各設備の装置条件や運転条件に合わせて適宜調整して応用され、次世代型ごみ焼却施設のさらなるダイオキシン類低減対策に寄与することを期待する。

3．3　システム分科会

昨年度は次世代型ごみ焼却処理施設の安全性を確保するため、リスク・イベントツリーを作成した。この目的は、以下の３点にある。

①どのような事象（事故や機能の作動）が起こりうるかを整理する。

②事象間の因果関係を整理する。

③各事象に対して、対策を整理する。

リスクとは、ある事象の発生確率と影響の重大さの積で定義され、ごく軽微な事故が連鎖的に広がって大きな事故につながることがある。システムにとって不都合な条件の発生、設備・機器の不具合の発生を完全に避けることは不可能だが、リスク・イベントツリーを描くことによって、どのようなことが起こりうるのか、その発生を制御するにはどうしたらよいか、さらに重大な事故発生への連鎖を断ち切るにはどうしたらよいかを明らかにすることができた。すなわち、この中に、システムの安全性を確保するために具備すべき条件がすべて記述されている。

本年度は、リスク・イベントツリーを元に、設計指針案を作成した。作成の考え方および方法は、以下のとおりである。

1）リスク・イベントツリーの文章化

解説の書き方としては、①制御・管理目的別、あるいは②具備すべき装置・機能別とし、その中に対策を記述する方法が考えられる。①の場合は「溶融の安定性確保」といった大きな目標と、「圧力管理」といったさらに細かい目的とがあるが、いずれの場合も内容の重複は避けられない。すなわち、制御目的と制御対象は一対一に対応せず、ある制御対象の記述が別の制御目的の項にも現れることになる。②についてはあまり議論しなかったが、例えば「圧力制御装置」はさまざまな目的のために必要とされるので、この場合は同一制御目的が、何度も書かれることになる。

リスク・イベントツリーは、こうした制御目標、制御対象間の複雑な関連を明確に整理したものである。上記①、②のまとめ方は、もう一度複雑な形に戻そうとい

うことに他ならない。リスク・イベントツリーには考え得る制御目標と制御対象がすべてまとめられているので、これを文章化した。

2）文章化のユニット

文章化のユニットは、リスク・イベントツリーにおける事象ごととした。各々の説明にはどのような対策が必要かを述べている。また、その事象を放置しておくとどのような事故発生に至るか（対策の必要性)、すなわちリスク・イベントツリーにおける因果関係を説明した。この方法により、リスク・イベントツリーに記述された制御目的と制御対象をもれなく文章化することができた。

3）文章のグループ化

全体を「ガス化安定性の確保」など大きな制御目標ごとに分類した。2）で作成した文章は複数の制御目標に関連するが、最も関連の強い制御目標の解説文に含めた。各解説の末尾には、設備構造面、運転管理面、維持管理面ごとに、どのような対策が必要かを整理した。さらに、各解説の前に解説内容の概要、主要な目的、制御対象をまとめた。すなわち、各制御目標ごとの解説は

①制御目標と制御対象の概要

②リスク・イベントツリーに対応する解説文

③必要な対策項目のまとめ

から構成されている。

なお、システムごとに制御目標、制御対象に違いがあるため、解説はタイプ別に作成した。

Study on the development of the new type of refuse incineration facility for the coming era

Summery of the report

1.Summary of the Studies and Investigations Made in 1998

1.1.Pilot Test and Experiment Plans

The gasifying melting processes proposed by each manufacture companies can be briefly divided into ① fluidized bed gasifying method, ② kiln gasifying method, and ③ shaft furnace gasifying method. The processes proposed by the participants are given below.

① Fluidized bed gasifying method (8 companies, 1 group)
(EBARA corporation. KAWASAKI HEAVY INDUSTRIES, LTD.
KOBE STEEL, LTD. Sumitomo Heavy Industries, Ltd. TSUKISHIMA KIKAI CO., LTD.
Babcock-Hitachi K.K. HITACHI ZOSEN CORPORATION.
MITSUBISHI HEAVY INDUSTRIES, LTD. KSTU Group.)

② Kiln gasifying method (2 companies, 2 group)
(IK Group. TAKUMA CO., LTD. MITSUI ENGINEERING & SHIPBUILDING Co., Ltd.
Hitachi group)

③ Shaft furnace gasifying method (2 companies)
(NIPPON STEEL CORPORATION. NKK CORPORATION.)

Notes; 1): The abbreviations used for company name are as follows;
IK group:(Ishikawajima-Harima Heavy Industries Co., Ltd. KUBOTA Corporation.)
Hitachi group:(Babcock-Hitachi K.K. Hitachi, Ltd.)
KSTU group:(KURIMOTO, LTD. SANKI ENGINEERING CO., LTD.
Toray Engineering Co., Ltd. UNITIKA, LTD.)

1.2. Joint Studies

1.2.1. Development of flyash produced by ash melting and Molten Ash Disposal Process
(flyash produced by ash melting and Molten Ash Subcommittee)

One of the conditions necessary for the new refuse incineration system for the coming era to be socially recognized is the recycling of the flyash discharged from facilities or its appropriate treatment. The purpose of this study is to evaluate the physical properties, marketability, cost efficiency, etc. of flyash or substances recovered from flyash and to determine points to note about recycling when flyash is regarded as a resource.

In fiscal 1997, the present state of the treatment of flyash generated from existing melting furnaces and the possibility of recycling of flyash were examined and problems were pointed out through ① questionnaires to local governments, ② investigation on heavy metal recovery technologies, ③ investigation on salt recovery technologies, and ④ investigation on technologies for producing pollution-free flyash produced by ash melting and Molten Ashes. In the fiscal year 1998, ① an investigation of the properties of flyash, ② a heavy metal recovery test, ③ an investigation of points to note about the recycling of flyash, and ④ an investigation on technologies for producing pollution-free flyash produced by ash melting and Molten Ashes were carried out for the flyash generated from the new refuse incineration system for the coming era (mainly demonstration facilities) on the basis of the results of the investigations conducted in fiscal 1997. These investigations are reported below.

The details of the research are as follows.

1) Investigation of the properties of flyash

Details:

An investigation was made into the properties of the flyash obtained from the demonstration facilities of new refuse incineration system (the gasifying melting process) proposed by each company and a comparison with the flyash obtained from ash melting furnaces, etc., were carried out. Furthermore, a basic test on heavy metal extraction from flyash was conducted and the results of the test including data on properties were submitted to the nonferrous refining industry (the Japan Mining Industry Association) to ask for an evaluation as a heavy metal resource.

Results:

The high-concentration components of the flyash produced by the gasifying melting process are chlorine, calcium, potassium and sodium. Heavy metals consist of zinc, lead and copper. The 11 kinds of flyash obtained from demonstration furnaces show relatively small differences in properties. A comparison with the flyash obtained from ash melting furnaces reveals that the concentrations of heavy metals are somewhat low and the concentrations of the components to be transported into slag (calcium, silicon and aluminum) are somewhat high.

A heavy metal extraction characteristic test was conducted on 10 kinds of flyash. In the extraction using purified water, the extraction ratio of lead, zinc and copper was 20% or less and low, and pH dependence exists. When hydrochloric acid and sulfuric acid (pH1, pH3) are used, the extraction ratio of lead and copper shows differences depending on the kind of flyash although that of zinc is 50-70% or less and high.

We obtained the nonferrous refining industry's view that technically, the flyash obtained by the gasifying melting process cannot be directly received in the refining process because of somewhat low concentrations of heavy metals and high chlorine concentrations, but can be received only for a reverse consideration, i.e., if the nonferrous refining industry is compensated, as with the flyash obtained from ash melting furnaces.

2) Heavy metal recovery test

Details:

A heavy metal recovery test by the acid extraction method was conducted on three kinds of melting flyash obtained from different types of furnace in consideration of a possibility that recovery technology may be added to the site of waste disposal facility. Recovered heavy metals were evaluated as nonferrous refining materials.

Results:

The test was carried out by setting test conditions in the acid dissolution process, the primary-sulfide formation process and the secondary-sulfide formation process by preliminary examinations for each kind of flyiash. Judging from the partition ratio of each sample, target heavy metal recovery was almost achieved. However, because the concentrations of silicon, calcium and aluminum in recovered heavy metals are generally high, target heavy metal concentrations are relatively low and the added values as recycled raw materials are low.

We obtained the nonferrous refining industry's view that heavy metals recovered from flyash cannot be evaluated as valuable recycled raw materials with the exception of part of the samples, but can be received only for a reverse consideration, i.e., if the nonferrous refining industry is compensated.

3) Investigation of points to note about the recycling of fly ash

Details:

On the basis of the results of various investigations and evaluation by the nonferrous refining industry mentioned in 1) and 2) above, points to note about the technology and social system for the recycling of flyash were investigated.

Results:

For technological points to note, there is a possibility that pretreatment aimed at the removal of chlorine, etc. and the concentration of heavy metals for reuse may be necessary in the recycling of heavy metals recovered from flyash. Furthermore, it is important that the occurrence of secondary environmental pollution be prevented in the recycling process including transport and storage.

As points to note in terms of social system, it is important for the nonferrous refining industry which receives recycled heavy metals and municipalities to build an efficient system, and it is necessary to build a system capable of positively supervising and controlling recycling (control cards, etc.).

4) Investigation of the treatment for making fly ash harmless

Details:

Various kinds of treatment for making harmless the flyash obtained from the demonstration furnaces adopted this time were carried out and an evaluation was carried out by an elution test (Environment Agency Notification No. 13).

Results:

It was ascertained that all kinds of flyash adequately meet the landfill standard through the addition of chemicals such as chelate. The amounts of chemicals differ greatly from one kind of flyash to another.

1.2.2. Re-synthesis Simulation Experiment on Dioxins by Small-Size Testing Machine (Exhaust Gas Subcommittee)

The generation of dioxins in new refuse incineration system for the coming era occurs very little because of high-temperature combustion. In order to further reduce dioxins, however, it is important to suppress re-synthesis in the heat recovery and temperature reduction processes downstream from the incinerating process. The effects of various factors on the re-synthesis behavior of dioxins have been partially qualitatively grasped in conventional actual furnaces, new system demonstration plants, etc. However, there are still many unclear portions for quantitative examinations. In the Exhaust Gas Subcommittee, the re-synthesis behavior of dioxins in boiler portions was confirmed and tested through the use of a model reaction system in which the re-synthesis of dioxins is excessive and under experiment conditions that allow the effect of each factor to be grasped as independently as possible. More specifically, dummy exhaust gases (O_2, CO_2, H_2O, N_2) were caused to pass, along with precursor vapor, HCl gas and SO_2 gas or without them, through a fixed reactor tube filled with flyash, and the concentrations of dioxins in the gases on the downstream side of the reactor and the concentrations of dioxins in the flyash remaining after the reactions were analyzed to investigate the effect of each factor. As a result, the following became evident.

1) Purpose and basic policy (Exhaust Gas Subcommittee)

In considering the behavior of dioxins in a waste disposal process based mainly on high-temperature combustion of "gasifying-melting", phenomena should be reproduced by setting conditions similar to those of a real process. However, there are many methods of gasifying process, experiments should be possible by means of a relatively small-scale device, and it is supposed that dioxins are almost decomposed in fields of high-temperature combustion. Therefore, it was decided to pay attention to the exhaust gas cooling process in which there is a possibility of re-synthesis also in the gasifying-melting process and to conduct an investigation by experiment.

In other words, the following basic policy was adopted in order to clarify what kind of formation characteristics dioxins have in a field where ash is present with properties probably different from those of the ash obtained from the conventional incinerating method.

(1) The test range is the slow cooling process of exhaust gas.

(2) Ash obtained after the melting process is used and a model organic compound of a precursor is supplied to this ash.

(3) Preliminary investigations, including the results of investigations and studies being carried out separately, are thoroughly carried out and test conditions are narrowed down, thereby obtaining experiment and analysis data with accuracy and reproducibility which can be evaluated.

(4) For the re-synthesis behavior of dioxins, the aim is to obtain quantitative data, which provides a standard, in a common field even when this data is qualitatively partially known.

2) Experiment

(1) Compositions of ash

The following five kinds of composition of applied ash are examined. In other words, they are a case where flyash obtained from the demonstration furnace of the gasifying-melting method is used, a case where it is considered that there is no possibility of formation of dioxins arising from ash due to the removal of coexisting organic substances from the above fly ash obtained from the demonstration furnace, a case where chlorides of copper from which the function of a catalyzer is expected is added to the flyash obtained from the demonstration furnace, a case where flyash is composed of only the basic matrix of ash and contains neither organic substances nor heavy metals, and a case where flyash from the conventional furnace considered to be a different kind of ash is used. The symbols of these kinds of ash used in this report are given below.

A:Flyash obtained from the demonstration furnace

B:Flyash obtained by removing organic substances from the above fly ash

C:Flyash obtained from the conventional furnace

D:Flyash obtained by adding chlorides of copper to the above fly ash obtained from the demonstration furnace

E:Flyash which contains neither organic substances nor heavy metals

(2) Atmosphere gas

The dry composition of atmosphere gas is N_2 80%, O_2 6%, and CO_2 about 10% and coexisting moisture is set at 20%. However, in initial experiments there were cases where the oxygen concentration was 10%.

(3) Organic components supplied

The following substances are taken into consideration as organic substances supplied. They include substances other than organic compounds of chlorine in addition to chlorobenzenes and chlorophenols, which are generally considered to be precursors.

① Chlorobenzene (C_6H_5Cl) selected from chlorobenzenes

② o-chlorophenol ($C_6H_4Cl(OH)$) selected from chlorophenols

③ Benzene (C_6H_6)

④ n-octane (C_6H_{18})

Because chlorophenols are the most typical precursors among the above organic substances supplied, o-chlorophenol is to be mainly used.

The concentrations of chlorobenzenes present in the exhaust gas obtained from the usual conventional incinerator are tens of micrograms per cubic meter as a total of dichlorides to hexachlorides (Kawamoto, 1993) and chlorophenols are also present in similar concentrations. Therefore, the supplied concentrations of the above organic substances in the range of from 100 to 200 mm/m3 are considered to be appropriate.

(4) Coexisting inorganic gases

Hydrogen chloride (HCl) which is usually present in exhaust gas and is considered to have an effect on the formation of dioxins is supplied at the same time as an organic component. In addition, a condition under which sulfur dioxide (SO_2) is supplied is also applied. For SO_2, it is pointed out that there is a possibility of suppressing the formation of dioxins.

3) Outline of this demonstration test

(1) Although the re-synthesis reaction of dioxins occurred also in the flyash obtained from the new

generation furnace, the total amount of formed dioxins on the gas side and ash side was about 1/30 of that of the ash obtained from the conventional furnace (the concentration in remaining ash was about 1/100 of that of the ash obtained from the conventional furnace, and the concentration on the exhaust gas side was almost equal to that of the ash obtained from the conventional furnace).

(2) Although the addition of copper chloride increased the concentration of dioxins on the gas side (about 5 times), the concentration on the ash side did not increase so much. The addition of copper chloride promoted the formation of PCDFs, in particular OCDF. When the organic substances (carbonaceous substances) in the ash obtained from the conventional ash were reduced by pretreatment before combustion, the amount of formed dioxins decreased to the same level as with the ash obtained from the next-generation furnace.

(3) In an experiment, the presence or not of a precursor in the dummy gas brought into contact with the flyash obtained from the next-generation furnace and the kind and concentration of the precursor were changed. In this experiment, there was no great difference in the concentration of dioxins between the exhaust gas side and the remaining flyash side. On that occasion, the distribution of isomers and congeners did not depend on the presence or absence and concentration of the precursor feed and was almost the same whether the precursor was an aromatic system or aliphatic system. From the above it was concluded that under such conditions under which the formation of dioxins is excessive as with the present case, the formation of dioxins is greatly influenced by the organic substances (carbonaceous substances) originally present in flyash rather than by the precursor in flyash.

(4) For the effect of the reaction temperature on the re-synthesis behavior in the flyash obtained from the next-generation furnace, it was found that the concentration of dioxins on the exhaust gas side reaches its peak at 350 – C and decreases abruptly at temperatures under and above this temperature (i.e., 275 – and 420 – C). The concentration on the ash side reached its peak at 275 – C and about half that concentration was observed even at 200 – C. The concentration was lower at 350 – C than at 200 – C and it was considered that dioxins are apt to disperse at that temperature.

(5) The effect of the retention time was in agreement with the behavior described in (3) above. The retention time of the gas including the precursor did not have an effect on the formation behavior of dioxins. In the present experiment in which the amount of charged flyash was changed on the assumption that the linear velocity is constant, the concentration of dioxins on the exhaust gas side increased in proportion to the amount of charged fly ash and the concentration on the ash side was constant. The distribution of isomers and congeners did not change.

(6) For the effect of the coexisting inorganic gases, it was ascertained from a comparison between HCl 0 ppm and HCl 1,000 ppm that this substance promotes the formation of dioxins. However, because polychlorinates increase, the increase in the amount of dioxins as a toxicity equivalent was not so great. For the effect of SO2, it was ascertained that the addition of 500 ppm is a somewhat effective in suppressing the formation of dioxins on the exhaust gas side. However, the effect of SO2 on the suppression was not ascertained with an addition of 50 ppm.

(7) The formation behavior of coplanar PCB was almost constant and its concentration was about 6% (concentration ratio by oxygen 12% conversion) on the average as the ratio to PCDD/Fs on the exhaust gas side. On the ash side, this concentration was about 10% (measured concentration ratio) in the ash

obtained from the next-generation furnace and about 2% (measured concentration ratio) in the ash obtained from the conventional ash. The component proportion of the composition was di-ortho: mono-ortho: non-ortho = 35: 45: 20 or so on the exhaust gas side. On the ash side, the proportion of di-ortho tended to be a little lower than the numerical value on the exhaust gas side and the proportion of non-ortho tended to be a little higher. The tendency for each factor was almost in synchronization with the behavior of PCDD/Fs and a similar tendency was ascertained also for the effect of the presence or absence of the above precursor feed and of the kind of ash.

The present simulation test on a small testing machine was carried out, as mentioned above, under a condition in which the effects of operating factors were extracted as independently as possible and changes were emphasized in order to quantitatively grasp the tendency. In actual machines each factor works in combination, and not singly. Therefore, the results of the present experiment are not always analogically reflected in actual operations and the absolute values of various kinds of data are not directly connected with actual machines or demonstration furnaces. However, because the results of the present experiment provide independent constituent test data, they can be applied and utilized on a common basis irrespective of the type of next-generation refuse incinerating facility. We expect that in the future, the results of the present experiment will be examined through the cross-reference with data obtained from actual machines and demonstration furnaces and applied by being appropriately adapted to the device conditions and operating conditions of each facility, thereby contributing to measures for a further reduction of dioxins in next-generation refuse incinerating facilities.

1.2.3. Concept of Preparation of Standard/Guideline of System (System Subcommittee)

In the last fiscal year, a risk-event scheme was prepared in order to secure the safety of new refuse incineration system. The purpose resides in the following three points:

① What kind of event can occur is thought out.

② The cause-and-effect relations between events are thought out.

③ Measures are thought out for each event.

A risk is defined by the product of the probability of occurrence of an event and the gravity of the effect of the event and a very slight accident may spread like a chain reaction, resulting in a serious accident. It is impossible to completely avoid the occurrence of conditions undesirable for a system and malfunctions in equipment and devices. However, by drawing a risk-event scheme it became possible to make clear what kind of event can occur, what should be done to prevent the occurrence of the event, and what should be done to cut off the chain reaction leading to a more serious accident. In other words, conditions to be provided to secure the safety of a system are all described in the risk-event scheme.

In the current fiscal year, a draft for a design guideline was prepared on the basis of the risk-event scheme. The concept and method of preparation are as follows.

1) Documentation of risk-event scheme

There are two cases as the methods for writing explanations. Explanations are written ① for each purpose of control and management or ② for each device and function to be provided and measures are described in the explanations. For ① above, there are a rough purpose such as "securing the stability of melting" and a further detailed purpose such as "pressure control". In either of the cases, duplication of descriptions cannot be avoided. More specifically, a purpose of control and an object to be controlled do not correspond on a one-to-one basis and a description of an object to be controlled appears also in the item of another purpose of control. The case ② has not been much discussed. For example, "a pressure controller" is used for various purposes and, in this case, therefore, the same purpose of control is written many times.

In the risk-event scheme, such complex relationships between the purposes of control and objects to be controlled are clearly defined and indicated. The above methods for writing explanations ① and ② are nothing less than bringing the plain context of an event into a complex form again. Because all conceivable purposes of control and objects to be controlled are summarized in the risk-event scheme, they were documented.

2) Documentation unit

A documentation unit was provided for each event in the risk-event scheme. Each explanation contains a description of what kind of measure is necessary. Furthermore, it describes what kind of accident occurs if the event is left as it is (necessity of taking measures), i.e., the cause-and-effect relation in the risk-event scheme. All the purposes of control and objects to be controlled could be documented by adopting this method.

3) Grouping of documents

The whole was classified according to rough purposes of control such as "securing the stability of gasifying". Although documents prepared in 2) above relate to multiple purposes of control, they were included in explanations of the purposes of control to which they are most strongly related. At the end of each explanation, what kind of measure is necessary was pointed out for each aspect of equipment structure, operation control, maintenance and control. Furthermore, before each explanation, an outline of the explanation, main purposes and objects to be controlled are summarized. More specifically, an explanation for each purpose of control is composed of:

① Outline of the purpose of control and object to be controlled

② Explanation corresponding to the risk-event scheme

③ Summary of necessary items of measure

Incidentally, because there is a difference in the purpose of control and object to be controlled between systems, an explanation was prepared for each type.

1.3. Summary

1.3.1. Estimation of Planned Amount of Heat from Refuse

In the fiscal 1996 estimation, the recycling ratios of plastics and paper were determined from the compositions of each type of refuse. In the current fiscal year, however, the amount of packing waste was set at 24.2% of paper waste and at 80.1% of plastics waste on the basis of the "Measuring Survey of Household Refuse, Etc. in the Tama District" carried out by the Tokyo Municipalities Survey Committee, and planned refuse quality was determined by assuming the recycling ratios from the results shown in Table 4.1.

Table 4.1 Refuse quality for recycling ratios (kcal/kg)

Recycling ratio (%)	Lower-class refuse	Standard refuse	Higher-class refuse
0	1,535	2,053	2,572
Paper 50 x plastics 50	1,312	1,754	2,195
Paper 50 x plastics 70	1,225	1,631	2,036
Paper 50 x plastics 80	1,177	1,568	1,960

For the setting of target recycling ratios, it was thought that it is difficult to substantially raise the recycling ratio of paper because each municipality has already promoted the recycling of paper and, therefore, the recycling ratio of paper was estimated at 50%. For plastics, there are uncertainties about the treatment method for fiscal 2000 and beyond and it is difficult to make a forecast. For this reason, in the fiscal 1996 survey it was decided to carry out a review in the current fiscal year when the basic policies of municipalities would become clear. However, the situation on recycling of plastics does not much change and the recycling ratio of plastics was estimated at 50% in consideration of various conditions.

In order to ensure that the design conditions of facilities can be suitable for a wider range of refuse, the quality of lower-class refuse is set as shown below by considering that the quantity of heat of higher-class refuse is about twice that of lower-class refuse on the basis of the numerical values shown in Table 4.1.

Lower-class refuse	Standard refuse	Higher-class refuse
1,300kcal/kg	1,850kcal/kg	2,600kcal/kg

1.3.2. Summary of Demonstration Tests

1) Number of demonstration facilities

Out of the 19 companies in the project, 12 companies independently constructed demonstration facilities (12 plants). The remaining 7 companies had the desire to conduct joint development; 4 companies formed a group, two companies formed a group, and the remaining one company formed a group with another company ,which conducts demonstration tests individually, in order to adopt a treatment method different from that adopted by this company. Thus, 3 plants were constructed by the three groups. As a result, demonstration tests are being carried out with a total of 15 plants.

2) Types of facilities and facility scale

The fluidized bed gasifying method is adopted by eight companies and one group. For facility scale, two facilities have the scale of not less than 30 t/day, five facilities have the scale of not less than 20 t/day, and two facilities have the scale of 10 t/d. The kiln gasifying method is adopted by two companies and two groups and the scale is 20 t/day. The shaft-furnace gasifying method is adopted by two companies and the scale of one facility is not less than 30 t/day and that of the other facility is 20 t/day.

Demonstration test data was submitted by 6 companies and one group for the fluidized bed gasifying method, by two companies and one group for the kiln gasifying method, and by two companies for the shaft-furnace gasifying method.

1.3.3. Results of Demonstration Tests (Properties of Exhaust Gas)

1) Exhaust Gas

The experimental results in each substance are shown as follows.

○ Nitrogen oxide

(the target value: below 50 ppm at the inlet of exhaust gas treatment facility,
below 10 ppm at the outlet of stack)

The number of measurements of the nitrogen oxide concentration at the dust collector is small and hence the result is omitted here. The target value of nitrogen oxide concentration of below 10 ppm was achieved only in two cases where de-NOx equipment was installed.

○ Dioxins (the target value: below 0.2ng-TEQ/m3N at the inlet of exhaust gas treatment facility,
below 0.01 ~ 0.05 ng-TEQ/m3N at stack)

The target value of dioxin concentrations at the inlet of exhaust gas treatment(dust collector) is below 0.2ng-TEQ/m3N and below 0.01 to 0.05ng-TEQ/m3N at stack. According to operational results, because high temperature in the melting furnace makes dioxins be decomposed, the dioxin concentration of exhaust gas is almost within the range of 0.1-0.7ng-TEQ/m3N at the inlet of exhaust gas treatment. Though depending on some different types of dioxin removal apparatus or whether there is dioxins remover or not, dioxins concentrations are distributed within the range of 0.001-0.07 ng-TEQ/m3N at outlet of stack.

Furthermore, the dioxins concentrations in the seven of 17 samples are under the target value at the inlet of dust collector. The dioxins concentration in only one sample of them is not less than 0.05ng-TEQ/m3N of the upper developing target value at the outlet of stack. On the other hand, dioxins concentration in the eleven of 22 samples are less than 0.01ng-TEQ/m3N of the lower developing target value.

○ Excess ratio of combustion air (the target value: below 1.3 in equivalent value of air ratio)

The target value of excess ratio of combustion air of not more than 1.3 was achieved in 11 cases out of 18. Furthermore, excess ratio of combustion air of 1.2 to 1.6 are in the most frequent distribution range.

2) The refuse quality

The refuse quality used in the demonstration is from 600 to 3,600 kcal/kg . An auxiliary fuel is necessary for ash melting depending on the quantity of heat of refuse used. The necessity for an auxiliary fuel differs depending on melting temperature, type of furnace, etc.

3) Slag

In all cases, slag showed values not more than the limit values of the environmental standard for soil prescribed for the elusion test provided for the "Environment Agency Notification No.46" . The use of slag as civil engineering materials and the development of its applications are expected.

4) Fly ash

For the recycling of heavy metals from fly ash, there is a strong possibility that the removal of contained chlorine and pretreatment for enrichment of recovered heavy metals will be necessary. If a social evaluation of the prevention of secondary pollution from these recycling steps and of their cost efficiency is determined, reduction at the mine can be taken into consideration as a promising method for effective utilization.

第１章　序

１．１　研究の目的

現在、わが国において発生する一般廃棄物は、年間約5,100万トンに達し、この約75％を焼却し埋立処分されている。この潜在エネルギーは、わが国が消費する石油エネルギーの12日分に相当すると言われている。「日本の廃棄物98」(厚生省監修)によると、全国約1,800施設余りあるごみ焼却施設で、その大方は断続運転の准連続燃焼式，機械化バッチ燃焼式が占め、廃熱の高度利用を目的とする発電施設を持つ全連続燃焼式焼却施設は、平成10年度末施設数で６～７％、ごみ処理能力で30～40％に相当し、発電能力は約46万kWで有り、年々増加する施設内の高度化による電力の増加に対処するため、廃棄されているエネルギーの有効法である発電設備のより普及が望まれている。

発電設備(廃熱ボイラー)を有する条件としてごみ処理施設構造指針では、原則として、全連続燃焼式であることや、300t／日規模程度以上の施設規模であることが示されていたが、ダイオキシン削減対策に端を発した「廃棄物の処理及び清掃に関する法律」の改正により、新設されるごみ焼却施設は、原則として全連続燃焼式で100t／日以上とし、可能な限り処理対象区域の広域化により、施設規模の大型化を行うとともに、ボイラーを設けて発電等の高度利用の推進が定められた。

ごみ焼却施設における熱回収技術は、熱回収ボイラーが排ガス中の腐食性の高い塩化水素対策により、高温，高圧化が困難なことや、ごみ質の変動が大きく、燃料として安定したものでないこと等が隘路となり、通常の石油等を燃料とした火力発電所と比較すると約１／３程度と低いレベルにある。

このような状況からごみ焼却処理施設は、最終処分場の逼迫による焼却残渣の減容化対策，排ガス中の有害物対策，省エネルギー，エネルギー有効利用の面を含めて、ごみ処理技術の基本的な見直しによる高度処理技術の確立が求められている。従来型のごみ焼却処理技術に対する高度処理技術として、実用化が図られているガス化溶融処理技術は、ごみを還元雰囲気で熱分解し、発生した可燃ガスを高温で燃焼して、熱回収を図るとともに、ごみ中の無機物を溶融しスラグとするものである。同時に、焼

却残渣の安定化・減容化・再資源化が可能で、ダイオキシン類や窒素酸化物に代表される大気汚染物質の低減や、熱回収効率，発電効率とも、次世代型ごみ焼却処理施設として優れているとされている。

本研究調査は、各種のガス化溶融実証プラントの実証試験により各種のデータを蓄積、解析し、実用化のため開発研究を図るため、平成８～10 年度の３ヶ年間実施した。

１．２　本開発研究委員会発足の経緯

平成６年８月「21 世紀初期に実用化を目指した、新しい考え方による「次世代型ごみ焼却技術の開発」を要旨として、厚生省，(財)廃棄物研究財団及び関係メーカ７社（石川島播磨重工業㈱，㈱荏原製作所，川崎重工業㈱，㈱タクマ，日本鋼管㈱，日立造船㈱，三菱重工業㈱）による検討会により、現行処理技術の見直しを多面的に行った。平成７年秋には、更にメーカ２社（新日本製鉄㈱、三井造船㈱）を加えた９社による検討を行い、次のような方向付けをした。

具体的には、現行処理技術の課題と対策技術を、図 1.2.1 に示す観点から整理し、21 世紀初頭に実用化可能な技術として、ガス化溶融技術と、シュレッド&バーン技術に絞り、ガス化溶融技術が、最も具現性のある将来技術に成りうるとの結論を得て、開発研究を推進するものとした。

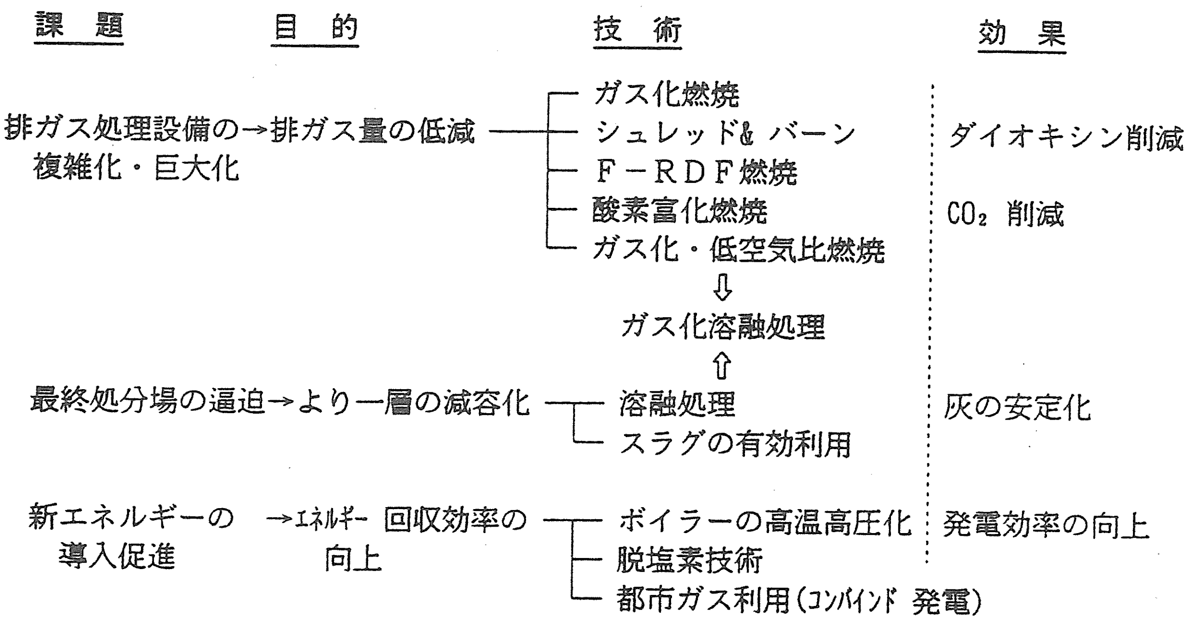

図 1.2.1　次世代型ごみ燃焼技術の方向性

この他、新処理技術の開発促進を図るため、現行の新処理施設採用に係る指針外技術の取扱について抜本的に見直すことと、技術開発資金援助等を、平成８年度からの厚生省、厚生科学研究として実施する予定の「次世代型ごみ焼却処理施設の研究開発」において審議するよう要望する。このほか、開発研究を円滑に推進するため、学識経験者，会員プラントメーカの参加時より設置される開発研究委員会に、新たに参加するメーカの入会資格及び、委員会を運営する幹事会の参加資格について定めた。

平成８年度予算化が実現し、「次世代型ごみ焼却処理施設の研究開発」プロジェクト事業として開発研究委員会が発足した。

１．３　「次世代型ごみ焼却処理施設の研究開発」プロジェクト事業の概要

１．３．１　開発研究テーマ

次世代型ごみ焼却処理施設の開発研究

１．３．２　内容

１）次世代型ごみ焼却処理施設のシステムフローの検討

２）システムフロー各部装置の模擬試験装置の開発

３）次世代型ごみ焼却処理施設の実証プラントの開発

４）次世代型ごみ焼却焼却施設の総合評価

１．３．３　期間

平成８年～平成10年度（３ヶ年）

１．３．４　研究開発目標

ごみの保有エネルギーを外部への熱供給や送電などを行い、最大限有効活用するとともに、焼却残渣の安定化・資源化等、大気汚染物質の低減等の研究目標を達成する。このために、次の開発目標の全部または大部分を満たすこと。

１）対象ごみ質について

容器包装リサイクル法施行後の分別可燃ごみ

２）排ガスに関して

・空気比：従来システムでの空気比1.3相当以下

・有害物質排出値：排ガス処理に係る経費の節減を図るため、燃焼装置での発生抑制を極力行う。

3）焼却残渣

有効利用可能なものとする。

4）飛灰に関して

飛灰は金属精錬等によって、再利用できる程度とする。

5）コストについて

イニシャルコスト，ランニングコストとも従来技術以下とする。

1.3.5　実証プラントに関して

実証試験と実用施設規模及び実証運転期間等については、下記のように定める。

1）実証プラントの規模と実用施設スケールアップについて

2）実証プラントの運転期間とごみ質

第２章　計画ごみ発熱量の推計

計画ごみ質について、「ごみ質とは、計画目標年次におけるごみ質をいい、過去の年次別季節別のごみ質の実績、将来のごみ収集計画を基にして決定する。」と定められており、ごみ焼却施設における計画ごみ質は、ごみの持つ熱的エネルギー量を示す低位発熱量（kcal／kg）で示される。

計画ごみ質の推定は、経済情勢の変動、市民意識の変化等不確定な因子が多く困難あるが、計画ごみ発熱量の設定如何によっては、焼却施設の処理能力が過大になったり、不足することもあり、施設計画に当たり慎重を要する基本的事項である。

近年、全国的に増えるごみ量と最終処分場の逼迫に対応して、容器包装廃棄物の有効利用と、ごみの減量化を目的とする容器包装リサイクル法（平成９年４月施行）に伴い、各自治体で策定した市町村分別収集計画では、焼却対象可燃ごみ中の紙類、プラスチック類の積極的リサイクルが定められている。このことから、容器包装リサイクル法が本格的に運用される平成12年４月以降の各都市の可燃ごみ量は減少することが予想される。また、焼却処理の対象となる可燃ごみで、熱的に重要な役割を占める紙類、プラスチック類の比率の低下は、ごみの持つエネルギー量の低下となり現れることになる。

２．１　調査対象施設

平成８年度計画ごみ質の推定のため行ったアンケート調査施設25施設から、計画ごみ発熱量から、計画低質ごみ質1,100kcal/kg以上の16施設と、計画低質ごみ質1,000kcal/kgの発電設備を持つ２施設を対象として検討した。ごみ質分析結果が湿ベース基準であるため、他の施設と同一に計算することが困難な２施設を除いた16施設を対象として検討した。

2．2　実績ごみ発熱量の整理

回答されたごみ発熱量の測定法がそれぞれ異なることから、各データより代表的例を抽出して横並びでの比較は困難である。このため、通常、簡易式として知られ広く活用されている３成分の式と、紙類、プラスチック類の減量化に関係の深いごみ種類別組成の計算式２種により実績値の整理した。

Ａ式　　３成分の式　　45.00Ｂ－6.00Ｗ

Ｂ：可燃分％　　Ｗ：水分％

Ｂ式　　88.2Ｐ＋40.50(Ｐa＋Ｇ)－6.00Ｗ

Ｐ：プラスチック％　Ｐa：紙類％　Ｇ：ちゅう芥他％

Ｗ：水分％

2.3 容器包装廃棄物の回収率とごみ発熱量との関係

○三成分計算による場合

推定計算はアンケート回答結果の「可燃分」「灰分」「水分」の三成分を厚生省が示す簡易計算式、三成分に基づいた計算式による見直しを行い、包装廃棄物紙類、プラスチック類の20～50%までの4段階でのごみ発熱量低減状態を算出した。この算出結果を表2.1.1、図2.1.1に示した。

表2.1.1　三成分での予想結果

地名	地名	資源化率			
		紙0、プラ0	紙50、プラ50	紙50、プラ70	紙50、プラ80
北石狩	B	1,787	1,770	1,731	1,710
郡山河内	C	1,963	1,980	1,929	1,902
仙台	D	1,959	1,869	1,821	1,796
埼玉東部	F	1,842	2,027	1,978	1,952
川口	G	1,568	1,395	1,366	1,351
入間	H	1,528	1,449	1,393	1,364
町田	I	1,772	1,721	1,688	1,671
横浜都筑	K	1,686	1,587	1,541	1,517
名古屋	M	1,554	1,892	1,867	1,857
門真	Q	1,948	1,918	1,875	1,853
大阪八尾	R	1,707	1,698	1,658	1,637
高槻	S	1,778	2,040	1,953	1,915
周南	U	1,560	1,543	1,523	1,513
広島	V	1,903	1,878	1,851	1,838
大分	Y	1,463	1,417	1,384	1,366
福岡西部	Z	2,018	2,009	1,972	1,953

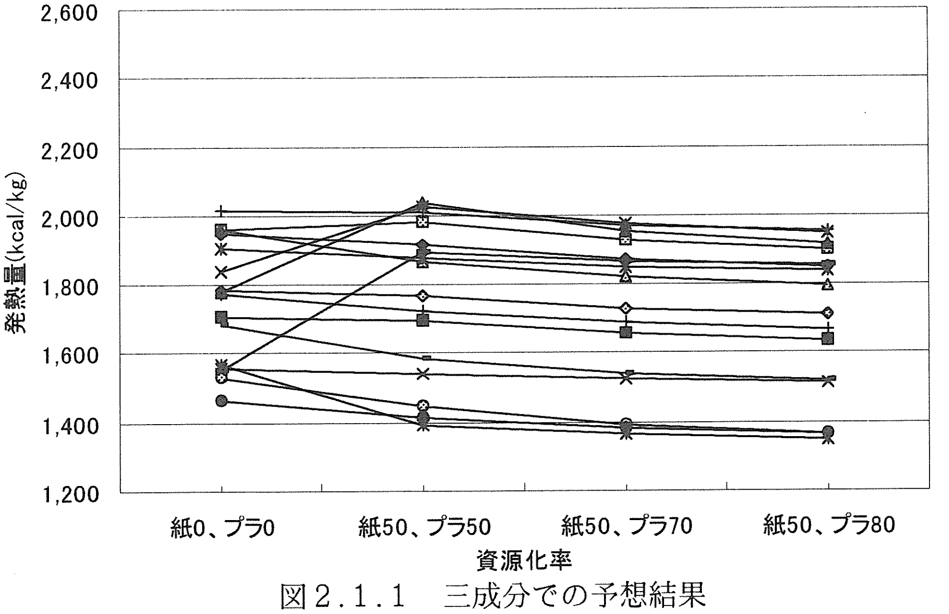

図2.1.1　三成分での予想結果