WASHING OF WASTE BY AN INJECTOR TYPE WASHING SYSTEM

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ABSTRACT
The structure of injector washing system for incineration ash allows the contact of the objects to be washed with high pressure washing water without fail. It is therefore expected to bring about high washing effect as well as facilitate facility layout planning.
The volume of washing water was determined to be five times that of raw ash, and supplied as rinsing water for solid-liquid separator. Supernatant of drainage of washing water was recycled as washing water for injector operation. No large fluctuation of washing water quality was observed even after continuous operation was performed.
The washed ash transferred by an injector underwent solid-liquid separation treatment of vacuum dehydration method using 2.0mm mesh wire net, but residue of fine particles of 100μm or smaller was observed at the percentage of 5 to 10%. The removal ratio of heavy metals and dioxins varied largely ranging from 25 to 75%. Since the contents of solid in drainage of washing water was higher than that of raw ash, much of them was assumed to be contained in fine particles, and consequently solid-liquid separation method with high classification performance was considered to be effective. Since chlorides are high in solubility, the removal ratio by injector washing was about 90%. The concentration of residual chlorine after washing was about 0.2%. If foreign substances that may hinder the transfer in pipes are removed, the compact system that allows quick washing with its high contact efficiency and strong agitation power is considered to serve as an efficient washing system.

INTRODUCTION
Self-cleaning function and washing of pollutant by rainfall bring about stabilization of final disposal site for general waste. We have been reviewing the Wash-Out Waste Landfill System (WOW System) that ensures stabilization and closure in an early stage by washing waste before landfill, thus contributing to the preservation of the regional environment. We are also reviewing the possibility of creating a waste recycling system that enables the use of incineration ash as raw material for cement by washing and desalinating it. We have submitted reports on washing characteristics obtained by performing basic experiments (Hirose et al., 2000) and the washing characteristics of spiral wet washing system, which has superior classification characteristics as a mechanical washing system (Tanioka et al., 2002). This paper describes the washing characteristics of injector type washing system, which is expected to have good washing effect by agitation, obtained through washing experiments we conducted using incineration residue from a stoker furnace.

OUTLINE OF INJECTOR TYPE WASHING SYSTEM AND WASHING FLOW
Washing Method by Injector
Fig. 1 indicates the outline of injector type washing system. Objects to be washed is sucked by negative pressure (A) generated by high pressure washing water injected from the nozzle, and sucked objects are
contacted with high-pressure water without fail, and consequently, high washing effect is expected. Since washed objects are transferred through pipes, the system layout can be compacted. However, to avoid clogging of pipes, bulky objects and wires must undergo pretreatment such as crushing and sorting.

**Flow of Washing System**
Fig. 2 indicates the flow of injector type washing system.

**SETTING WASHING CONDITIONS**
Washing conditions of the system were established based on the preliminary experiment performed in advance.

**Pretreatment of Raw Ash**
Since the incineration ash used for experiment was the incineration residue of general waste obtained through incineration in a stoker furnace, and a lot of wires and nails were mixed in even after the screening with 10mm sieve (Photo 1), screening was performed with 6mm sieve in this experiment. Recovery rate by sieving was about 50%. Bulky residue on the sieve was directly put into the solid-liquid separation tank and washed by water spraying.

**Washing frequency**
Circulation washing is made possible by receiving washed ash that is pressure fed from the injector into the washing tank once again. We therefore reviewed the elapsed time of circulation washing and the change of electric conductivity (EC value) inside the washing tank. Fig. 3 indicates the flow of circulation washing, and Table 1 lists the results obtained. With the elapsed time of circulation, salt content was dissolved, and then, EC value increased. Removal ratio of about 95% was obtained after two times of circulation. To simplify the system, circulation washing was not performed with this experiment, and one-path washing, single-stage washing, was performed. If higher washing effect is required, two-stage washing could be adopted to ensure improved washing effect.

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\text{Removal ratio} = \frac{(\text{Each EC value} - \text{Initial EC value})}{(\text{Saturated EC value} - \text{Initial EC value})}
\]

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**Fig. 2 FLOW OF INJECTOR TYPE WASHING SYSTEM**
Setting the Amount of Washing Water
Drainage of washing water is recycled and used for injector washing, and the supply water for this system is supplied as rinsing water for the solid-liquid separator. Washing water (50L) of the same volume as washed ash was sprayed to the solid-liquid separator, and the decreasing tendency of EC value in the drainage was examined each time it was sprayed. Fig. 4 indicates the washing frequency and the obtained EC value. After five times of spraying, the EC value was kept almost constant. The same result was obtained when the 5 times amount of washing water sprayed at one time (in the third washing). Based on the above result, the amount of washing water was determined to be 5 times as the raw material inlet.

RESULT OF WASHING EXPERIMENT
Twenty-four batches were performed as total number of washing experiments under the conditions described above. Samples were extracted during RUN10, and washing effect was analyzed.

Change of EC Value of Circulating Washing Water
After sedimentation treatment, drainage of washing water was circulated as washing water. Fig. 5 indicates the change of EC value of the drainage. As the washing number increases, EC value gradually increased. But since it was diluted with supply water at rinsing, the EC value stably fell within the range from 550 to 650ms/m. The EC value of drainage increased once after injector washing, but it returned to approximately the same as before injector washing because rinsing water diluted it.
**Result of Washing**

Table 2 indicates the result of washing in RUN 10.

**Removal ratio:** Large fluctuation of the removal ratio of heavy metals such as Cd, Pb, As, Hg, Zn, and Cr was observed, ranging from 25 to 75%. Based on the fact that the concentration in the sediment in drainage of washing water was high, they assumed to be contained in fine particles. Since the removal ratio of Cl was about 90%, and its concentration in sediment was low, it was assumed that its high solubility in water ensured high desalination effect.

**Recovery ratio:** Fig. 6 indicates the particle distribution of each sample. Washed ash underwent solid-liquid separation treatment by vacuum dehydration method using 2.0mm mesh wire net, but residue of fine particles of 100μm or smaller was observed at the percentage of 5 to 10%. The recovery ratio was calculated to be 84.4% from the average weight of washed ash recovered by each RUN of 42.2kg. The particle distribution analysis revealed that the size of most of the particles in drainage was 15μm or smaller, particles of the diameter of 15μm or smaller in raw ash made up 20%, and that the volume contained in washed ash was about 5%. The recovery ratio of this system was therefore estimated to be about 85%.

**Removal of dioxins:** Table 3 indicates the dioxins contained in sediment in raw ash, washed ash and sediment in drainage. The dioxins in washed ash were reduced by about 50%. Also, since the concentration in sediment in drainage of washing water was high, they assumed to be contained in fine particles, and consequently washing method with high particle classification performance was considered to be effective.

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**Table 2 RESULT OF COMPONENT ANALYSIS**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Raw ash</th>
<th>Washed ash</th>
<th>Removal ratio %</th>
<th>Sediment in drainage of washing water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cd</td>
<td>mg/kg</td>
<td>10.4</td>
<td>8</td>
<td>23.1</td>
</tr>
<tr>
<td>Pb</td>
<td>mg/kg</td>
<td>960</td>
<td>580</td>
<td>39.6</td>
</tr>
<tr>
<td>As</td>
<td>mg/kg</td>
<td>10</td>
<td>8</td>
<td>25.0</td>
</tr>
<tr>
<td>Hg</td>
<td>mg/kg</td>
<td>1.95</td>
<td>1</td>
<td>48.7</td>
</tr>
<tr>
<td>Cu</td>
<td>mg/kg</td>
<td>38,600</td>
<td>1,910</td>
<td>95.1</td>
</tr>
<tr>
<td>Zn</td>
<td>mg/kg</td>
<td>13,800</td>
<td>3,410</td>
<td>75.3</td>
</tr>
<tr>
<td>Cr</td>
<td>mg/kg</td>
<td>124</td>
<td>76</td>
<td>38.7</td>
</tr>
<tr>
<td>Mn</td>
<td>mg/kg</td>
<td>4,380</td>
<td>728</td>
<td>83.4</td>
</tr>
<tr>
<td>Na</td>
<td>mg/kg</td>
<td>18,900</td>
<td>5,150</td>
<td>72.8</td>
</tr>
<tr>
<td>K</td>
<td>mg/kg</td>
<td>12,100</td>
<td>6,200</td>
<td>48.8</td>
</tr>
<tr>
<td>Ca</td>
<td>mg/kg</td>
<td>8,830</td>
<td>5,740</td>
<td>35.0</td>
</tr>
<tr>
<td>Mg</td>
<td>mg/kg</td>
<td>8,340</td>
<td>7,780</td>
<td>8.7</td>
</tr>
<tr>
<td>Cl</td>
<td>mg/kg</td>
<td>16,500</td>
<td>2,140</td>
<td>87.0</td>
</tr>
</tbody>
</table>

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**Particle diameter [mm]**

- 1. Raw ash
- 2. Washed ash (before)
- 3. Washed ash (after)
- 4. Sediment in drainage of washing water

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**Table 3 REMOVAL OF DIOXINS**

<table>
<thead>
<tr>
<th></th>
<th>Raw ash</th>
<th>Washed ash</th>
<th>Removal ratio</th>
<th>Sediment in drainage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ng-TEQ/g</td>
<td>ng-TEQ/g</td>
<td>%</td>
<td>ng-TEQ/g</td>
</tr>
<tr>
<td>PCDDs</td>
<td>0.4</td>
<td>0.18</td>
<td>55</td>
<td>1.4</td>
</tr>
<tr>
<td>PCDFs</td>
<td>0.7</td>
<td>0.3</td>
<td>57</td>
<td>2.2</td>
</tr>
<tr>
<td>CoPCB</td>
<td>0</td>
<td>0.0076</td>
<td>-</td>
<td>0.047</td>
</tr>
<tr>
<td>Total</td>
<td>1.1</td>
<td>0.49</td>
<td>55</td>
<td>3.7</td>
</tr>
</tbody>
</table>
CONCLUSION
(1) Since the washing method by injector is based on transfer through pipes, the main ash, into which foreign matter such as wires, nails and annealing wires are expected to be mixed, must undergo pretreatment such as sieving and crushing.

(2) Washing by injector can be expected to have higher washing efficiency by adopting multi-stage washing. However, since sufficient washing effect was obtained with even single-stage washing, the experiment of this time adopted one-path washing with the simplification of the system taken into consideration.

(3) The amount of washing water was determined to be five times as raw ash, and it was supplied as rinsing water for solid-liquid separation.

(4) The removal ratio of heavy metals such as Cd, Pb, As, Hg, F, Zn and Cr varied by washing. Since the content in fine particles that formed the sediment in drainage was high, it was anticipated that large part was contained in fine particles. Solid-liquid separation method with high classification performance is required as washing method.

(5) Since chlorides are high in solubility, the removal ratio by injector washing was about 90%. The concentration of residual chlorine after washing was about 0.2%. The system with high contact efficiency with washing water and high agitation capability was considered to be effective.

(6) The removal ratio of dioxins was about 50%.

This paper represents a part of the results of the research conducted in 2002 by Wash-Out Waste Landfill System (WOW System) workshop.

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REFERENCES