Heavy Metals Recovery System for Dust from NKK Electric-resistance Furnace

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Vitrification is considered a principal process for future waste disposal because the treatment can render harmless even wastes that include harmful substances, and it can recover resources in the waste. NKK has commercialized an electric-resistance ash melting furnace[1),2)] for processing residues from solid waste incineration plants, a high temperature gasifying and direct melting furnace[3)] for processing wastes, and a swirl flow melting furnace[4)] for treating sewage and sewage bottom ash that use vitrification technology developed by NKK over many years.

Residues from solid waste incineration plants are separated into slag, metal, and dust by vitrification treatment and then discharged. The metal is utilized for weights, while the dust is discarded in landfills after harmful metals in the dust are stabilized. The dust contains concentrated heavy metals such as Zn, Pb and Cd that were contained in the residues, so the present disposal method, in which the dust is stored and accumulated in a disposal area, is undesirable considering environmental preservation and resource recycling. Therefore, the dust should be reclaimed as a raw material for smelting.

The NKK electric-resistance ash melting furnace can volatilize the zinc and lead in residues at high rates using reduction melting and then concentrate these metals in the dust. NKK developed a heavy metal recovery process in which zinc and lead in the dust are reclaimed as a raw material for smelting by making the best use of the characteristics of the dust. Also, NKK proposed a system for reusing heavy metals as resources by incorporating a smelting process for zinc and lead in the heavy metal recovery process and dem-

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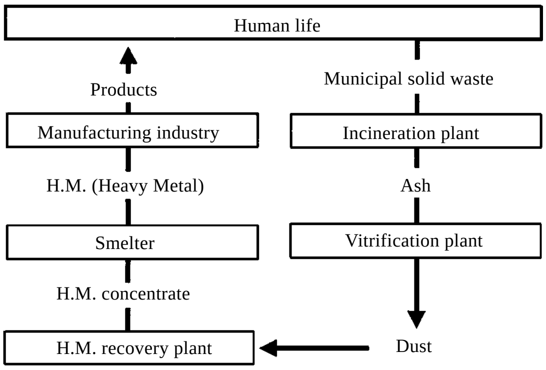
About 50 million tons/year of waste is generated in Japan. 77% (in fiscal 1996) of this quantity is incinerated, generating about 6 million tons/year of bottom ash and fly ash residues. Bottom ash is an ember, and fly ash is the incinerator gas dust.

[illegible] gives an example[6] of chemical compositions of bottom ash and fly ash. Bottom ash contains a large quantity of metallic elements with a high boiling point, such as Fe, Cu and Mn. The fly ash is composed of a condensate of volatile components from the incineration process and ash in the incinerator gas. Fly ash contains a large amount of low boiling point metallic elements, such as zinc, lead and cadmium, and salt elements such as sodium, potassium and chlorine.

The content of metallic elements in the bottom and fly ash generated from 1 ton of solid waste was estimated on the basis of chemical composition data[7] for bottom ash and fly ash obtained through questionnaires at 57 municipal solid waste incineration plants in Japan. The result is given in [illegible] 2. It was estimated that the 160 kg of residue (134 kg of bottom ash + 26 kg of fly ash) from 1 ton of solid waste contain 480 g of zinc and 140 g of lead.

[illegible] gives the calculated amount of zinc and lead in the 6 million tons/year of residue generated in Japan, which was obtained from [illegible] 2. The amount of zinc in the residue from municipal solid waste in-and dust by vitrifying treatment. Heavy metals, low boiling point elements, such as zinc, lead and cadmium, are concentrated in the dust.

At present, most of the dust is disposed of in landfills after toxic metals in the dust are stabilized. If the dust containing the heavy metals is used as a raw material[8], the "recycling of heavy metals in residues from municipal solid waste incineration plants" shown in Fi[illegible] becomes possible. Also, disposal of the dust in landfills is not needed, and the "zero emission treatment of residues from municipal solid waste incineration plants" shown in Fi[illegible] 2 can be achieved.



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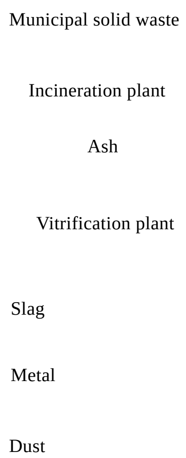

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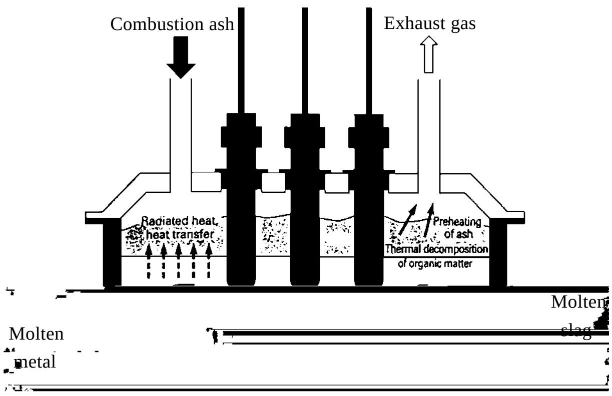
Dust is composed of a concentrate of components that volatilize in the melting furnace, ash scattered from the residues supplied to the melting furnace, and ash entrained in the exhaust gas. Slaked lime is sometimes blown into oxidizing atmosphere furnace melting systems to remove the generated hydrogen chloride[9]. The reaction product and unreacted slaked lime currently migrate to dust. The composition, compound form, and amount of dust generated are affected by the melting process (e.g., melting system, furnace construction, atmosphere, temperature, and exhaust gas treatment method) and the composition of the supplied ash[9]. The components of the dust are as follows:

(1) Concentrates of volatile component: Na, K, Cl, Zn, Cd, Pb, etc.
(2) Ash scattered from the residues supplied to the melting furnace: Si, Ca, Al etc.
(3) Ash entrained in the exhaust gas: Si, Ca, Al etc.
(4) Product from slaked line injection: Ca, Cl, etc.

[illegible]

[illegible]

The construction of the NKK electric-resistance ash melting furnace[1] is shown in Fi[illegible]. This electric-resistance ash melting furnace uses a system in which electric current flows through molten slag in the furnace, and incineration residues are melted by the generated resistance heat. The incineration residues supplied to the furnace float on the molten slag layer, and melt gently into the molten slag, so that the amount of ash scattered is small, compared to the other ash melting methods. Also, an electric furnace is used, so the amount of exhaust gas generated is small, and the amount of ash entrained in the exhaust gas is also small. The melting furnace has an enclosed construction, and the interior of the furnace is maintained in a reducing atmosphere. Therefore, zinc is reduced in the incineration residue and volatizes as metallic Zn. The volatizing metallic Zn is oxidized into ZnO in the discharge process. Also, very little hydrogen chloride is generated, so that slaked lime is not necessary. Since the molten slag layer is kept at a temperature of 1400–1500°C, components with a high boiling point such as Si do not volatize. Features of the NKK electric-resis-



Fi[illegible]

tance ash melting furnace concerning the generation of dust are as follows:

(1) Gentle melting: The amount of fly ash is small.

(2) Less exhaust gas: The amount of ash entrained in the exhaust gas is small.

(3) Reduction melting: Zn volatizes at high rates

(4) Less generated hydrogen chloride: Slaked lime need

Thus, cadmium, zinc and lead in incineration residue can be separated from the dust at high rates by the unique melting principle and melting system of the NKK electric-resistance ash melting furnace.

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As shown in **F**, dust from the electric-resistance ash melting furnace is composed of NaCl and KCl, which are water soluble components, and ZnO, PbO and $PbCl_2$, which are water insoluble components. Therefore, NaCl and KCl are extracted by washing treatment of the dust, and Zn and Pb concentrate can be obtained as residue[12].

F 6 shows the heavy metal recovery process for dust from the melting furnace. The process includes washing treatment, solid-liquid separation treatment, and cleaning treatment by solvent. **6** gives the chemical composition of heavy metal concentrate obtained by washing treatment and by heating after washing. Dust subjected to washing treatment is a zinc and lead concentrate that additionally contains small amounts of copper, tin and cadmium.

The zinc and lead concentrate can be used as a raw material for ISP (Imperial Smelting Process) smelting, which is a process for simultaneously smelting Zn and Pb. Although the allowable quality of raw material for ISP smelting is determined by the individual smelt-
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mum chlorine content of 1% have been identified as an example quality[13].

The dust subjected to washing treatment as specified in **6** contains 48% zinc, which meets the allowable quality for a raw material for smelting. The chlorine content of 2–3% can be reduced to 0.5% or less by heating at a temperature of at least 800℃, although there are possible restrictions. The chlorine content was reduced to 0.4% by heating at 800℃ and to 0.01% and below at 900℃. Features of the heavy metal recovery process are as follows:

(1) Equipment configuration is simplified by the use of a washing treatment.

(2) Disposal of residues is unnecessary because washed residues are reused as resources.

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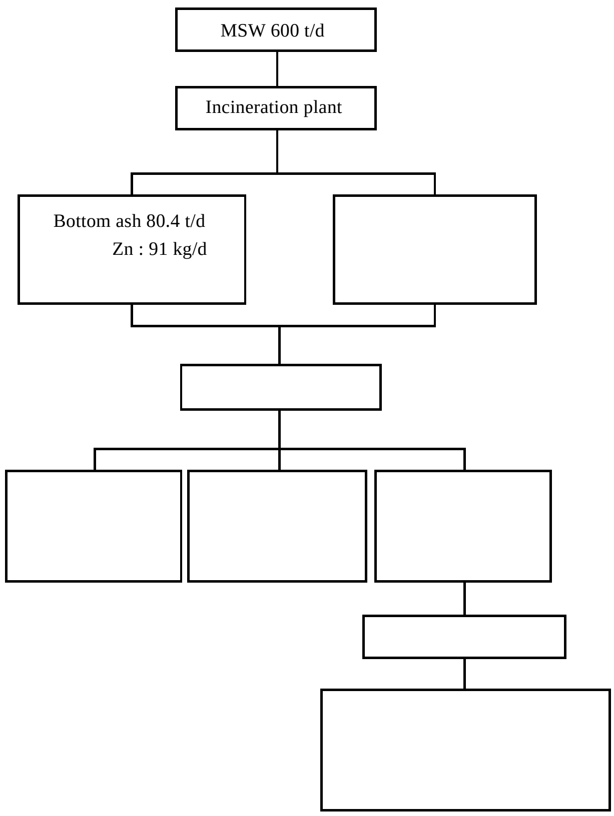
Heavy metals contained in solid waste are concentrated in incineration residues by the incineration treatment and are then concentrated further in the dust by vitrification treatment. A material balance for zinc and lead in an incineration and vitrification plant with a refuse throughput of 600 tons/day was calculated on the basis of and . The result is shown in Fig. 7. The amount of zinc reclaimed by supplying Zn and Pb concentrate recovered from dust to an ISP plant was calculated to be 95 tons/year, and the amount of lead reclaimed was calculated to be 28 tons/year.



recovery, as shown in Fig . The energy consumption and CO_2 emission for these three routes were evaluated[5].

energy consumption and CO_2 emission are the lowest.

(2) Washing treatment done in vitrification plant and heating treatment in smelting plant (R2)

The energy consumption and CO_2 emission take intermediate values between R1 and R3, and are about two times those of R1.

(3) Washing and heating treatment in vitrification plant (R3)

The volume of transportation is low, and therefore the energy consumption and CO_2 emission in transportation are low. However, since washing treatment and (electrical) heating treatment are conducted using small equipment at the vitrification plant, the energy consumption and CO_2 emission are the highest, being about three times those of R1.

Thus, significant saving of the energy consumption and CO_2 emission required for resource recovery treatment of dust should be possible by utilizing large equipment in the smelting plant[5]. In determining the route nificance. The most valuable function of the vitrification of incineration residue is to render it harmless.