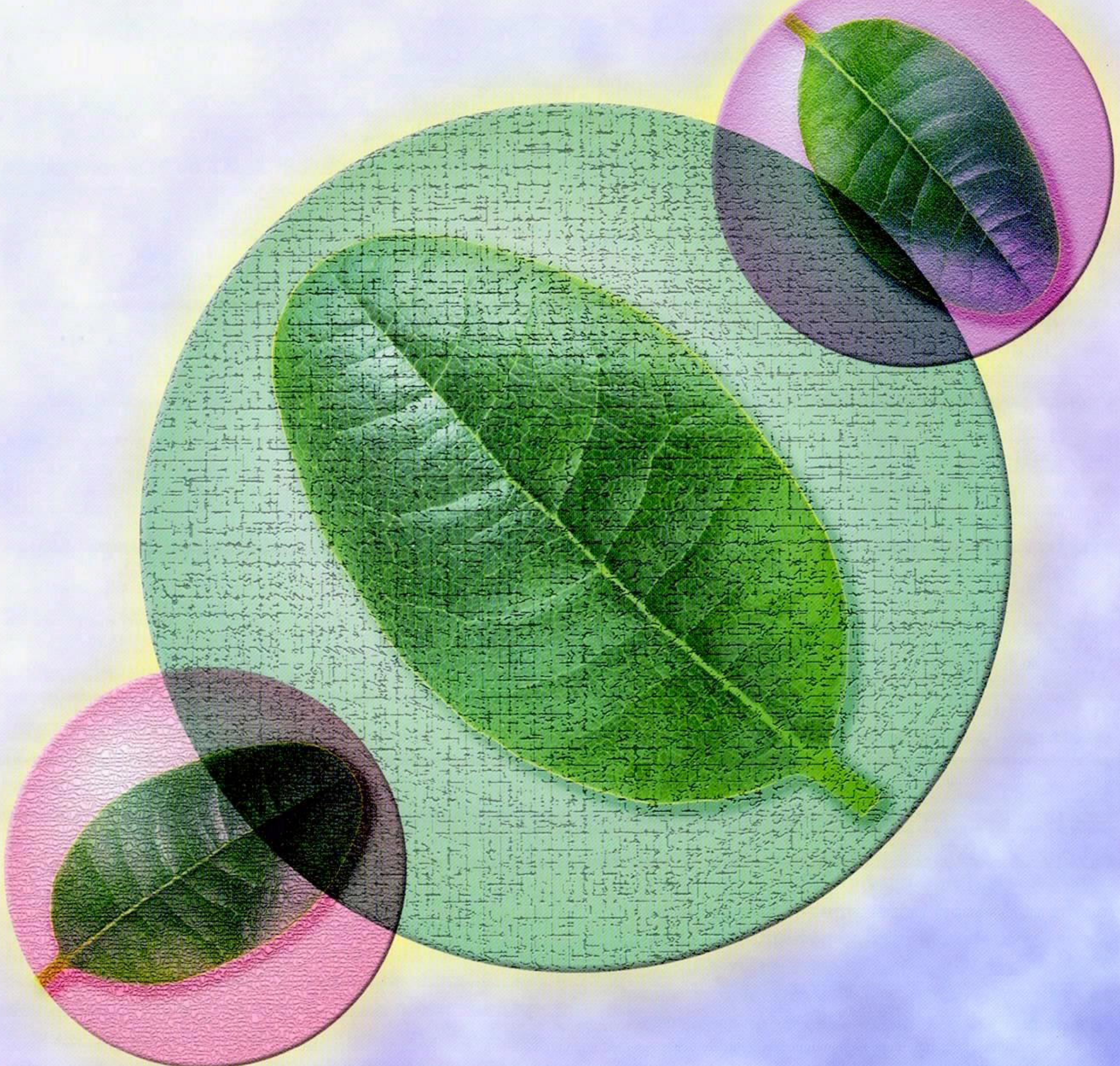
INTERNATIONAL CENTER FOR ENVIRONMENTAL TECHNOLOGY TRANSFER



ICETT NEWS

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Environmental Technology Transfer Promotion Project
Survey on Industrial Waste in the Philippines

Introduction

The International Center for Environmental Technology Transfer (ICETT) has been carrying out its Environmental Technology Transfer Promotion Project entrusted by Japan's Ministry of International Trade and Industry since 1993. This project seeks to investigate the extent of pollution in developing nations, determine the technology suited to the sites for smooth dissemination in developing nations, and to suggest a variety of ways to contribute to resolving any existing problems. In 1999, ICETT undertook its Survey on Industrial Waste in the Philippines as proposed by the Board of Investment (BOI), the Department of Trade and Industry of the Philippines at the Japan-Philippine Policy Dialogue under the Green Aid Plan Project.

Background and Purpose of the Survey

In recent years, multinational corporations from Japan and elsewhere have been establishing a presence in the Philippines; in particular, more and more electronics corporations have initiated production there. On the other hand, as a result of these business activities, the Philippines has been compelled to face the serious issue of how to treat and dispose of enormous quantities of industrial waste. Under the circumstances, ICETT undertook an investigation to determine the extent of the problem and suggest solutions involving technologies and methods suitable to the Philippines.

In this survey, we visited 31 electric, electronic, chemical and petrochemical corporations in the Manila metropolitan area (Metro Manila), Laguna and Cavite, where more than 60% of the corporations in the Philippines are located, to determine the types, amounts, treatment, and disposal of industrial waste and the associated problems.

Survey schedule:
Preliminary survey: October 3-9, 1999
Formal survey: November 17-December 18, 1999

Results of the Survey

Our survey uncovered the following problems:

1. Lack of Enforcement of Laws and Regulations

We discovered relatively good maintenance of laws and regulations on toxic waste and other industrial wastes, specifically the Law of the Republic of the Philippines No. 6969 (RA6969; enacted in 1990) and its enforcement rule, the Ordinance of the Department of Environment and Natural Resources No. 29 (DAO; enacted in 1992). However, they are not fully enforced due to a lack of administrative resources such as financial resources; administrative powers and competence; human resources; and physical resources such as devices and equipment for monitoring, analysis, and assessment.

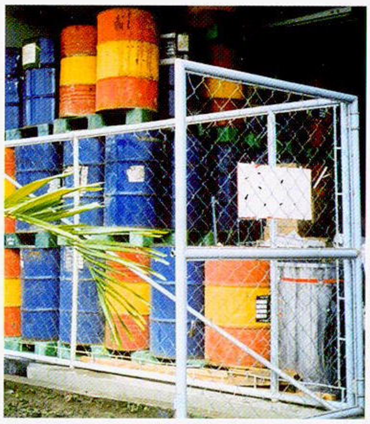
2. Delay in Provision of Facilities for Treatment and Disposal of Toxic Industrial Waste

Industrial waste is roughly classified into two categories: toxic waste specified in RA6969 and DAO; and other waste.

Toxic waste is defined as plating waste; waste acids and alkalis; inorganic chemical waste; reactive chemical waste; paint, resin, latex, ink, dye, adhesives and organic sludge; organic solvents; decomposing waste and organic waste; fabrics; oils; containers containing toxic matter; and other wastes. The regulations specify all the responsibilities regarding the generation, storage, transport and treatment or disposal of toxic waste. However, no treatment or disposal facilities currently exist for toxic industrial waste in the Philippines. Therefore, corporations generating such wastes are forced to store them at their plants unless they treat or dispose of them by themselves. Storage of such waste is a physical, technological, and economic burden to these corporations in terms of storage space and management costs. Under the circumstances, some of the toxic industrial waste is improperly disposed of in unmanaged landfills. What is worse, some is illegally dumped in alleys or into the sea, rivers, and channels. Some corporations consign waste treatment to overseas. Only a limited amount of recyclable or reusable toxic waste is treated for recycling by government-authorized treatment facilities.

Solid toxic waste stored in a factory

On the other hand, non-toxic industrial waste not specified in DAO29 is actively recycled or reused, except for that which is heavily fouled or damaged. Much of it is disposed of through a process of buying and selling. This includes cartons, paper bags, timber and plastics used for wrapping and packaging; metal containers; scraps of cloth from textile manufacturers; and metals from metal processors. Strictly speaking, this may not be waste because it is reused, but continued monitoring of this situation is essential from the viewpoint of industrial waste management.


Liquid toxic waste stored in a roofed warehouse

3. Laws Banning Incineration

The Clean Air Act (RA8749) enacted in 1999 generally prohibits the incineration of wastes that produce hazardous fumes, although some exceptions exist. This law raises the significant issue of general household waste as opposed to industrial waste.

Needless to say, incineration discharging hazardous fumes should not be allowed. Here in Japan, however, about 75% of general waste is incinerated. That plays an important role in reducing the amount of waste disposed of in landfill and in promoting sanitation. Therefore, the time has come for the Philippines to reconsider the incineration of waste.

4. The PRIME Project

In cooperation with the United Nations Development Programme (UNDP), BOI is implementing the PRIME Project (1998-2001) for environmental management together with the private sector. One of its objectives is the establishment of a system for exchanging by-products at five pilot industrial complexes, taking the approach that "by-products (wastes) of a factory are the raw materials for other factories." This approach targets the establishment of zero-emission systems in specified areas. We expect that the project will achieve outstanding success.

Suggested Measures for Implementation

From the results of this survey, we believe that the Philippines should implement the following measures in order to manage their industrial waste:

1. Short-term Measures

1) Establishment of a system for secure enforcement of existing laws and regulations
   - Establish analysis and assessment technologies and standards as well as clear definitions of toxic waste
   - Provide the necessary analysis instruments
   - Train personnel and secure budgets for enforcement of laws and regulations
2) Implementation of further detailed surveys for the installation of comprehensive facilities for the treatment and disposal of toxic industrial waste
   - Determine the situation regarding generation of toxic industrial waste
   - Investigate the scale, type, location, and technology for appropriate treatment and disposal facilities
   - Examine appropriate systems for the installation, operation, and management of treatment and disposal facilities
   - Survey the management of overseas treatment and disposal facilities
3) Further promotion of the PRIME Project mentioned in section 4 of the survey results.

2. Medium-term and Long-term Measures

1) Further strengthening of the system for enforcing laws and regulations
   - Establish a system to monitor how laws and regulations are enforced
   - Arrange medium-term and long-term systems for personnel and budgets
   - Train personnel in administration and private corporations over the medium term and long term
2) Installation of model plants for comprehensive treatment and disposal of toxic industrial waste on a trial basis
   - Investigate and select locations for model plants
   - Construct model plants
   - Operate model plants and examine their achievements
   - Examine proper management of treatment and disposal facilities
   - Transfer model plant successes to other areas
3) Reinforcement of a system of cooperation between the government and the private sector
   - Develop the successful waste recycling activities of model industrial complexes to other areas
   - Examine fields of industrial waste management in which the government and the private sector can cooperate


Solid industrial waste dumped illegally in the mountains

International Environmental Cooperation by Local Governments Environmental Cooperation Program for Asia

Program Achievements and Future Developments A Program Consigned by the Mie Prefectural Government

Introduction

For a three-year period beginning in 1997, ICETT implemented the Environmental Cooperation Program for Asia (ECPA) for the Imus Municipal Government in Cavite, the Philippines, by applying three concepts:

1. international cooperation between local governments;
2. sustainable development; and
3. comprehensive environmental conservation.

We introduced these program concepts in issue No. 5 of this newsletter. Here, we would like to refer to the achievements of our program during these three years and to address forecasted developments. The program for the Imus Municipal Government is abbreviated as "ECPA-IMUS."

Program Achievements

In order to promote key strategies in the environmental plans for Imus, ICETT arranged training programs in Japan, sent experts there, and provided other forms of support. Consequently, by making every effort to achieve success with their plans, they have achieved initial successes in general waste management and four other areas.

1) Pilot Compost Project in Barangays: General Waste Management

Selecting the barangays (the minimum administrative units) of Poblacion I-A and Bayan Luma VI as pilot barangays, the Imus Municipal Government began sorting the refuse and composting the garbage of 100 households designated as "monitor" households. Pagcor (a national corporation that manufactures and repairs game machines for casinos), is one of the corporations cooperating in this project. It manufactured the collecting pit cages and composting equipment for households on a trial basis (Photo 1).

Photo 1. Collecting Pit Cages

2) Examination of Colored Effluent Treatment: Industrial Effluent Control

CKL Corporation, a textile and dying company that is cooperating in this project as a pilot company for industrial effluent measures, is conducting experiments for practical application by means of bench-scale experiments. The COD level of plant effluent has been reduced by an average of 24% (Photo 2). As pilot companies in the business area, Liwayway (food industry), Pagcor (mentioned above), CKL, and two other corporations are involved in activities such as industrial effluent treatment measures and 5S activities.

Photo 2. Experiments for Practical Application

3) 5S Activities: Pollutant Reduction & Productivity Enhancement

Liwayway and Pagcor are conducting 5S activities,which aim to reduce pollutants discharged from manufacturing processes and to enhance productivity. It seems that the training held at ICETT in September 1999, in which personnel from the two companies participated, encouraged them to initiate such activities. Now, the two companies are undertaking these activities under the leadership of their management (Photo 3).

Photo 3. Tools maintained in order as part of 5S Activities

4) River Cleaning Project

The Imus Municipal Government has started campaigns to clean ditches and channels running through the city.

5) Preparation of Outlines of Supplementary Readers for Environmental Education: Environmental Education

Under the "JICA Program of Dispatches of Experts," ICETT assisted "Environmental Education & Learning Encouragement Project of Imus," derived from ECPA-IMUS, and dispatched experts to Imus. Consequently, educators in the municipality prepared the outlines of supplementary readers for environmental education as separate modules for teachers, junior and senior high school students, and schoolchildren.

Project Development and Future Support

The ECPA-IMUS Program, which had been implemented for Imus since 1997, was completed in 1999. Making full use of the knowledge and experience gained during the three-year period, ICETT hopes to encourage the Philippines and its neighboring nations to pay more attention to environmental issues (Figure 1).

1) Program Development in Imus

ICETT will provide continuous support in the areas of general waste management, industrial effluent control, environmental education, and environmental monitoring, where assistance has been provided intensively under the ECPA-IMUS Program and JICA Program. We expect that the Imus Municipal Government will further promote advanced environmental measures.

2) Project Development among Neighboring Local Governments

From the experience in Imus, ICETT will select model cities among neighboring municipalities and conduct surveys and provide guidance on the settlement and promotion of environmental plans. ICETT will also examine effective approaches for the promotion of wide area strategies involving several local governments, such as cleaning of rivers and treatment and disposal of waste. These will lead to the settlement and implementation of environmental plans at other local governments as well as the establishment of extensive cooperative relationships among local governments.

3) Project Development in Neighboring Nations

ICETT will provide environmental information possessed by the Imus Municipal Government to local governments in neighboring nations. This will allow local governments in other developing nations to utilize the knowledge gained by Imus and to establish cooperative relationships between Imus and local governments in other nations.

Japan's Approach in Providing Support to Developing Nations

One approach to obtaining good results in the environmental arena is to make good use of the expertise possessed by local institutions such as local governments and NGOs. Moreover, in ODA projects, local government personnel should be involved in the projects from the planning stage as experts, although the "bilateral" project framework will not be changed.

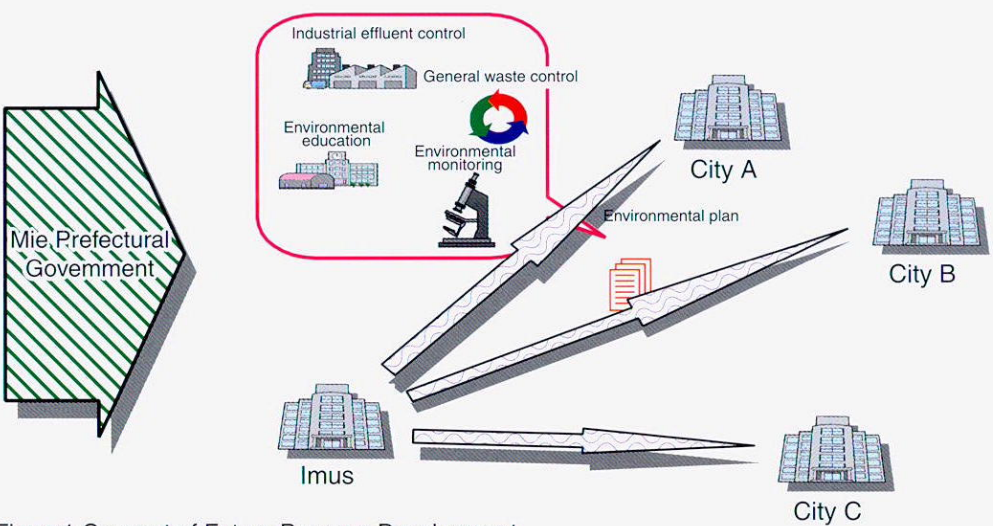


Figure1.Concept of Future Program Development

Environmental Technologies:Japanese Corporations' Efforts

Japanese corporations are willingly addressing global environmental issues by applying their accumulated technologies. In this section, we will introduce some examples of this.
This example involves Chubu Electric Power Company Inc., one of Japan's 10 electric utilities.

Environmental Conservation Efforts at a Coal-fired Power Plant through the Full Application of Up-to-date Technologies

Efforts and Basic Policies on Environmental Issues

Chubu Electric Power Company Inc. has promoted activities according to the "Six Points on the Global Environment—Autonomy and Harmony" adopted in 1993 as a basic policy and concrete action plan for coping with global environmental issues. Since 1994, the company has publicized its annual achievements in its Global Environmental Annual Report.

It is said that the 21st century will be the Century of Environmental Conservation. Clearly, we cannot exist in harmony with the Earth unless we promptly repair environmental damage because our conventional system of mass production, mass consumption, and mass disposal is reaching its limits. It is indispensable that our global corporate citizens are committed to environmental issues.

Chubu Electric Power Company, which considers global environmental issues to be a key management challenge, is implementing business activities that address conservation of the global environment in all respects.

Measures to Conserve the Atmospheric Environment at a Coal-fired Power Plant

Chubu Electric Power Company is constructing Units Nos. 4 and 5 (each with a capacity of 1,000MW) at the Hekinan Thermal Power Plant. We are scheduled to start operation in November 2001 and November 2002.
Utilizing our experience and technology in the construction and operation of coal-fired power plants to ensure technological reliability, we have adopted the best technologies for these stations in order to conserve local environments, improve generation efficiency, and address the need for global environmental conservation.
The following is an outline of the equipment used by our company to preserve the atmospheric environment.

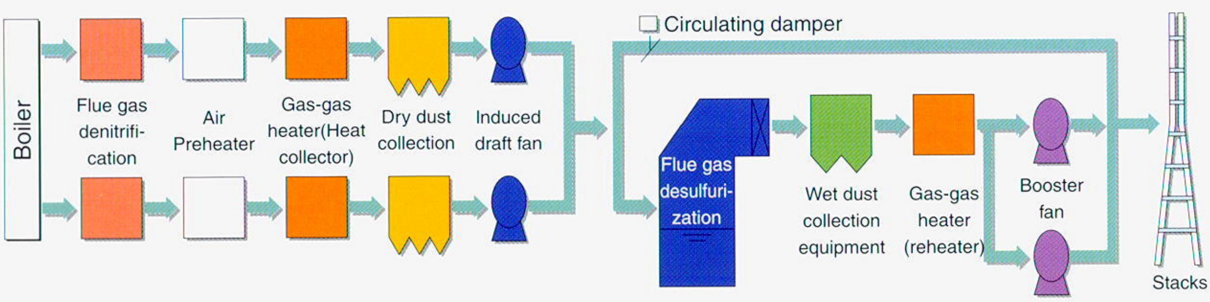
Illustration depicting power stations Nos. 4 and 5 of the Hekinan Thermal Power Plant when completed

1. Basic Concepts of Environmental Conservation Equipment

As part of the construction of power stations Nos. 4 and 5 at the Hekinan Thermal Power Plant, the existing stations Nos. 1-3 are being strengthened under the agreement to ensure "maintenance of current conditions" so that the emission of smoke and soot does not exceed that specified in the Agreement on Pollution Prevention for stations Nos. 1-3. The equipment for stations Nos. 4 and 5 is designed to meet the strictest environmental regulations in Japan. These measures enable the company to control the emission of sulfur oxides, nitrogen oxides, and dust at current levels.

System flowchart of gas treatmentequipment for power stations Nos.4 and 5

Nitrogen oxide concentration	≦15
Sulfur oxide concentration	≦25
Dust concentration	≦5



The system flow of the flue gas treatment equipment for stations Nos. 4 and 5 is shown below. This system offers excellent reliability and economy by adopting a sophisticated low-low-temperature electrostatic precipitator (EP) flue gas treatment system. Moreover, costs are reduced by providing desulfurization equipment for the gas-gas heater as one system.

2 Features of the Atmospheric Environmental Conservation Equipment

(1) Sulfur Oxide Measures

A low-low-temperature system with advanced dry electrostatic precipitator has been adopted to reduce dust at the inlet of the desulfurization equipment. Therefore, a soot-mixing method without a gas cooler has been introduced for desulfurization equipment. A modified compact absorber with integrated outlet flue has been adopted for reduced costs and ease of maintenance.

A highly reliable vacuum belt filter has been adopted for the gypsum separator, which collects high-quality gypsum.

(2) Nitrogen Oxide Measures

The two-stage incineration method further improves upon conventional equipment, while low-NOx burners have been adopted for boiler incineration equipment in order to control generation of nitrogen oxides at the boiler outlet.

As for flue gas denitrification equipment, the gas flows upwards and downwards to prevent coal ash from accumulating, and the denitrification rate for coal burning, at 90%, is the highest in Japan.

(3) Dust Control Measures

Power stations Nos. 4 and 5 have a very efficient dust collection system boasting a total dust collection rate of 99.975%. It employs advanced electrostatic precipitators (both dry and wet types) and benefits from the dust collection effect of the desulfurization equipment. The features of this system are as follows:

- Adoption of a low-low system has enabled the advanced dry electrostatic precipitator to enhance dust collection efficiency while reducing its size.
- Adoption of mobile electrodes for the last segment enables the dry dust collector to prevent dust from being regenerated during hammering.
- A non-leak gas-gas heater has been adopted to treated side to the untreated side. A steel-shot cleaning system is also effective at eliminating dust adhering to the heat exchange tubes.

In addition, the following measures have been taken for power stations Nos. 4 and 5:

- To ensure the reduction and effective use of waste, various equipment is being installed to effectively use all the coal ash produced from the boiler and gypsum produced from the desulfurization equipment.
- For environmental conservation, a vast amount of wastewater produced by the desulfurization equipment is condensed and caked. As well, water condensed through evaporation is collected in the condensation process and reused as supply water for desulfurization with wastewater treatment equipment as part of the flue gas desulfurization.
- The largest block construction method in Japan (the steel frame, ducts and pipes integrated in the plant are installed on-site) is being adopted for the gas-gas heater to enhance safety and quality at the construction site and to simplify the installation process.

Technological Development for Environmental Conservation

Development of Desulfurizing and Denitrification Technology with Electronic Beams

Electronic beam flue gas treatment technology enables simultaneous desulfurization and denitrification through the application of electronic beams to flue gas from the boiler. The byproducts of ammonium sulfate and ammonium nitrate are also used effectively as nitrogen fertilizers. Chubu Electric Power Company has confirmed the effectiveness of this approach through validation testing at a pilot plant.

This technology has been adopted at thermal power plants in China. The company also provides technology for application to thermal power plants in Poland as part of its international contribution to global environmental preservation.

On the other hand, Chubu Electric Power Company is constructing electronic beam flue gas treatment research equipment as its flue gas treatment equipment for power station No. 1 (220MW) at the Nishi Nagoya Thermal Power Plant.

Project to Promote Development of Industrial Technologies for Global Environmental Conservation

Since 1990, ICETT has been supporting the development of industrial technologies targeting global environmental conservation. In this effort, ICETT has employed subsidies provided by the Ministry of International Trade and Industry. In this issue, we will introduce two such projects for which research and development were completed in 1999.

Research Development Project

Minimizing Offensive Odors from a Synthetic Rubber Manufacturing Plant and Reducing the Amount of Hydrocarbons Released into the Atmosphere

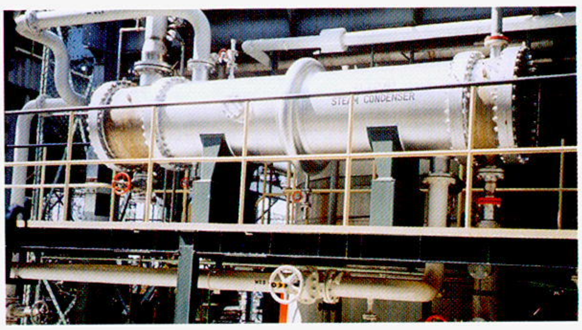
Development Period: 1997-99

Group W, Kawajiri Laboratory, ICETT
JSR Co., Ltd.

● Development Goal

The source of the malodorous exhaust gas containing hydrocarbons is the drying step of the synthetic rubber manufacturing process. Absorption and incineration are the general methods for treating hydrocarbons contained in the exhaust gas. However, these are end-of-pipe treatments, which require initial and operating costs for the treatment equipment.

The purpose of this development is to drastically reduce the generation of exhaust gas containing hydrocarbons by improving the drying process, not by applying end-of-pipe technology. As part of the current drying process, hot air, a general drying medium, is used. Our target process is one in which steam (water vapor) is used as a drying medium. This steam drying process enables drying to take place in a closed loop, which leads to the collection of condensed hydrocarbons together with water vapor.



● Development Results

1. Current Process Problems

In the drying process for solution polymerization rubber, the mechanical dryer (main dryer) and the hot air dryer (sub dryer) are generally used for post-drying. When the rubber, which has been exposed to high temperature and high pressure in the mechanical dryer, is pushed out of the tip of the dryer, it is quickly exposed to atmospheric pressure, which causes moisture contained in the rubber to evaporate explosively. The rubber extruded from the mechanical dryer is supplied to the hot air dryer along with the evaporated water as vapor. Hot air is supplied to the sub dryer because the vapor should be eliminated promptly before condensation occurs.

The water and hydrocarbons evaporated by the hot air dryer are discharged into the atmosphere together with hot air (see "Schematic of Current Drying System").

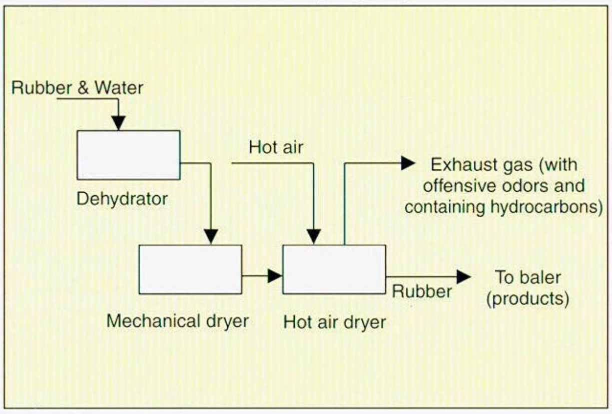
Some post-treatment equipment is required to collect hydrocarbons contained in the exhaust gas.

2. Development of the Superheated Steam Drying Process

The process to be developed is one in which a flash dryer is attached to the outlet of the mechanical dryer as a sub dryer in order to separate the steam flow from the rubber. This occurs after post drying of the rubber has been achieved with superheated steam in the flash transport pipe.

In this process, the separated vapor flow is recycled for flash drying, while the vapor increased in the system during the flash drying (water and hydrocarbons evaporated from the rubber) is removed from the branch pipe for collection via condensation (see "Schematic of

Schematic of Current Drying System



Steam Drying System").

To develop the process, a lengthy plant operation test, which will be required in actual production, has been conducted at one of the production lines to solve any problems.

The following are the major technical issues:

a) Development of a technology for smooth transport of rubber without clogging the transport pipe of a flash dryer or the cyclone with rubber (because rubber adheres easily)

b) Development of a technology to cut rubber coming out of the mechanical dryer to a size suitable for flash drying and the conveyor carriage in the subsequent process

c) Development of a technology to separate rubber dried in flash dryer from vapor flow

d) Development of a technology to seal the vapor atmosphere in the flash drying equipment

e) Development of a control technology to condense excess steam (vapor evaporated from the rubber) removed from the recycling vapor in the flash drying equipment

Regarding the above issues, items a)-c) were examined through preliminary transport testing by air in 1997 to obtain the necessary data for full-scale test equipment.

In 1998, the plant test equipment — on the scale of a commercial plant — was completed from design through construction, and testing was initiated on items d) and e), among others.

In 1999, lengthy plant operation required under actual production was tested with the main grades. Improving the problems, we sought to establish technologies on the scale of a commercial plant. In the testing, time was required to resolve the adhesion and clogging problems with rubber in the flash dryer process, mainly to the cyclone. We made improvements to the cyclone and to different aspects of the operating conditions of the flash drying, which led to a level at which continuous lengthy operation resulted in no problems in actual production.

As for solvent collection, about 50-80% of that volatilized at the outlet of the mechanical dryer will be condensed for collection.

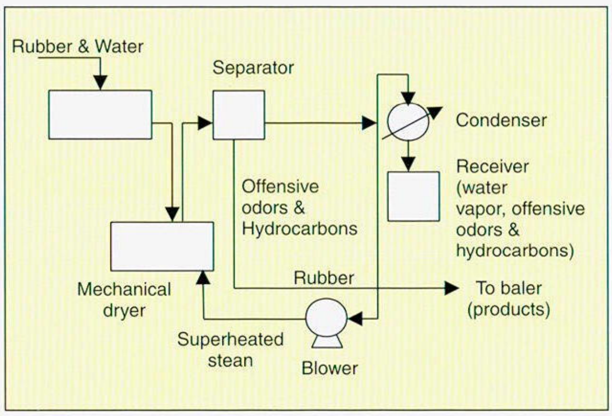
The largest problem was the adhesion of rubber in the flash drying process. This type of problem cannot be addressed until lengthy testing is conducted at the actual plant. In that sense, it was clear that moving toward testing at the actual plant was preferable to lengthy testing on a pilot scale.

Among grades made of the same material, differences were found in the adhesiveness of the rubber. It is essential to check the adhesiveness in advance when this process is applied to a process in which rubber of different material is manufactured.

● Conclusion

It has been verified that introducing a closed loop with superheated steam to the drying process enables collection of most solvents that are conventionally released into the atmosphere. We will examine the application of our technologies to other solution polymerization rubber plants.

Schematic of Superheated Steam Drying System



Research Development Project
Development of Technology to Control the Generation of Methane and CO_2 in Reducing Sludge Capacity

Development Period: 1997-99

Group X, Hanyu Laboratory, ICETT
Akebono Brake Central Technical Institute Co., Ltd.

Development Goal

Sludge generated from wastewater treatment facilities at petrochemical and other plants is the largest component of industrial wastes in Japan, representing 44 wt% of all effluent. Currently, this vast amount of sludge is incinerated, landfilled, and composted by means of high-speed composting. However, only 2% of all sludge is effectively used by means of composting and other media. Actually, considerable amounts of CO_2 and methane are generated during the treatment processes for incineration and landfilling. We believe that reducing the greenhouse-effect gasses generated from these processes will contribute greatly to control of global warming. We directed our attention to the possibility of controlling generation of methane gas — whose greenhouse-effect rate is 25 times that of CO_2— through efficient aerobic volume reduction treatment in a composting system.

However, there are few quantitative indexes to ensure efficient operation of any composting systems, and composting now depends on the experience of the operator. Therefore, the goal of this research and development project is to develop a new BOD sensor using biotechnology as a device to support the composting system controller. This will enable the formulation of quantitative indexes in the composting treatment process. It will also result in a technology to support control of the generation of greenhouse-effect gasses.

Results of Development Project

Figure 1 shows the flow of this research and development project. Specifically, we developed a mediator-type BOD sensor and a reactor-supporting device, conducted field experiments, and made assessments.

1. Development of a Mediator-type BOD Sensor

1) Search for and Assessment of Microorganisms

Using activated sludge from a sewage treatment plant, we isolated several microorganisms through screening with a minimal medium, using L-glutamic acid as a carbon source. Among them, we selected the strain L-GL3, which exhibited the best response to an L-glutamic acid solution in the electrochemical redox reaction system containing the mediator (electron transfer compound). We confirmed that this strain also responded to a standard BOD solution of JIS, artificial effluent according to OECD, and effluent from a food manufacturing plant.

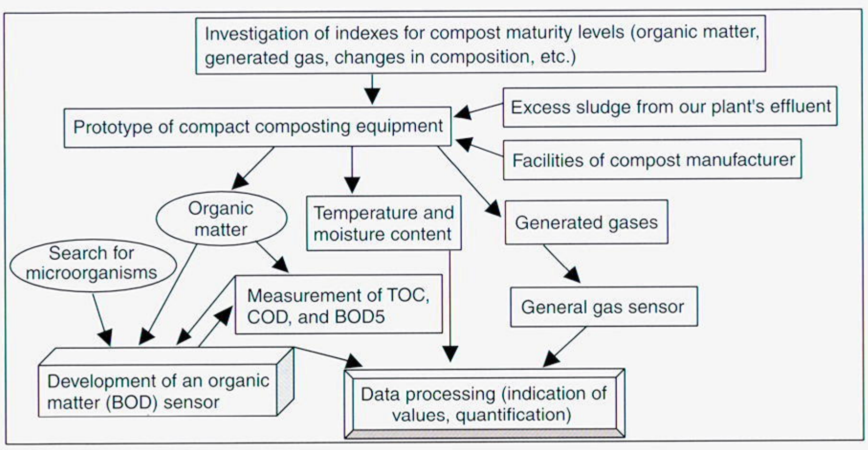
2) Development of a Microorganism Immobilization Method

The entrapment immobilization method with calcium alginate gel was adopted because of its ease of use under moderate conditions. A combination of hydrophobic mesh and electrodes enabled us to immobilize a bacteria solution uniformly and quantitatively on the surface of the electrode. The electrode part consisted of a working electrode and a counter electrode. We confirmed that achieving immobilization at both electrodes equally provided better stability in response values and ease of operation.

3) Development of Electrode Elements

We examined the conditions of carbon printing on electrode substrates by means of screen printing, and assessed the characteristics of the carbon electrodes. The optimum printing conditions under W squeegee mode were 10mm/s in squeegee speed, 0.5-1.0 mm in print gap, and 5 in

Figure 1. Research and Development Flow



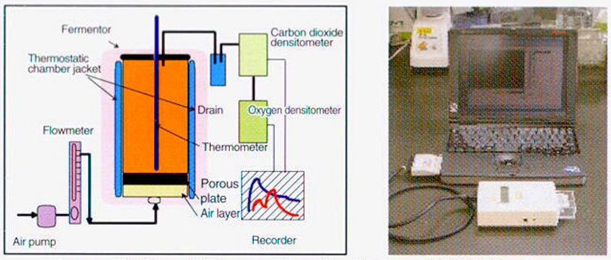


Figure 2. Small Composting System and BOD Sensor

squeegee pressure when DEK's DEK278 was used as the printer and Achson's ED423 was used as the ink. The materials of the substrate were glass epoxy resin and PET. In particular, the technology for manufacturing the carbonprinted electrodes with PET substrates is essential to low-cost mass production of disposable electrodes. The relative standard deviation in current response values at these electrodes showed good stability at about 1.0%. In addition,we conducted an immersion test with a 100 mM phosphate buffer solution containing 10 mM NaCl for a month, which resulted in no change in stability.

4) Development of a Small Transducer

A conventional oxygen electrode-type BOD sensor was developed for continuous long-term measurement. Therefore, specimens should be measured individually. Moreover,great amounts of standard solution, buffer solution and cleaning solvent are necessary, as are many liquid supply pumps and waste liquid tanks. In addition, regular maintenance of contaminated pipes is necessary. In contrast, disposable electrodes are used in each measurement for this mediator-type BOD sensor as maintenance is unnecessary. A small transducer was also developed to simultaneously measure multiple points of the specimen. We enabled the data analyzer to measure a maximum of 15 points at a time. We found that simultaneous measurement of multiple points would reduce dispersion in response values among the electrodes.

5) Experiment to assess sensor performance

Measurements combining a multi-point simultaneous measuring device and reaction cell with integrated immobilizing electrodes allowed us to assess reproducibility and dispersion. Adoption of deviation (%) and relative standard deviation (%) allows for relative assessment of sensor performance. Using a standard solution together with a measured specimen is preferable. We confirmed that the activity and stability of both free cells and microorganism-immobilizing electrodes during preservation remained unchanged for at least one month. The electrodes should be put in a sealed polyethylene bag for cold storage at around 4℃. We measured artificial effluent and domestic effluent from our plant with immobilizing electrodes stored for 27 days, which resulted in a high relativity of $R^2>0.98$.

2. Development of a Device to Support Reactor Control

We made a prototype of the small reactor for a model composting experiment. Our preliminary test did not result in good aerobic compost. Consequently, we examined the operating conditions after modifying the temperature control and aeration of experimental equipment. That resulted in improved changes in hours in fermenting temperature and a BOD5 to a level equivalent to that of the composting equipment. We found that a combination of the small reactor and the mediator-type BOD sensor, which allows for simultaneous measurement of multiple points, as well as monitoring of fermenting temperature and the BOD values as indexes of the compost maturity level, enabled us to quantitatively determine the changes in fermenting conditions of the compost. Figure 2 represents a schematic of the small composting system and a photo of the portable BOD sensor.

3. Field Experiment and Assessment

We examined various indexes relevant to organic compounds in the composting process by using specimens collected from a public sewage treatment plant. BOD5 showed the most significant change in hours in the primary fermentation. Figure 3 shows the results. Then, we measured actual compost specimens with the sensor we had developed, which indicated a high relativity to the rate of change against BOD5, as Figure 4 indicates.

As mentioned above, the following two points are effective quantitative indexes and are easy to check on-site to determine whether initial raw material treatment is going well in the compost fermenting process over two months:

1) the primary fermentation temperature should rise to around 60℃; and
2) readily biodegradable organic compounds should be reduced 80% in the primary fermenting process.

It is not necessary to prepare calibration curves and convert current values directly read from the sensor into BOD5 values in order to determine changes in the amount of organic matter that is easy to dissolve with this sensor. It is easier and more practical to predict it according to the rate of change in current values read directly.

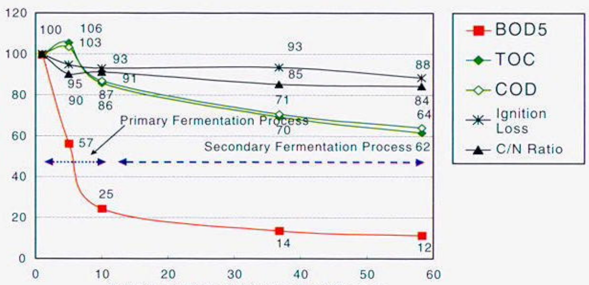


Figure 3. Investigation of Indexes for the Composting Process

Conclusion

Dissemination of the technology and equipment for efficient composting of the massive amounts of sludge generated by industrial effluent and sewage treatment plants provides for control of methane, CO_2, and dioxins generated from incineration and landfills. During this research period (1997-99), we specified the indexes to assess the maturity of compost, determined their measuring conditions, and developed measuring equipment and technology. We accomplished our initial goal by acquiring a quantitative index and a technology to support the determination of the compost maturity level, which conventionally depended on human senses and operator experience. New instrumentation technologies can be more widely expected in the environmental arena. The issues to be resolved are the promotion of technological development for practical application, such as practical application, production technologies, costs, and marketing of this technology. This strongly requires development in cooperation with an appropriate partner.

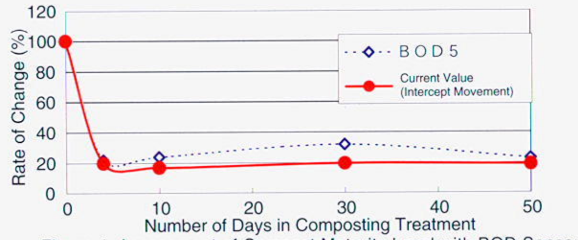


Figure 4. Assessment of Compost Maturity Level with BOD Sensor

The Seasons of Japan

The Japanese enjoy the four seasons by participating in events and sampling foods unique to each season. In this section, we would like to introduce some of Japan's seasonal events and foods.Let's consider autumn in Japan.

Maple-Tree Viewing

You may have heard of the practice of hanami, or cherry-blossom viewing in spring. Do you know how the Japanese enjoy autumn? One of the most popular ways to enjoy the season is "maple-tree viewing," a custom known as momijigari. We enjoy watching the leaves of the maple trees turning red or yellow in the mountains as the season changes from autumn to winter. It is said that leaves begin to turn brilliant colors as the difference between the highest and lowest daily temperatures is the greatest. In contrast to the northward movement of the "cherry blossom front" in spring, the leaves begin to change their colors beginning in Hokkaido in the north, and gradually spread southward. Many people visit famous spots to see the colored leaves every weekend from the end of September into October. Many of these sights are shown on TV. While the practice of hanami in spring involves the enjoyment of a cheerful picnic under the blossoming trees, the custom of momijigari in autumn involves enjoyment of scenic beauty as one quietly walks in and near the forest. It is a way to enjoy the fleeting glory of nature in the days before the cold season arrives.

Now, we'd like to introduce the recipe for daigaku imo.
Although it is not associated with maple-tree viewing, this snack of sweet potatoes is loved by the Japanese as a typical autumn dish. It is easy to prepare, so why not give it a try?

Daigaku Imo Recipe (Candied Sweet Potatoes)

1. Peel several sweet potatoes, cut them into slightly larger than bite-size pieces, and soak the pieces in water.
2. Pat the pieces dry and fry them in oil at 170℃ (338° F) until crisp and light brown.
3. In another pan, boil down water, soy sauce, and sugar until it becomes a glaze and produces sticky threads. Add the fried potatoes and sesame seeds to the pan and mix well.

Ingredients (Serves 4)

400 g of sweet potatoes, 80 g of sugar, 2 tablespoons of water, 2 teaspoons of soy sauce, 1 teaspoon of black sesame seeds (if available), and sufficient oil for frying.

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