Feasibility Study of the Refuse Management Systems using the Floating Refuse Incineration Plants

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Summary

Approximately 500 megatons in weight as much as 25% of input resource are disposed a year as refuse. And the municipal refuse that is approximately 50 megatons and more significantly 70% of the municipal refuse are disposed by incineration plants of all municipalities districts of Japan.

In 1983, the inhabitants near the location of incineration plants were thrown into a panic on realizing the high density dioxin emission from the flying ash of the refuse incineration plants, and this trouble has developed into a social problem in Japan. So, approximately 4600 plants of the refuse incineration as much as 17% are suspended to operate by the dioxin emission control of the Japanese Government.

It is low possibility to operate the refuse incineration plants again, because of the financial difficulties of municipalities and the difficulties of a general consensus among inhabitants in which the neighboring areas.

In this paper, a concept of the refuse management systems that is the combination systems of the floating refuse incineration plants and the refuse collection systems on shipping is proposed for solving these defective points. And as the practical example of applying the proposal concept to the region of Ariake sea and its feasibility study are stated briefly.

1. Introduction
The material flow of 1998 in Japan is shown in Fig.1. Amount of input resources is an approximately 2 gigatons a year, and at the end of material flow approximately 500 megatons as much as 25% of input resource are disposed a year as refuse. And the municipal refuse that is approximately 50 megatons and more significantly 70% of the municipal refuse are disposed by incineration plants of all municipalities districts of Japan.

Fig.2 shows the comparison of the ratio of quantity of refuse by incineration between in Japan and in other country. This figure shows that the ratio of quantity of refuse by incineration in Japan is top ranking in the world. Because Japan has a large population in its limited area, it is need to reduce the volume of refuse by incineration treatment. The great deal of refuse disposal cause the serious refuse problem such as a toxic dioxin emission problem and a rapid decrease problem of landfill for refuse disposal.

In this paper, a concept of the refuse management system that is the combination systems of the floating refuse incineration plants and the refuse collection systems on shipping are proposed for solving these defective points. And a feasibility study that the refuse management system is applied to the region of Ariake sea as the practical example is stated briefly by comparing the initial and running cost benefit with some transferring case.

2. Recent Refuse Problems in Japan
Many refuse problem come to the surface in Japan recently. Some case such as dioxin emission problem, solid refuse landfill problem and recycle are explained below.

2.1 Dioxin Emission Problems
In 1983, the inhabitants were thrown into a panic on realizing the highest density dioxin emission from the flying ash of the refuse

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incineration plants, and this trouble has developed into a social problem in Japan.

The tentative regulations for the density of dioxin emission to environment come into force since 1999 in Japan as shown in Table 1. And the regulations of the density for control to the dioxin emission from the refuse incineration plants are shown in Table 2 according to the disposal capacity for the refuse.

When the refuse incineration plants don't satisfy the density of dioxin emission in these table, to bring the operation to a halt, to reconstruct and to disuse the plants are instructed administratively. For the sake of these value are set as a low limitation, approximately 4600 plants of the refuse incineration as much as 17 % of all plants are suspended to operate by control of the Japanese Government, especially a large number of incineration plants to be small disposal capacity are disused, because not to reach a high temperature inside the incineration bring an occurrence of dioxin.

To make matter worse, it is low possibility to operate the refuse incineration plants again, because almost municipalities that are in financial difficulties cannot manage to raise the funds for improvement of the new incineration plants to be a low dioxin emission type. Furthermore when the construction plan for the refuse incineration plants are decided on a budget, as matter of fact, a general consensus among inhabitants in the neighboring areas are not reached to agreement, though the regulation of the dioxin emission are cleared sufficiently.

2.2 Solid Refuse Landfills

The solid refuse landfills is used as a dumping area for garbage disposal, trash, ashes from the refuse incineration plants.

In recent year, the capacity of remaining landfills is only 11 years in 1997 averagely in Japan. Furthermore it is difficult to secure the location for landfills, especially near the Metropolitan area such as Tokyo, because of a land price problem, a movement of local resident against the new construction of landfills, and which a local financial difficulties fall on.

2.3 Recycle

The new concept of lows of recycle system has attracted a great deal of social attention in Japan. This purpose is a propulsion of 'reduce', 'reuse' and 'recycle', sometimes called as '3R on the recycle systems'.

Here is main law that come into force a point in 2000:

(1) Containers recycle;
The separating collections of a plastic container as the major share of refuse disposal.
(2) Electrical appliances recycle;
The scrap charge for four electrical appliances such as a television, a washing machine, a refrigerator and an air conditioner.
(3) Foods recycle;
The utilization of garbage from the food industry as feed.

There is an increase in the ratio of recycle from 4% to 10% after enforcement by the lows of recycle due to attract a social attention to an environmental problem. But actually, it is difficult to drive this recycle system because of the cost problem of the refuse collection generally.

Exceptionally, a case in point is given in Minamata city where residents had experienced a pollution disease that was caused by mercurialism. The refuse to be collected by residents in Minamata city is called a treasure, because of the complete separate collection of refuse by activity of local residents.

3. Refuse Disposal in Japan

a) Grouping of refuse on regal definition in Japan

There are following three refuse category on regal definition generally in Japan:
(1) The municipal refuse such as garbage, trash, and waste from home generally and waste from office.
(2) Industrial refuse such as discharge in the process of production
(3) Special control refuse such as PCB, strong alkaline, strong acid and medical waste.

Fig.3 shows the comparison of the quantity of refuse between from home and office. This figure shows that the quantity of refuse from office grows up with GDP, on the other hand, the quantity of refuse from home keeps almost constant level. This figure means that the municipal refuse problem in Japan is mainly caused by an increase in the quantity of refuse from office with economic growth.

b) Regal liability for the refuse disposal

The refuse disposal is bound to each municipality accountability, on the other hand, municipalities can bear the expense as tax collection legally.

Fig.4 shows the total of refuse disposal expense and the item of refuse collection cost. This figure shows that the expenses pile up as year pass by, and the refuse collection cost to be about 60% of the total expense accounted for one of main item of the refuse disposal expense. In the near future it is estimated that the refuse collection and transferring expense will be more increase. There are following main two reasons:
(1) More long distance between the location of refuse emission and the location of disposal area such as the landfill and incineration plants.
(2) More higher frequency of the refuse collection corresponding on the trends of recycle movement, which is include with a contradiction in the
present refuse collecting system.

4. A refuse Management Systems by the Floating Incineration Plants

In consideration of these refuse problems that were stated previously, a conceptual illustration of a refuse management systems by the floating incineration plants are proposed as shown in Fig.5. This concept is constructed in main three processes. First, the municipal refuse are collected by the refuse vehicle like a packer vehicle or carried at the public refuse collecting station by residents. Then, the collected refuse are packed into the large container at the first transfer station, thirdly the packed refuse in the container are transported to the floating incineration plants by shipping through the second transfer station in the port. Finally the refuse container are handled in the floating incineration plants.

The below advantages of this system are expected:
(1) When the floating incineration plants keep mooring in the center of large bay such as Tokyo Bay, Ise Bay, Ariake sea and Seto Inland Sea where are densely populated around about 20km from the coastline, it is easy to collect the great deal of municipal refuse by low cost.
(2) The consensus of residents for the new construction of refuse incineration plants is achieved comparatively, but several confliction can be foreseen between fisherman.
(3) In near future when the refuse are decreased by effect of recycle, it is easy to move to another area where have a refuse problem, and so on.

Fig.6 shows a concept of lay out on the first and second transfer station.
At the second transfer station, the refuse container is transferred to the refuse container ship mainly where the function of the first transfer station is combined [1, 2].

Fig .7 shows a concept of lay out of the floating incineration plants. The main flow of container is explained following. The refuse container is transferred on the pallet by gantry crane and carried to the inlet of incineration. Furthermore the container is cleaned and disinfected, and some container is filled inside the stabilized ashes that are discharged from the stabilization plant for ashes through the incineration plant. Finally the container is carried to the container storage yard and transferred to the refuse container ship for the next collecting.

5. Feasibility Study of the Refuse Management Systems

The proposal concept of the refuse management systems is applied to the region of Ariake sea as the practical example and the procedure of feasibility study are taken as follows.

Firstly, it is need to assume a major factor for the expenses in this refuse management system such as, where the floating refuse incineration plants is located in the bay, where the second and transfer station are located along the coastline, and how many the station are to be constructed.

Here is the following assumptions are taken into consideration: the floating plants is located only one point somewhere in the Ariake sea, the number of the second transfer station is assumed a constant five stations, the first station is located the middle of each municipal because of the municipal refuse in the present system is incinerated on each district, and an object of study of the refuse disposal is the municipal refuse [category 1, as stated above 3.(a)].

Secondly, three trial cases for a feasibility study of the refuse management systems are considered as shown in Fig.8. There are some difference on the refuse container carrying systems such as the long distance for transporting by chassis in case C, and the mooring location of the floating refuse incineration plant such as the middle of the refuse collecting area in case A to C as for example.

Thirdly, following calculations are cumulated on this feasibility study:
(1) The region of an object of this study is divided by one kilo meter square meshes and the roads for track are connected as network on the divided meshes.
(2) The municipal refuse in each municipality is roughly estimated by the statistics data of the density of population on each mesh [3].
(3) The minimum root for refuse collecting network is calculated on the divided meshes.
(4) The quantity of municipal refuse that is collected at each refuse transfer station is calculated by the method of Volonoi [4].
(5) The weight is shown as the ratio of expense that is calculated based on the official announcement data of the present refuse management systems by some municipal URL.
(6) A cost of transferring container is taken according to the shipping data and transportation data [5]. Etc.

As the calculated example, the expenses of the refuse management system are summarized in Table 3. These results are estimated on a comparison of the differential cost of the trial cases and the present systems as a basic cost. Both case A and B that are taken the shipping transporting system are estimated as a cost advantages because of the merits of the ship transportation such as a great deal of freight and low cost.

6. Conclusion
A concept of the refuse management system that is the combination system of the floating refuse incineration plants and the refuse collection systems on shipping are proposed for solving defective points of present refuse management system.

And a feasibility study that the refuse management system is applied to the region of Ariake sea is stated briefly as the practical example. It is revealed that this proposal concept such as the refuse management systems using the floating refuse incineration plants is estimated as a cost advantages.

In future, more detail analysis, for example, some calculation of an optimum collecting root and an optimum mooring position of the floating plants are need more to take into consideration as a planning study.

References
The quantity of refuse 

\[10^6 \text{ tons}\]

GDP 

\[10^{12} \text{ Japanese Yen}\]

Fig. 3 The comparison of the quantity of refuse between from home and office

Table 1 Dioxin emission regulation

<table>
<thead>
<tr>
<th>Tolerance</th>
<th>4 [pg-TEQ/(Kg·day)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerial</td>
<td>0.6 [pg-TEQ/(N·m^3)]</td>
</tr>
<tr>
<td>Water</td>
<td>1 [pg-TEQ/l]</td>
</tr>
<tr>
<td>Soil</td>
<td>1000 [pg-TEQ/g]</td>
</tr>
</tbody>
</table>

TEQ: A toxicity level that is equivalence of most poisonous dioxin 2,3,7,8-TCDD

Table 2 Dioxin emission regulation on the refuse incineration

<table>
<thead>
<tr>
<th>Disposal capacity [ton/hour]</th>
<th>New construction case</th>
<th>Under operation Till Nov./2000</th>
<th>After Dec./2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over 4</td>
<td>0.1</td>
<td>80</td>
<td>1</td>
</tr>
<tr>
<td>For 2 to 4</td>
<td>1</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Under 2</td>
<td>5</td>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>

Unit: [ng-TEQ/(N·m^3)]]

Fig. 4 The refuse disposal expense
Fig. 5 A conceptual illustration of a refuse management systems by the floating incineration plants.

Fig. 6 Layouts of Transfer station and Container paking station.
Fig. 7 A concept of layout of the floating incineration plants

G/C: Gantry Crane
L/G: Lifting Gear
P/S: Pallet and Skidding
**Evaluation Items**

<table>
<thead>
<tr>
<th>The refuse collection cost (Present system)</th>
<th>Weight</th>
<th>Case (See Fig.8)</th>
<th>Unit</th>
<th>Expense per year $[10^8 \text{ JYen/Year}]$</th>
<th>A share of the expense per a municipal (Case A) $[10^8 \text{ JYen/Year}]$</th>
</tr>
</thead>
<tbody>
<tr>
<td>An increase in cost</td>
<td>6</td>
<td>5.0</td>
<td>A</td>
<td>3300</td>
<td>120</td>
</tr>
<tr>
<td>By this collection system</td>
<td></td>
<td></td>
<td>B</td>
<td>180 180 830</td>
<td>6.6 6.6 30.3</td>
</tr>
<tr>
<td>Container Loading</td>
<td></td>
<td></td>
<td>C</td>
<td>180 150 60</td>
<td>6.6 5.5 2.2</td>
</tr>
<tr>
<td>Construction cost</td>
<td>2</td>
<td>1.7</td>
<td></td>
<td>1000</td>
<td>40</td>
</tr>
<tr>
<td>For the plants</td>
<td></td>
<td></td>
<td></td>
<td>26 24 24</td>
<td>0.69</td>
</tr>
<tr>
<td>(Deduction of price of land)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Running cost (For the plants and station)</td>
<td>3</td>
<td>3</td>
<td></td>
<td>1665</td>
<td>61</td>
</tr>
<tr>
<td>Landfill for ashes</td>
<td>1</td>
<td>0.8</td>
<td></td>
<td>555</td>
<td>20</td>
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<tr>
<td>Consensus among the residents</td>
<td>7</td>
<td></td>
<td></td>
<td>(F:Fair, B:Better)</td>
<td></td>
</tr>
<tr>
<td>In the port</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For the plant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig.8 Trial case for a feasibility study of the refuse management systems

Table 3 A comparison of expense of the refuse management systems