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Environmental Engineering Business by Kawasaki Steel

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1 Introduction

Kawasaki Steel's engineering business is based on the company's own technologies, which have been developed in the course of more than four decades of steelworks construction and operation. The engineering division has also taken advantage of the strength of steel as a basic material to develop a wide range of business activities, beginning with the marketing of steel production equipment and construction of steel frame structures and extending to plant construction, civil works, pipeline construction, architectural construction, and further, to total city development.[1] As part of this history, the engineering division has been active in the field of environmental engineering, which is currently an important topic. Based on the construction and operation of environmental protection equipment in its steelworks, we have developed a number of environmental engineering businesses, beginning with wastewater treatment facilities, which comprise one of the important characteristic technologies for environmental protection, and further to sludge treatment facilities, refuse incinerators and melting plants for incinerated ash, and facilities for converting municipal garbage into refuse derived fuel, in response to the needs of the times.

This paper will begin by summarizing the major trends in Kawasaki Steel's environmental measures for steelworks, and will then discuss the cumulative growth and expansion of the company's environmental engineering businesses, presenting the results achieved to date and the outlook for the future in various areas of environmental engineering.

2 History of Environmental Measures at Kawasaki Steel

Kawasaki Steel has put first priority on the prevention of environmental pollution since the initial stages of the construction of its two integrated steelworks at Chiba and Mizushima. The company has not only complied with laws and regulations, but also has carried out advance environmental assessments and concluded pollution prevention agreements with local governments in the areas where it operates as part of its effort to comply with the world's strictest environmental standards.

Since 1974, a series of exhaust gas desulfurizing plants have been constructed at the company's coke ovens and sintering plants, and in 1976, the large-scale denitrification facilities for exhaust gas of coke oven and sintering furnace were constructed and put into operation for the first time in Japanese steel industry. In those days, the company had spent more than 10% of its total investment in environmental countermeasures for air pollution prevention (SO_x, NO_x, dust, soot and other particulates), water pollution control (circulating water, waste water, waste acids, waste oil), industrial waste countermeasures (effective use of blast furnace and converter slag, dust recycling, etc.), plant greening, and other measures. Considerable effort has also been

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directed to the development of environmental technology, and technologies such as high-efficient dust collection techniques by means of artificial tornado[2] and fluorin of waste water removal process have recently been developed.

Moreover, with global environmental problems now attracting worldwide attention, responding to the CO_2 in greenhouse gases has become a particularly important problem for the steel industry because the industry uses carbon in the form of coke as a reducing agent for iron ore. The amount of coke used in blast furnaces has already been restricted to the minimum necessary level, making further reductions impossible. So it has been concluded that realistic countermeasures for the CO_2 problem must be energy saving, and therefore a system for promoting energy saving in this direction and more efficient energy use throughout the entire company has been created. Specific measures which are now being implemented include the following:

(1) Broad-scale process elimination and continuation in production processes (near-100% adoption of continuous casting and continuous annealing, etc.)
(2) Operational improvements
(3) Introduction of high-efficiency equipment (new oxygen plant, gas-turbine combined cycle electric power plant, introduction of high-efficiency impellers on blowers, etc.)
(4) Waste energy recovery (coke dry quenching equipment, blast furnace top pressure recovery turbine, coal moisture control equipment, etc.)

Further, because Kawasaki Steel has long grappled with the environmental problem in its entirety in a positive, multi-faceted manner, a company-wide Global Environmental Management Committee was established in 1991 and environment-related activities centering around this organization started. Also a set of Action Guidelines for the Global Environment as a policy for corporate action was published. This policy sets out concrete guidelines for environmental protection, energy saving, resource saving, the development and production of "environment-friendly" products, rationalization of distribution, ozone layer protection, the development of innovative technologies, international cooperation, coexistence with society, and other aims.

3 Kawasaki Steel's Environmental Engineering Businesses

3.1 Water Treatment

Kawasaki Steel's wastewater treatment technologies are based on the company's experience in the planning, design, construction, operation, and maintenance control of equipment for the treatment of industrial water and waste water at its steelworks. Because steelworks use enormous quantities of water, large-scale technologies and know-how for water quality control, water flow rate control, wastewater treatment, wastewater reuse, and others have been accumulated. The development and application of these technologies and know-how has made it possible for Kawasaki Steel to respond to a number of social needs, beginning with sewage treatment, and has supported the company's entry into a wide range of water treatment businesses.

3.1.1 Industrial water and waste water

This business has developed in pace with overseas orders for steel plants, centering on water treatment equipment for the iron- and steelmaking processes. The recent record of orders includes Ton Yi Industrial Corporation and Tung Ho Steel Enterprise Corporation in Taiwan, as described in greater detail elsewhere in this issue.[3] With active steel plant construction in China, Thailand, Malaysia, Indonesia, and other countries, Kawasaki Steel foresees an increase in steel plant orders, and can therefore expect to receive orders for water treatment plants in these regions. In projects unrelated to steel plant construction, Kawasaki Steel has already been responsible for the waste water treatment facilities at the painting line of Philippine Honda and for the industrial and waste water treatment facilities at Nihon Semiconductor Corporation in Japan. Where semiconductor plants are concerned, the company's technologies for ultra-pure water treatment and waste water treatment can make a major contribution to water treatment facilities at the semiconductor plants which are expected to be built in southeast Asia in the coming years.

3.1.2 Sewerage

The current rate of diffusion of sewerage in Japan is approximately 50%, but this number is to be increased to 70% under the 8th 5 Year Plan for Sewerage. This plan, supported by greater public spending on sewerage, makes sewerage a promising field of business. Kawasaki Steel has an extensive record as a water treatment equipment maker, particularly in machinery and equipment for grit chamber, sedimentation tanks, and sludge thickeners. In addition, the company has an extensive lineup of products with special features, including U-chain rakes, circular grit chamber with rotary cylinder, Keslite deodorizing equipment, and high-efficiency sludge dehydrator. In the future, increased needs are expected in the field of high-level treatment aimed at effective use of sewage and reduction in the nitrogen and phosphorus content of waste water. The company has therefore established a system, which can cater to each user's requirements, by means of development and commercialization of activated sludge process with membrane separation. With regard to relay pump stations for sanitary sewage and storm water, a considerable record in this field, including equipment for rainwater quality improvement, has been obtained. In particular, it is possible to construct compact pumping stations in locations with limited space by using a circular grit

chamber technology with a rotating cylinder, which the company spent a number of years developing to a commercially viable level.[4] In July 1994, Kawasaki Steel received an order from Chiba City for the machinery equipment at the Soga Pumping Station (30 m^3/s), which is the largest scale storm water pump station in Japan.

In the area of water treatment for farming and fishing communities, Kawasaki Steel has completed the development of planning and design software which will enable the company to propose equipment plans responsive to customers' needs and is prepared to offer specialized systems, such as the oxidation ditch (OD) system with K-JET (ultra-fine bubbling aerator) not found in domestic design standard.

3.1.3 Water quality improvement for closed water areas (dams, lakes/marshes, bays)

In recent years, the increasing public demand for a more pleasant living environment has strengthened the trend to recognize anew the value of bays, lakes and marshes, rivers, and dams as "friendly" water areas. Purification techniques for water areas of these types have also drawn attention from the viewpoint of preserving water resources.

Kawasaki Steel was quick to respond to this problem and developed purification technologies using biofilm filtration, the contact aeration process, and others in water quality purification equipment for rivers and small lakes and marshes. For dams and large lakes and marshes, the company has commercialized various types of flow creation and aeration equipment, and can propose plans which correspond to water depth, surface area, and other topographical conditions and to the needs of customers.

In addition, Kawasaki Steel has developed a simulation system for pollution purification and has established a system which makes it possible to present proposals to clients visually, showing the conditions before and after the application of purification equipment.[5]

3.1.4 Diagnostic technology for water treatment equipment

In metropolitan and other areas, the new construction of sewerage and water supply equipment is basically complete, but in the future, maintenance control of these public facilities will become an important problem. In view of the serious impact of a water treatment facility or pump shutdown due to hardware failure, equipment is progressively refurbished beginning with aging items, as a preventive maintenance measure. An accurate grasp of the proper timing for equipment replacement is critical information for efficient equipment investment.

The equipment diagnosis system developed jointly by Kawasaki Steel and Kawatetsu Advantech Co., Ltd. with the city of Tokyo converts the characteristic vibration frequency and amplitude of rotating mechanical equipment into pulse wave form for early detection of equipment abnormalities and deterioration. The system is particularly well suited for use as an automatic equipment diagnosis device at aging large-scale pumping stations.

3.2 Sludge Treatment Plants

With the greater diffusion of sewage systems, the amount of sewage sludge is continually increasing. In the past, it was general practice to reclaim, in the form of sludge cake, the sludge which was produced in the treatment of sewage. However, pressure on disposal land has heightened the need for sludge incineration/resource recovery and composting, and the development of the following technologies has been realized.

Kawasaki Steel has made considerable effort to develop a new technology as a system for economically and safely treating the annually increasing output of sewage sludge accompanying the greater use of sewerage systems. This technology centers on a fluidized bed incinerator with a belt press dehydrator and powerful mechanical compression dehydrator in the pretreatment process forming a two-stage dehydration process, which is used with a dehydration agent. A feature is the energy saving direction of the technology, which uses carbonized sludge made from sewage sludge as raw material.

Further, the incinerated ash produced when sludge is incinerated is converted into fused slag with plasma melting equipment, making it possible to provide a system which gives harmless, stabilized slags.

Following a study made by the combined efforts of the Kawasaki Steel Group to determine possible uses for fused sewage slag, the stage at which a significant amount can be reused has already been reached. As one example, Kawasaki Steel Group has developed KAWAPROM ACE® pavement block manufactured by recycling fused sewage slag. This has been used by local governments throughout Japan.[6]

In order to diversify sludge treatment methods, Kawasaki Steel markets the dehydration agent mentioned above and composting plants. Composting equipment for sewage sludge includes a unit which was purchased and put into operation by the Okayama Regional Promotion Bureau in Okayama Prefecture. We also expect to see wider use of this technology with progress in the restoration of forests and farmland.

In addition, development of a production process for activated carbon, which is a raw material for sewage sludge, is now in progress.

3.3 Refuse Incinerators

This field involves the incineration of municipal refuse discharged by ordinary households. In recent years, with higher standards of living, both the amount of refuse produced and the types of refuse have increased. Kawasaki Steel has grappled with the construction of refuse incineration facilities requiring total technical capabilities, based on the incineration technol-

ogy and exhaust gas treatment technologies used in its steelworks and its know-how as a user of furnace materials, utilizing the plant technologies developed through its engineering businesses. In fiscal 1994, the company received an order for a refuse incinerator built around a parallel oscillating step grate stoker furnace in Kumamoto Prefecture.

In the future, technical development in this field will not be limited to simply incinerating refuse. Technology development is now underway at Kawasaki Steel with thermal recycling (power generation from waste) and the melting furnace as key words.

3.4 Refuse Incineration Ash Melting and Resource Reuse Systems

In the past, the incinerated ash discharged by refuse incinerators was buried in the final disposal area without further processing, but the amount of such ash has now reached approximately 6 million tons per year in Japan. In recent years, particularly in urban areas, the shrinking disposal land, difficulty in securing sites for new disposal land, and environmental preservation in the vicinity of disposal land have all become acute problems urgently requiring a technical solution. Moreover, effective use of resources and recycling have also become matters of serious public concern. Against this background, there is a strong demand for a volume reduction of refuse incinerated ash, measures to render ash harmless and stabilized, and recycling.

Kawasaki Steel carried out fundamental experiments on a plasma melting furnace for refuse incinerated ash jointly with The Tokyo Electric Power Co. Inc.,[7] and in a four-way joint effort which included Kawasaki Heavy Industries, Ltd. and Chiba City, conducted a proof experiment with this equipment at the Kita-Yatsu Refuse Disposal Plant in Chiba City.[8]

This melting system uses electric plasma as a heat source. Because the directionality of the energy is high and stable, the amount of exhaust gas is smaller than with fossil-fuel heat sources, comprising only the plasma working gas and the combustion gas of unburned portion. These features make possible a compact equipment design. Further, because it is easy to realize high temperatures with electric plasma, it is possible to obtain stable, completely melted slag. Where the life of the plasma electrodes is concerned, actual records of more than one month of continuous operation were confirmed as a result of the ample accumulation of technology gained in long term operation of the pilot facility, demonstrating that there is a good possibility that the electrodes will be capable of withstanding 2 to 3 months of continuous use.

A study in connection with designated (hazardous) industrial wastes has been carried out, confirming the effectiveness of this system in treating these substances. Kawasaki Steel is also promoting research aimed at applying the plasma melting furnace to sewage sludge incinerator ash.

As mentioned previously, paving materials have been manufactured using the technology for producing KAWAPROM ACE from fused slag made by applying plasma melting to refuse incinerator ash. This product has been purchased by Yotsukaido City in Chiba Prefecture.

As discussed above, Kawasaki Steel possesses technologies which make it possible not only to incinerate refuse, but also to melt and recycle the resulting ash, demonstrating that the company is a total planner which can provide integrated treatment and recycling systems for the refuse produced by cities.

3.5 Waste Solid Fuel Conversion System

Against the background of heightened awareness in Japan of the environmental importance of recycling together with increasing pressure on disposal lands, national policy in regard to refuse is undergoing a major change, drawing attention to waste treatment methods which do not simply incinerate refuse, but rather convert these substances into solid fuel. The Environmental Basic Plan adopted by the Cabinet in the last fiscal year states that Japan "should promote positive recycling of virtually all wastes by the early 21st century, rather than simple burning and burial, and when incineration is used, the country should promote a conversion to methods which utilize the resulting thermal energy."

The method of converting refuse to solid fuel has the following advantages in comparison with the conventional incineration method:

(1) Because treatment does not involve burning refuse, and therefore does not produce smoke, it does not pollute the environment and is more acceptable to the public.
(2) Long-term storage is possible and handling is easy because refuse is converted to the form of solid fuel.
(3) Refuse treatment and energy consumption need not be related in time or space.
(4) Thermal recycling is possible even with small-scale refuse treatment processes.
(5) Small-scale decentralized treatment is possible with the solid fuel process; consequently, this process avoids the traffic problems caused by refuse collection trucks, which occur in centralized processes with large-scale incinerators.

Kawasaki Steel was the first to undertake the development of a solid fuel conversion system for refuse, and with Itochu Corp. Group set up a joint venture named Recycling Management Japan, Inc. which constructed practical plants in Nogimachi, Tochigi Prefecture, and Haibaracho, Nara Prefecture. In 1993, Tonami-gun, Toyama Prefecture placed an order for a refuse solid fuel conversion plant as No. 1 Unit of the Nanto Recycling Center, which received financial support approved by the Ministry of Health and Welfare. The plant has been operating smoothly since start-up in March 1995.

Current applications for the solid fuel produced by this process include a variety of uses as fuel, etc., in public facilities, for example in the boiler of a municipal-operated spa in Nogimachi, Tochigi. In Toyama Prefecture, the fuel is used in air conditioning and hot water supply equipment at a home for the aged in Fukumitsumachi and in snow melting equipment used on-site at the Nanto Recycling Center.

Use of this solid fuel in electric power generation is under study in Mie Prefecture with the support of the Ministry of Home Affairs and NEDO. Under the concept of electric power generation from solid fuel being considered in Mie Prefecture, solid fuel conversion plants will be constructed by each local government, and the fuel produced will be collected for use at a central power plant. In addition, a number of local governments outside of Mie Prefecture either have begun or are scheduled to begin studies of power generation from solid fuel using Mie-type systems.

3.6 Composting Systems for Raw Garbage

The preceding sections have discussed waste treatment from the viewpoints of incineration/melting and solid fuel conversion. As a different perspective, systems for returning raw garbage to the natural environment by composting are now attracting attention. A system for producing compost from raw garbage has been put into operation by Recycling Management Japan, Inc. at Nogimachi in Tochigi Prefecture. In this locale, raw garbage with a high moisture content and combustible refuse are collected separately with the cooperation of area residents. The wet raw garbage is then composted, and the compost product is returned to the local residents free of charge, winning a favorable response for the system.

The Nogi-type system, in which raw garbage is converted into compost and other types of combustible refuse are converted into solid fuel, is expected to spread to other local governments in rural areas which include forest and/or farm land.

4 Future Directions of Business Development

(1) Use of Technologies Available in the Steelworks
In the future, as environmental protection expands to the global scale, it is conceivable that environmental standards, emission standards, and other regulations will become increasingly strict. The continuing development of new technologies to the stage of practical application is therefore expected. The environmental technologies and auxiliary technologies related to steelmaking still include many technologies and systems which can contribute to society if applied to the general environment. Kawasaki Steel is therefore promoting technical development by a company-wide system for grappling with this problem, so as to provide the optimum hardware and software capable of contributing to society through the development of the urban infrastructure and other means.
Concretely, we will work toward the development of a direct melting furnace for municipal refuse industrial waste (particularly abandoned automobile shredder dust) and sewage sludge, and the early commercialization of desulfurization, denitrification, dust collection, and other systems for the prevention of atmospheric pollution.

(2) Coexistence with Urban Areas
Kawasaki Steel is also wrestling positively with the problem of coexistence between cities and steelworks. As one example, the byproduct gas from Mizushima Works is refined and adjusted to a calorific value of 5 000 kcal/Nm^3 for supply to Okayama Gas Co. This energy source now meets more than 80% of the city gas requirements of the cities of Okayama and Kurashiki. However, this type of one-way flow of energy from the steelworks to the city will not be sufficient in the future; it will also be important to make the mutual relationship a firm and organic one by creating a flow of waste from the city to the works.

(3) From Thermal Recycling to Material Recycling
Because natural resources are limited, thoroughgoing recycle of waste is desirable in the present. For the future, material recycling will be increasingly essential. We will therefore participate in such large-scale projects as the Waste Recycling Plaza and Sewage Sludge Wide Area Treatment (Ace Plan), and make vigorous efforts to establish economical, energy-saving, and space-saving technologies such as those mentioned below.
- Reuse technology for molten slag
- Composting technology for organic wastes
- Direct melting technology for sewage sludge
- Crushing and separating technology by utilization of liquefied nitrogen

(4) Reclamation of Natural Environment
Rivers and sewage treatment plants release a heavy pollution load into closed marine bodies such as Tokyo Bay and Osaka Bay, which border on major urban areas, and on large marshes and lakes, of which Lake Biwa is a typical example. Moreover, this kind of inflow is rich in nitrogen and phosphorous, which tend to accelerate entrophication. Organic substances are then produced in these bodies of water, and algae and the "red tide" phenomenon occur repeatedly each year. The consequences include major public problems such as injury to fisheries due to the extinction of fish and shellfish stocks, injury to agriculture by the pollution of agriculture water, and a threat to human health by the formation of carcinogens such as trihalomethane and others resulting from the excessive purification treatment required by the pollution of drinking

water sources.

The conceivable measures for the problem pollution load are direct purification of the marshes, lakes, and rivers after pollutants have entered into these bodies of water, and reduction in the inflow of pollution load. Techniques of the former type include aeration and the creation of artificial flows to avoid internal generation of organic matter in marshes and lakes and to avoid the decay of organic matter due to anaerobic conditions. Kawasaki Steel is now putting considerable effort into this area. Where techniques of the latter type are concerned, because more than half of the nitrogen input into Tokyo Bay, for example, originates from household waste water, we are actively working to develop a new sewage treatment process which gives consideration to high-efficiency removal of nitrogen and phosphorous. If, as a result, progress is made in recycling treated wastewater, multiple benefits can be expected, including the preservation of water sources.

Among problems not related to water, soil pollution is considered important. In the future, as former industrial areas in and near cities undergo redevelopment, simplified, economical techniques for investigating soil pollution and purifying polluted soil will be desirable. Kawasaki Steel is conducting survey and research work in this field as well. As one example, the company has applied a ground water survey technique using acoustic tomography to investigate soil pollution.

5 Concluding Remarks

The aims of Kawasaki Steel's environmental engineering business are to use technology developed in the company's steelworks as a base for contributing to society by producing environmental technologies developed on the basis of the requirements of the times, and to serve as a total planner which provides services to the neighboring region in a form which makes full use of the infrastructure and equipment of its steelworks. We hope to concentrate the total capabilities of Kawasaki Steel and the Kawasaki Steel Group in this direction.

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