5

Present Status and Problems Associated with Waste Disposal Technologies Aiming at Efficient Utilization of Energy Contained in Combustible Wastes

MASAHIRO NEMOTO AND KUNIO YOSHIKAWA (AFFILIATED FELLOW)
Environment and Energy Research Unit

5.1 Introduction

The construction of a recycling-oriented society is one of the highest goals in the environment-related policy area for which a nationwide consensus has been formed.

What we have to recycle primarily in such a society are generally visible resources and wastes and, in this sense, such a recycle can be called as the "Material Recycle."

The law system to encourage the Material Recycle has been improved steadily and is beginning to produce tangible results. However, given our current technological level, it is still difficult to recycle every material for reuse. And that is where the "Thermal Recycle" in which wastes, etc., are utilized as a source of energy, comes in as a means to fill the gap and utilize what is difficult to recycle or reuse as a material.

The "Thermal Recycle" can be seen as a means to make possible effective utilization of energy that is currently unutilized and wasted. Today, among the wastes discharged from general household and industrial activities, a huge amount is just incinerated without being recycled and the thermal recycling of them, if realized, will help save resources on a rather substantial scale.

So then, we are confronted with a problem. We have not yet developed efficient and safe waste burning technologies that are basis of the Thermal Recycle.

In this paper, we will discuss the present status and problems associated with waste incineration technologies which is indispensable to the Thermal Recycle, focusing on utilization of energy recovered from wastes.

5.2 Present status of the Thermal Recycle

5.2.1 Present status of heat recovery from wastes

It is possible to identify the size of each category of the sources generating wastes from press releases by the former Ministry of Health and Welfare (MHW) and the white paper issued by the former Environment Agency. According to statistics released by MHW in June 2000, the amount of municipal solid wastes discharged annually from homes, etc., was 51,200,000 tons in 1997, indicating that each one of us generated about 1.1 kg of wastes everyday. Approximately 70% of these wastes was disposed of by means of direct incineration, while the rest was disposed of as bulky wastes or recycled as resources. (See Chart 1)

By far, much larger amount, however, is discharged as industrial wastes. The total amount discharged in 1997 reached approximately 415,000,000 tons, 43% of which or surprisingly about 180,000,000 tons went to direct incineration. (See Chart 2)

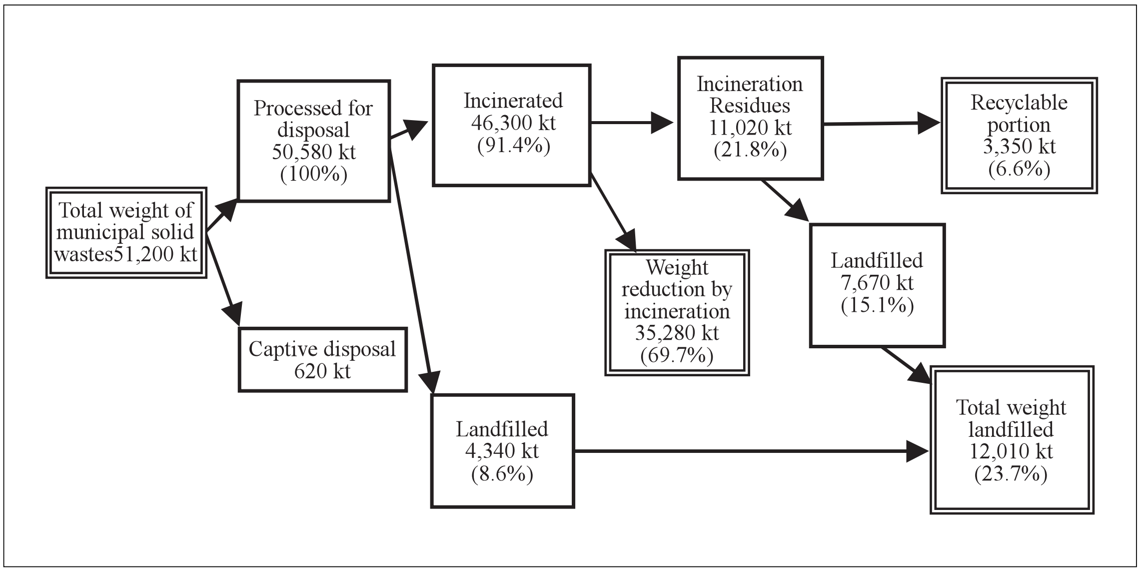
For instance, to examine plastics among recovered wastes, they have an energy density as large as 37 giga joules/ton. These potential sources of energy, however, are just burned in relatively simple, small or medium-scale incinerators and the huge amount of waste heat are almost in no use.

5.2.2 Institutional aspect of the Thermal Recycle

Today, the law system to promote the construction of a recycling-oriented society has been improved to a considerable level. In our law system, the following four laws have been legislated as regulatory measures taking the characteristics of particular products into consideration: "Law for Promotion of Sorted Collection and Recycling of Containers and Packaging (Container and Packaging Recycle Law)," "Law for Recycling of Specified Kinds of Home Electric Appliances (Home Electric Appliance Recycle Law)," "Law for Recycling of Materials involved in Construction Work (Construction Material Recycle Law)," and "Law for the Promotion of Recycling of Recyclable Dietary Resources (Food Recycle Law)."

Among these laws, the Home Electric Appliance Recycle Law and the Construction Material Recycle Law have recognized the Thermal Recycle as one possible form of recycling, while they give priority to the Material Recycle as the most desirable form. The Home Electric Appliance

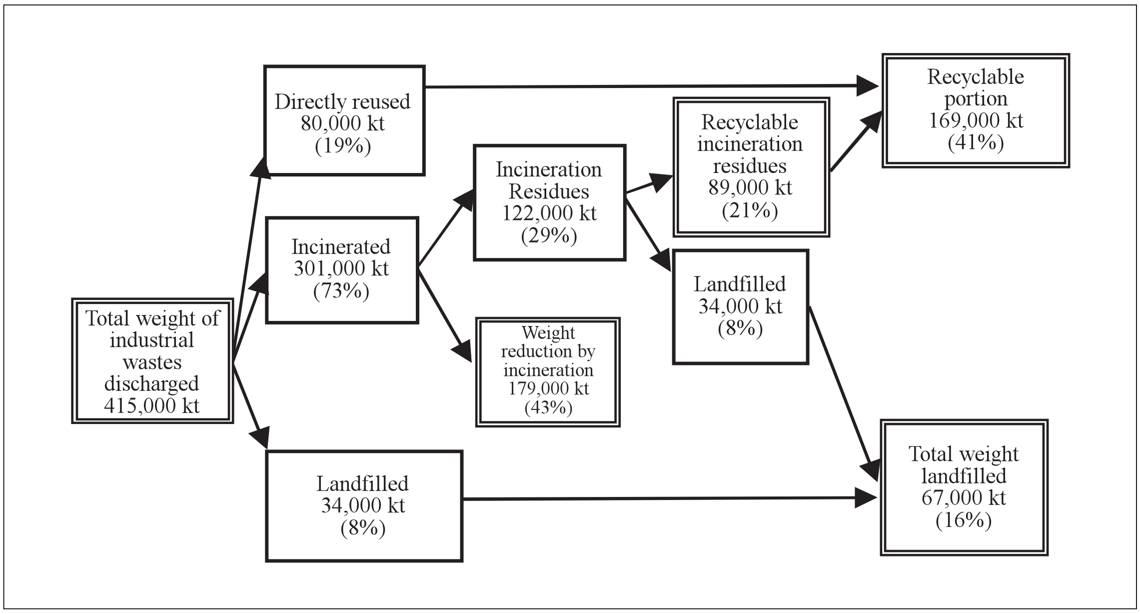
Chart 1: Disposal flow of municipal solid wastes in Japan



Source: "The status of municipal solid waste generation and disposal in FY1997" http://www1.mhlw.go.jp/houdou/1206/h0623-2_14.html MHW's data were summarized and compiled into the above chart by the Science & Technology Foresight Center

Note: Due to measurement rounding, there are cases where percentages shown do not total to 100% when added.

Chart 2: Disposal flow of industrial wastes in Japan



Source: "The status of industrial waste generation and disposal in FY1997" http://www1.mhlw.go.jp/houdou/1206/h0623-2_14.html MHW's data were summarized and compiled into the above chart by the Science & Technology Foresight Center

Note: Due to measurement rounding, there are cases where percentages shown do not total to 100% when added.

Recycle Law, however, does not specify quantitative lefel for the Thermal Recycle, which utilizes plastic parts, etc., as a fuel, while it specifies recycle-rate requirements for the Material Recycle, which recycles or reuses waste parts and materials in future products. The Construction Material Recycle Law, which will be put into effect in April 2002, adopts a principle that the Thermal Recycle should be considered for combustible wastes that are rarely reusable or technically difficult to recycle as material.

5.3 Present status of incineration technologies supporting the Thermal Recycle

5.3.1 Incineration in the form of RDF

Nearly 70% of the combustible wastes discharged from homes goes to incineration as shown in Chart 1, and its utilization as an heat resource has already been practiced in the process of volume reduction of wastes.

One embodiment is power generation from wastes, in which combustible wastes are processed into pelletized solid fuel called RDF (Refuse Derived Fuel) and burned in a fluidized bed furnace, etc. RDF, which is produced by crushing raw wastes and compacting it into pellets of about 1.5 centimeters in diameter and several centimeters long after dehydration, is lightweight and does not have any offending smell. RDF offers a number of advantages including that it can reduce the weight of raw wastes containing a lot of water and, therefore, also transportation costs, that it opens the way to a more economical disposal system through expansion of the scale to cover an extensive area, and that it will allow a large-scale furnace to operate continuously at a high temperature so that generation of dioxins can be suppressed.

On the other hand, RDF still has some problems. In the technical aspect, it requires selective removal of foreign matters such as pebbles and metals to protect crusher equipment used in the production process. In the economic aspect, 1 ton of raw wastes requires 65 liters of kerosene for processing (trial calculation by the Enterprise Agency of the Mie Prefectural Government), making RDF's production cost very expensive. In the environmental aspect, volume reduction or effective utilization of remaining ash after burning is necessary due to an increase in the ash content resulting from the addition of quick lime. It has been pointed out that solutions are needed for these problems. Thus, there are still many problems awaiting solutions before efficient Thermal Recycle is performed with RDF power generation.

5.3.2 Conventional type incineration

One of the conventional methods still employed by many incineration facilities up to today is the stoker method. In this method, wastes are placed on a grid called a stoker, conveyed slowly and burnt, while air is blown from the underneath. The efficiency of power generation from wastes is normally very low, measuring at something between 10 and 15%. The reason is because operation at a low temperature is preferred based on the following grounds and this, as a result, forces a boiler to accept low-temperature steam: (1) when the combustion gas of wastes rises to a high temperature beyond 300 ℃, hydrogen chloride gas contained in the combustion gas and alkali-metal salts having a low-melting point will make the boiler superheater steel tubes corrodible easily; and, (2) a furnace bed holding wastes for incineration tends to deteriorate more from oxidation when the combustion temperature becomes higher, and thus low temperature operation ensures longer useful life of the equipment.

For the problem of superheater tube corrosion, development of a stainless steel based new material together with some operational improvements such as the adoption of combustion at a low air-fuel ratio is believed to provide a solution. For the problem of furnace bed deterioration, several major furnace manufacturers proposed the adoption of a water cooled internal structure to avoid excessive heating of a furnace bed in addition to the improvement of the furnace bed structure itself. With these improvements, a system offering over 20% efficiency of power generation using high-temperature, high-pressure steam of 400 ℃ and 40 atmospheric pressure produced in a boiler has been put to practical use. Furthermore, major manufactures are conducting experiments to materialize over 30% power generation efficiency by raising the temperature and pressure of steam to 500 ℃ and 50 atmospheric pressure, respectively.

5.3.3 Commercialization of an ash-melting gasification furnace

Besides its low power generation efficiency, the conventional power generation system using wastes is known for having the problem of dioxin generation due to low-temperature combustion. To overcome these problems, an ash-melting gasification furnaces were developed by about 20 major manufacturers and is beginning to be put to practical use.

The basic mechanism of an ash-melting gasification furnace is to gasify wastes through thermal decomposition at a temperature between 300 and 600 ℃ in the gasification furnace section, and then to extract molten ash (slag) and metals such as iron at over 1200 ℃ in the melting furnace section. The boiler section does not only exstracting heat but also uses it for power generation, while exhaust gases are released through a stack to the open air after removing chlorides with a gas purification system and ash with a dust collector.

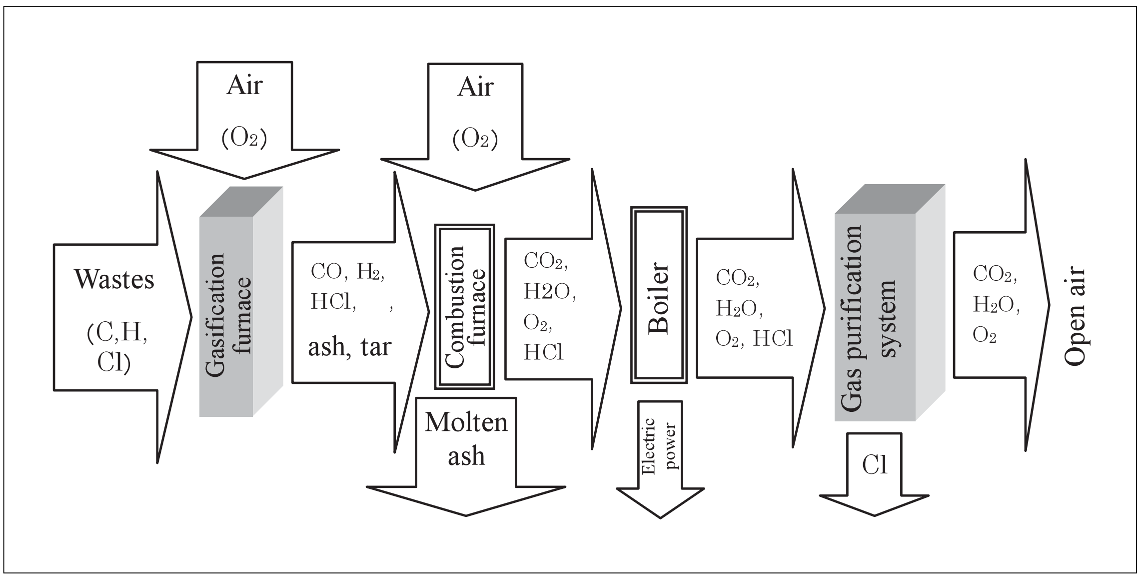
Ash-melting gaasification furnaces are grouped into three types depending on their gasification furnace and melting furnace structures. They are the direct melting furnace (shaft furnace) that has a combined gasification and melting furnace, the kiln type furnace that burns wastes in the melting furnace after gasifying it in a rotating drum furnace (gasification kiln) heated to about 450 ℃, and the fluidized bed type furnace that blows air from the bottom of the gasification furnace heated to around 600 ℃ and fluidizes hot sand in the furnace to gasify wastes. Chart 3 shows a schematic flow of the process common to them together with the composition of gases.

Ash-melting gasification furnaces depicted here were developed under MHW's basic policy to concentrate waste disposal to large-scale furnaces with a view to reducing the concentration of dioxin emission, as well as being designed to handle several hundred tons of wastes a day. They draw high expectation as promising means for materializing the Thermal Recycle.

5.3.4 New trend of ash-melting gasification furnace technologies

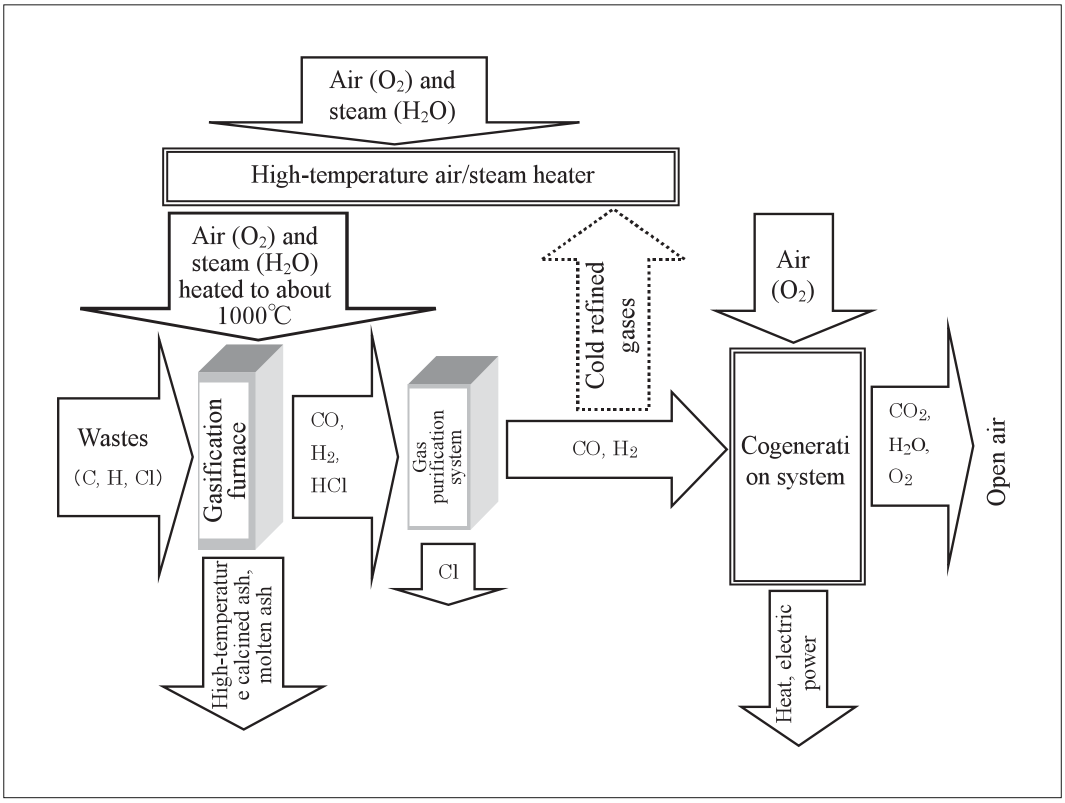
While a large-scale ash-melting gasification furnace is a promising technology, it is not a suitable choice for an enterprise or local governments whose volume of waste discharge is several tons to several ten tons a day. As one example of technological developments addressing such smaller needs, a new incineration technology employing a small-scale ash-melting gasification

Chart 3: Schematic system of an ash-melting gasification furnace and flow of gas components



Prepared by the Science & Technology Foresight Center

Chart 4: Schematic system of power generation using a new ash-melting gasification technology and flow of gas components



Prepared by the Science & Technology Foresight Center

system has been developed at Tokyo Institute of Technology under the sponsorship of the Japan Science and Technology Corporation as a part of the CREST (Core Research for Evolutional Science and Technology) Project.

While the process of this new system is depicted in Chart 4, its major difference from a large-scale ash-melting gasification furnace lies in that high-temperature fuel gases extracted from the gasification furnace are, after they are cooled and purified, introduced to a cogeneration system (an engine generator and a boiler) to convert them into electric power and steam.

Another characteristic point of the new system is that it can minimize dioxin generation because it has a high-temperature reducing atmosphere created with high-temperature air/steam of about 1000 ℃ introduced to a gasification furnace, with fuel gases removed of chlorides burned in a cogeneration system as depicted in Chart 4.

The most advantageous point of this system is that it can utilize exhaust heat produced upon combustion at the site of waste generation, as the compactness of the system allows its installation near the site of waste generation. When these advantageous features of the system are fully utilized, it is expected to make a positive contribution to the advancement of waste heat utilization as well as power generation. If it is installed in each factory or building, it is expected to not only establish a positive waste disposal model as a vein system for a recycle-oriented society but also, at the same time, to open the way to utilize as distributed energy sources materializing the Thermal Recycle.

5.4 Future R&D Problems

5.4.1 High-efficiency power generation technology

Local governments, which are beneficiaries of the large-scale ash-melting gasification furnace technologies aspiring for high-efficiency power generation, hold high expectation on it. Furthermore, medium to small-scale entities discharging wastes are increasing expectation on the new ash-melting gasification furnace technologies, as it may allow them to secure waste disposal means and energy sources at the same time.

While high expectation is placed on these technologies, their commercial viability as a system, including power generation efficiency, has yet to be assessed to determine whether they are feasible technologies capable of sustaining the Thermal Recycle. In the meantime, the new ash-melting gasification furnace technologies still have many problems requiring solutions including gas production from wastes and operation of a generator with low-calorie gases. While small to medium-scale factories and small-scale local governments need to dispose wastes whose amount is several tons to several ten tons a day, a system may be required to operate intermittently, such as on each alternate day, and the reliability of a system in such an intermittent operation mode will also be required.

5.4.2 Peripheral technologies

Waste incinerators such as represented by ash-melting gasification furnaces need to incorporate a system that causes little environmental loads, while they are capable of sustaining the Thermal Recycle. In other words, it is essential to keep close watch on substances produced in the incineration process such as NOx and dioxins.

In addressing environmental problems, establishment of measuring technology is the first thing to be achieved. With regard to dioxins generated in the process of waste incineration, technology making direct and real-time measurement possible has yet to be developed. For direct measurement of dioxin concentration, a laser method is regarded as the most promising option and some private enterprises are exploiting this possibility. However, examination and classification of a huge volume of optical molecular data will be necessary before estimation of a concentration from measurement results becomes possible.

Besides, there are a number of problems requiring solutions, including technology to remove dioxins remaining within incinerators.

5.5 Conclusion

To promote the construction of a recycling society, it is necessary to establish the Thermal Recycle, to say nothing of the promotion of the Material Recycle, for the utilization of wastes not covered by the latter. To further promotion of the Thermal Recycle, establishment of technology that provides a basis together with institutional development is a pressing necessity.

Key technologies to sustain the Thermal Recycle including an ash-melting gasification furnace are expected to play important roles in achieving energy saving through utilization of waste heat, and we need to steadily advance research and development to materialize effective utilization of waste heat while minimizing impacts on the environment.