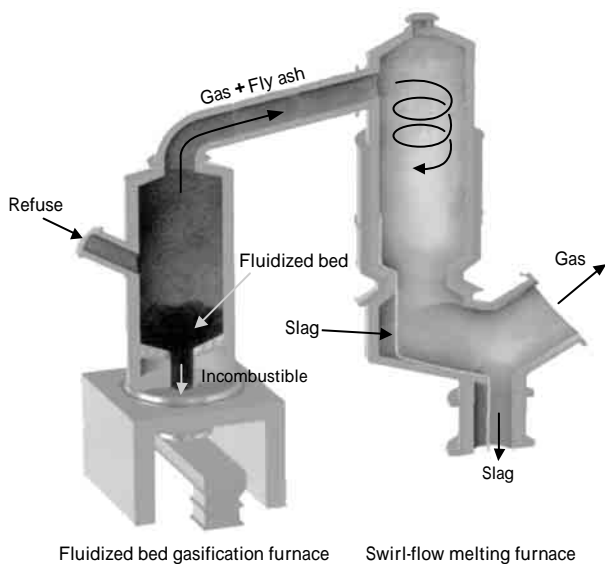


Fig. 1 Schematic draw of fluidized bed gasification and swirl-flow melting system

efficiency, and reaches high temperature with a small amount of air. The ash, carried by the swirl flow, is melted by the heat of the combustion into slag, which flows down the inner wall of the furnace and is discharged out from the furnace through the slag port at the furnace bottom. The slag chute below the

Table 2 Total discharge of dioxins

Run No.	1		2	
	Concentration (ng-TEQ/m ³ N) (ng-TEQ/g)	Total discharge (μg-TEQ/t-refuse)	Concentration (ng-TEQ/m ³ N) (ng-TEQ/g)	Total discharge (μg-TEQ/t-refuse)
Flue gas	Unit 1:0.0069 Unit 2:0.0074	0.045	Unit 1:0.0033 Unit 2:0.0078	0.034
Slag	0.000099	0.0032	0.000050	0.0016
Incombustibles	0.0016	0.031	0.00098	0.019
Fly ash	0.093	1.2	0.026	0.37
Dehydrochloric residue	0.0056	0.042	0.011	0.11
Total		1.3		0.53

slag port is water sealed so that the molten slag from the furnace is water-cooled, solidified and collected.

Table 2 shows the total dioxins emission from the Ishinomaki-plant²⁾. The guaranteed value for the dioxins content, in the exhaust from the facility, is 0.01ng-TEQ/m³N, however, its stable operation not only assures the guaranteed value, but shows very low total emissions in the range of 0.53 ~ 1.3 μg-TEQ/ton of waste.

Table 3 Commercial plasma ash melting furnace plants

Delivery places	Location	Capacity of facility	Kinds of refuse to be treated	Completion
Tokushima prefecture (Mima) environmental management association	Mima county, Tokushima pref.	5 t/16 h	<ul style="list-style-type: none"> • Single melting of fly ash from municipal refuse fluidized bed incineration furnace • Attached to the fluidized bed incineration furnace with a capacity of 72 t/16 h 	March, 1997
Shimonoseki city	Shimonoseki city, Yamaguchi pref.	41 t/24 h	<ul style="list-style-type: none"> • Melting of incineration residue from municipal refuse stoker type incineration furnace • Attached to the new furnace with a capacity of 180 t/16 h. The ash from new furnace is mixed with the incineration residue from the existing furnace with a capacity of 220 t/24 h for treatment. 	November, 2002
Imizu regional area-wide administrative association	Imizu county, Toyama pref.	12 t/24 h	<ul style="list-style-type: none"> • Single melting of fly ash from municipal refuse fluidized bed incineration furnace • Attached to the fluidized bed incineration furnace with a capacity of 138 t/24 h 	March, 2003
Kakogawa city	Kakogawa city, Hyogo pref.	30 t/24 h	<ul style="list-style-type: none"> • Single melting of fly ash from municipal refuse fluidized bed incineration furnace • Attached to the fluidized bed incineration furnace with a capacity of 432 t/24 h 	March, 2003

1.2 Plasma ash melting technology

Table 3 summarizes actual installations of plasma ash melting furnaces. The plant in Shimonoseki City is a stoker-type incineration furnace, in which incinerated ash and fly ash are mixed to be melted. The other three facilities have furnaces which melt fly ash from fluidized bed furnaces. All the furnaces employ metallic plasma torches and use air for plasma gas.

Figure 2 shows a schematic diagram of a plasma ash melting furnace. Ash, discharged from combustion furnaces, is first stored and then continuously charged into the plasma melting furnace. The ash is melted by high temperature plasma. A slag pool is accumulated in the furnace for a sufficient period of time until it forms a stable pool of slag, and the slag is discharged continuously out from the furnace. The discharged slag can be cooled either by water or air, however,

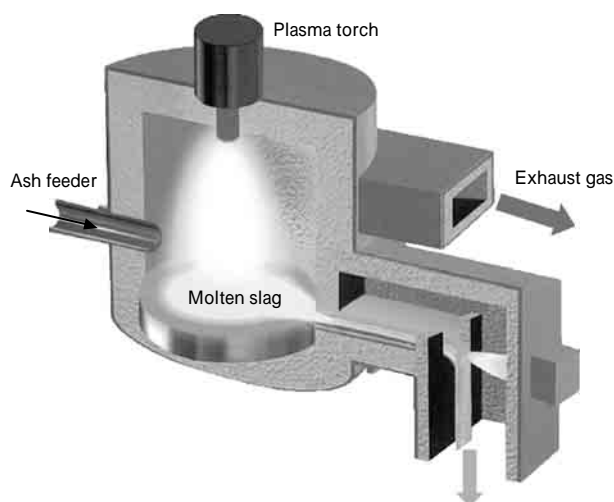


Fig. 2 Image of plasma ash melting furnace

water cooling is the treatment of choice for most cases for its smaller space requirement and ease of handling. The plasma melting has an advantage over combustion in that neither carbon dioxide nor sulfur oxide is generated from its heat source and the total exhaust emission is reduced.

2. PCB treatment technology

2.1 Dechlorination technology (SP method)

A process (the SP process) was developed to react PCB and similar chemicals with metallic sodium to dissolve the PCB and such into non-toxic biphenyl and sodium chloride³⁾. The process flow is shown in Figure 3.

PCB and PCB containing oils are mixed with a dispersing element of metallic sodium. The dispersing element is a liquid at normal temperature, containing metallic sodium dispersed in mineral oil, and is featured by its mild reaction with air and water.

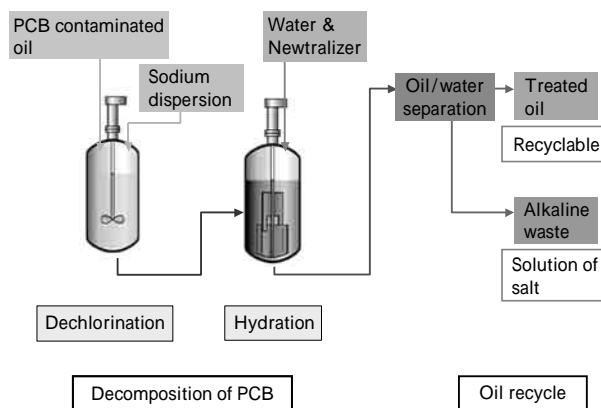


Fig. 3 Flow of SP process

After the reaction, product salt is dissolved into water to separate oil. The oil, thus detoxified, can be re-utilized as reclaimed oil.

The process is combined with other processes, such as solvent extraction and decomposition process (SED process), a method for extracting PCB from pollutants, and reduction heating, to configure integrated PCB contaminant treatment processes and POP contaminated soil treatment processes. The SED process is used in the Toyota and Hokkaido facilities of Japan Environmental Safety Corporation (JESCO) and the SP process is employed in the Hokkaido facilities of JESCO.

2.2 Treatment technologies for PCB/dioxins contaminated soils

Figure 4 shows a soil treatment process, the RH-SP process⁴⁾, in which a reduction heating process is combined with the SP process. Soils and bottom sediments contaminated by PCB and such are indirectly heated at a relatively low temperature of about 600 to separate PCB and dioxins. The separated contaminants are cleaned and collected by the oil scrubber of an exhaust gas treatment apparatus and the collected oil is detoxified by the SP process previously described.

The amount of emission gas is relatively less, because there is no need for secondary combustion and cooling apparatus, and the whole equipment is downsized.

Table 4 shows a representative result of the treatment according to the PH-SP process. Soils, sediments and concrete wastes, contaminated by PCB and/or dioxins are detoxified.

The present system is authorized as a technology for cleaning soils contaminated by dioxins, removing PCB from PCB polluted sludge and detoxifying port and harbor bottom sediments polluted by dioxins.

Table 4 Experimental results of RH-SP process

Material	Soil	Soil	Soil	Sediments	Sediments	Concretes
Main contaminants	PCB	PCB	Dioxins	PCB	Dioxins	PCB
Initial PCB (mg/kg)	3,400	3,400	-	26	-	14
Initial DXNs (pg-TEQ/g)	5,700	5,700	3,100	130	7,000	460
Treatment time (h)	6	1	1	3	3	3
Final PCB (mg/kg)	0.019	10	-	0.0038	-	0.085
PCB elution (mg/ℓ)	ND	ND	-	ND	-	ND
Final DXNs (pg-TEQ/g)	0.0075	70	0.02	0.0026	58	0.029

2.3 Plasma melting and decomposition technology for PCB contaminated substances

PCB contaminated substances include materials, such as carbonless copying papers and ballasts, from which it is difficult to remove PCBs and mixed rubbish, in which various contaminants are enclosed. A plasma melting and decomposition technology⁵⁾ was developed to treat those contaminated substances.

Substances contaminated by PCB and such are sealed in a metal drum and the drum is charged into a plasma melting and decomposition furnace having a plasma heat source. Thus, the process does not require any pre-treatment, such as disassembly, cleaning and breaking. Contaminated substances, charged into the furnace in a drum can, are efficiently melted and decomposed by the combined effect of plasma, from a torch maneuvered through a camera monitoring the furnace interior, and the molten pool of slag heated to a temperature higher than 1,400 .

Photo 1 shows the appearance of a demonstration plant having a PCB contaminated substance treatment capacity of one ton a day. A pail can was used in a demonstration, instead of a drum can. **Photo 2** shows a melting state during the demonstration.

No PCB contaminated substance is accumulated

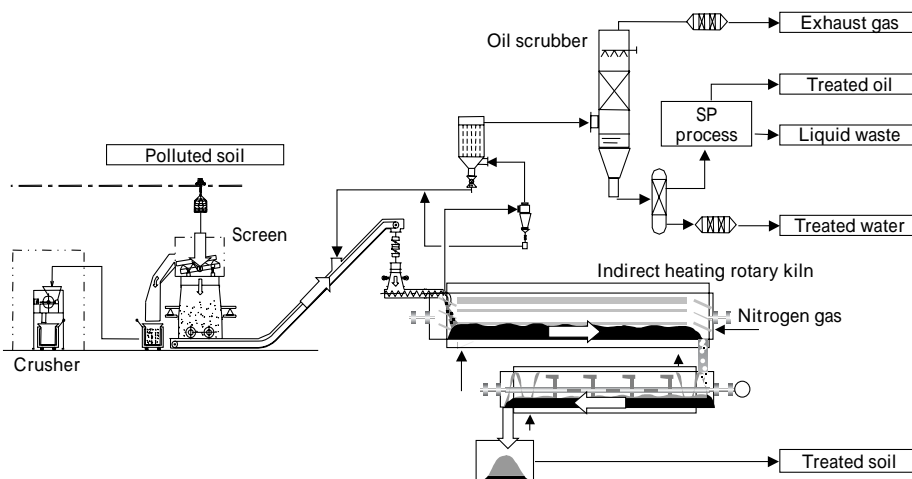


Fig. 4 Flow of RH-SP process



Photo 1 Overview of test plant

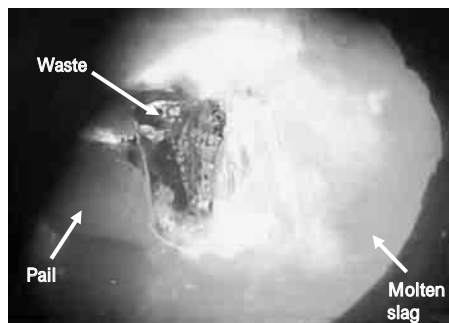


Photo 2 Melting in plasma furnace

in the furnace, because a new drum is charged only after the previous batch of drum is completely melted and decomposed. Any trouble-shooting can easily be done by stopping the charge of drums and, thus, melting and decomposition are carried out in an assured manner.

PCB and combustibles are decomposed completely into CO₂ and H₂O in the plasma furnace. Therefore, the exhaust from the furnace can be treated in the same manner as conventional incinerators, however, an activated carbon absorber is placed at the end of the exhaust line for additional safety.

Incombustibles in the contaminated substance are melted into slag and discharged from the furnace. The discharged slag is checked for its PCB content and, only after no PCB content is confirmed, transported outside for recycling and other final treatments. Solids, collected by a bag filter, are checked for their PCB content, chemically treated to prevent emission of heavy metals and transported out of the facility for final treatments.

Table 5 shows independent results⁶⁾ from treatments for ballasts, copying papers, sludge and cloth waste, which are representative substances containing PCB. The product after the treatment indicated very low levels, less than regulatory amounts, of PCB and dioxins and better than 99.9999% of decompositions were achieved in all the treatments.

Table 5 Results of PCB decomposition

			Ballasts	Copy papers	Sludge	Cloth wastes	Regulations
IN	Waste	PCB (mg/kg)	15,000	6,500	270,000	210,000	
	Slag	PCB (mg/kg)	N.D.	0.0000028	0.000017	0.0000092	0.01
		DXNs (mg/kg)	0	0	0	0	3
OUT	No.1 BF dust	PCB (mg/kg)	0.00089	0.0071	0.00074	0.0025	0.01
		DXNs (mg/kg)	0.0036	0.0038	0.10	0.068	3
	No.2 BF dust	PCB (mg/kg)	0.00018	0.00095	0.0013	0.0082	0.01
		DXNs (mg/kg)	0.0019	0.0000072	0.016	0.093	3
	Catalyst tower gas	PCB (μg/m ³ N)	0.019	0.023	0.012	0.024	150
		DXNs (ng-TEQ/m ³ N)	0.041	0.044	0.00023	0.068	0.1
PCB decomposition (%)			99.9999944	99.999945	99.9999965	99.9999978	

Conclusions

Fluidized-bed gasification plus swirl-flow melting, and plasma ash melting, along with plasma ash melting and RH-SP for treating PCB contaminated substance, have been introduced as our detoxification technologies for persistent organic pollutants, such as dioxins and PCBs.

The advent of those technologies has enabled waste incineration facilities, which used to be regarded as the source of dioxins, to reduce dioxins in wastes and to detoxify PCBs and PCB polluted substances, which used to have no way of treatment but had to be stored.

We will strive to treat solid waste and PCB contaminated substances using those technologies and contribute to the prevention of the diffusion and accumulation of persistent organic substances.

References

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