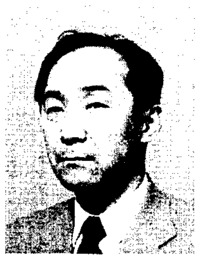
KAWASAKI STEEL TECHNICAL REPORT No. 44 June 2001

Aiming at an Environment-Conscious Steel Works*





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Synopsis:

Kawasaki Steel has been aggressively executing many activities, such as environmental improvement, energy saving and recycling of resources to comply with the motto of, 'To carry out global vusiness activities, the first priority should be given to environmental preservation'. In executing the above-mentioned activities with the supports of every development in technology and engineering, significant progress has been achieved. And now, it is strongly expected to look at environmental issues from a global viewpoint and to contribute to the establishment of a community where sustainable growth is ecpected. In regard to the prevention of global warming, environmental preservation and the establishment of recycling society, results and future subjects for the activities of Kawasaki Steel are reported in this paper.

1 Introduction

With the rapid growth of the Japanese economy, environmental pollution became a widespread problem beginning in the latter half of the 1960s. However, many pollution problems were solved by strengthening the legal and regulatory system, which includes the Basic Law for Environmental Pollution Control of 1967, revisions of that law and 14 pollution related laws of 1970, together with numerous environmental countermeasures. On the other hand, beginning in the second half of the 1980s, the importance of global scale environmental problems, such as global warming and the destruction of the ozone layer, gradually gained international recognition. An earth summit (United Nations Conference on Environment and Development) was held in Rio de Janeiro in 1992, and the Framework Treaty on Climate Change was concluded for the purpose of preventing global warming. The 3rd Conference of the Parties (COP3) to the Framework Treaty on Climate Change was held in Kyoto in December 1997, and agreement was reached on an international framework directed toward prevention of global warming. As Japan's target for the years from 2008 to 2012, the country is to reduce the amount of emissions of greenhouse gases, mainly CO_2, by 6% in comparison with levels in 1990. As can be seen from the above, the perspective on environmental problems expanded from pollution problems of the conventional type to environmental problems on the global scale beginning around 1990.

The key elements in conventional environmental preservation activities at Kawasaki Steel were reduction of the environmental load generated in production processes, energy saving activities, and activities to recycle the company's own byproducts. Various technical development activities also bore fruit, and it was possible to realize important benefits in these activities. In order to respond to the globalization of environmental problems, Kawasaki Steel established a Global Environment Administration Committee in 1991 (reorganized as the Global Environment Committee in 1997), and enacted a set of company Guidelines for Preservation of the Global Environment in 1993, thus creating a system for conducting company-wide policy and planning. The company also constructed an environmental management system (EMS) in order to achieve further reductions in the environmental load in all stages of its business activities and obtained ISO 14001 certification at its main plants between 1997 and 1999. Together with the creation of this type of system, Kawasaki Steel has also promoted positive efforts to preserve the global environment. The following describes activities to date in connection with measures to prevent global warming through energy saving activities, measures to reduce the environmental load, and efforts to construct a recycling

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type society, together with the results of those activities and future efforts.

2 Prevention of Global Warming

2.1 History of Energy Saving Activities

The Japanese steel industry developed full-scale energy saving activities following the 1st Oil Crisis, which occurred at the end of 1973. Kawasaki Steel began its 1st stage energy saving activities in 1974, and since that time, has continuously promoted energy saving activities up to the present 9th stage. As a result, actual energy savings exceeding 20% have been achieved, as shown in **Fig. 1**. Although these energy saving activities were carried out in the past from the viewpoints of reducing energy consumption and improving energy costs, the perspective changed greatly from the beginning of the 1990s. Specifically, because the CO_2 which is generated when energy is consumed is a greenhouse gas, energy saving has undergone a major change in purpose, and is now considered part of the solution to the problem of global warming, which is a global scale environmental issue.

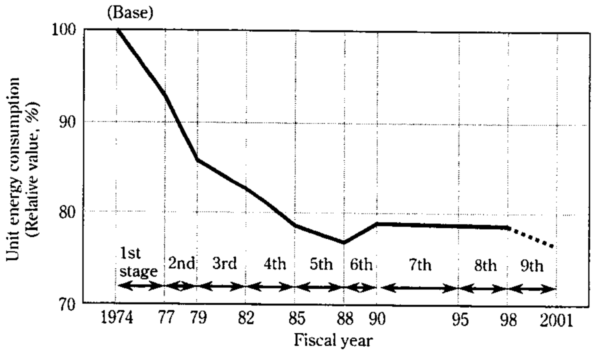


Fig. 1 Reduction in unit energy consumption

2.2 Energy Saving Measures

Broadly summarizing the energy saving strategies which have been promoted by Kawasaki Steel, these may be classified into the following three types of measures.[1]

(1) Reduction of energy consumption by introducting energy saving equipment in steel manufacturing processes and improving the efficiency of energy conversion facilities such as power plants.

(2) Optimization of energy costs by construction of a total energy management system.

(3) Contribution to energy saving in society by higher value-added products, and creation of added value in energy by sale of liquefied gas, etc.[2]

Kawasaki Steel has implemented the optimum measures by adjusting these strategies to meet changes in the energy situation, the economic environment, social requirements, and other conditions prevailing at the time. The following describes the main measures in the respective areas.

2.2.1 Reduction of energy consumption

(1) Introduction of Energy Saving Equipment in Steel Manufacturing Processes

This is the measure which produces the greatest effect among energy saving measures and has been achieved by large investment items since the 1st Oil Crisis. Broadly classified, energy saving equipment comprises waste energy recovery equipment and process elimination/process continuation. The main equipment is as follows.

(a) Waste Energy Recovery Equipment

In waste energy recovery, the main facilities are equipment for recovery of the sensible heat of solids, liquids, and gases which are generated in iron- and steelmaking processes. Representative examples include coke dry quenching (CDQ) facilities, sintering cooler waste heat recovery, blast furnace top pressure power generating equipment (top-pressure recovery turbine: TRT), hot stove waste heat recovery for the blast furnace, and converter gas sensible heat recovery equipment.

(b) Process Elimination/Process Continuation

In the steel manufacturing process, final products are produced by a series of process which, if performed independently, require repeated heating and cooling. However, energy savings can be achieved by eliminating or combining processes in which the temperature drops. As representative energy saving equipment in this category, pulverized coal injection (PCI) equipment for the blast furnace, the continuous casting machine, various types of direct hot rolling, and the continuous annealing line (CAL) may be mentioned.

(2) Higher Efficiency in Energy Conversion Equipment

Kawasaki Steel has a long history of developing and applying technologies which convert the byproduct gases generated from coal to electric power, steam, and oxygen with high efficiency. As representative examples of high efficiency power plants, the company started operation of a byproduct gas-fired combined cycle power plant[3] at Chiba Works in 1987 and is currently constructing a blast furnace blast/gas turbine cogeneration plant at Mizushima Works. Moreover, an integrated steel works consumes large quantities of pure oxygen in the steelmaking process, and substantial energy savings have also been achieved at the company's oxygen plants by improving the efficiency of air separators and variable absorption equipment.

(3) Operational Improvements by Thinking Group Activities

Kawasaki Steel has a long history of thinking group activities (TG activities), which are carried out in the form of small group and have also incorporated energy saving activities. These activities have earned an excellent evaluation for their social contribution, including numerous awards from the National Conference on Outstanding Examples of Energy Saving, which is sponsored by the Energy Conservation Center (foundation).

2.2.2 Optimization of energy costs

In an integrated steel works, coal and coke are used to reduce the raw materials for iron and steel. Consequently, more than 90% of the energy consumed in an integrated works is supplied by coal or coal-based substances. Moreover, fuel gases are also generated as a secondary product of various steel manufacturing processes, and it is important to use these gases effectively, not losing any opportunity for efficient conversion to other forms of energy such as electric power, steam, oxygen, etc.

(1) Construction of Total Energy Control System

Energy is generated and consumed in a steel works in large quantities and numerous kinds, and the mutual conversion between types of energy is complex. In order to utilize these forms of energy with high efficiency by total control, an energy control system was created and is operated in a centralized manner by works' energy centers.[4,5] Energy centers have been constructed at both Chiba Works and Mizushima Works, where they are demonstrating their effectiveness.

(2) Effective Use of Coal-based Energy

An integrated steel works produces iron and steel products by using coke to chemically reduce the raw material iron ore. However, a byproduct gas is generated in the process of manufacturing coke from coal. This coal-based gas is relatively inexpensive in comparison with petroleum-based fuels. Optimum blast furnace fuel ratio operation is carried out in order to use this byproduct gas effectively and efficiently, and as a result, the energy cost of the steel works as a whole is minimized. Pulverized coal injection equipment for the blast furnace, which achieves energy savings by eliminating the cokemaking process, is effective.

2.2.3 Contribution to energy saving by higher value-added products

High value-added products such as high tensile steel sheets and high efficiency electrical steel sheets make a large contribution to energy saving in society. Moreover, the conversion and sale of forms of energy with higher added value, such as electric power, liquid oxygen, liquid nitrogen, etc., using steel works energy equipment, is contributing to energy saving utilizing the infrastructure of the steel works.

2.3 Measure to Prevent Global Warming

2.3.1 Voluntary action plan of steel industry

From an early date, the steel industry has made positive efforts to realize more efficient energy use, and achieved a total energy saving of approximately 20% between the 1st Oil Crisis and the present. The Japan Iron and Steel Federation strongly recognizes the importance of countermeasures against global warming, and responded to a call from Japan Federation of Economic Organizations (Keidanren) for further efforts in the area of energy saving measures by establishing a "Voluntary Action Plan for Environmental Preservation by the Iron and Steel Industry" in December 1996. This voluntary action plan sets a target of reducing energy consumption in iron and steel production processes by 10% by the year 2010, with energy consumption in the year 1990 as the base line.

In September 1997, in response to a request from the government, the industry also agreed to make a supplementary effort to reduce energy consumption. This supplementary effort, which is preconditioned on the creation of a collection system and other necessary conditions, is an energy saving measure in which waste plastics will be used in the blast furnace and other facilities, targeting a 1.5% reduction in energy.

2.3.2 Energy saving plan and tasks for the future

(1) Promotion of 9th Energy Saving Plan

Kawasaki Steel is positively participating in the voluntary action plan of the Japan Iron and Steel Federation, and is promoting a company-wide plan aimed at achieving the target for 2010. In 1999, in combination with its 2nd Mid-Term Management Plan, which was begun as a three year plan, the company also started its 9th Energy Saving Plan. Under this plan, Kawasaki Steel will attempt to achieve a company-wide energy saving ratio of 3% and an energy cost reduction of ¥6 billion per year. Main items include modernization of the blast furnace blast plant at Mizushima Works by introduction of a gas turbine/cogeneration system, and the introduction of energy saving equipment such as regenerative burners for reheating furnaces.[6] This plan will represent a large advance toward achieving the target of the voluntary action plan of the Japan Iron and Steel Federation. Together with properly starting up the planned energy saving projects and ensuring that they demonstrate their effectiveness as scheduled, it is also necessary to take up the challenge of innovation in technology, which will change greatly, and to seek out new subjects while responding flexibly to environmental changes.

(2) Response to Kyoto Mechanism

The Kyoto Mechanism, which was approved at the 3rd Conference of the Parties (COP3 Kyoto Conference), refers to the so-called international flexibility mechanisms of joint implementation, the clean development mechanism (CDM), and emission trading. At present, the establishment of rules for the Kyoto Mechanism is in a fluid condition. However, Kawasaki Steel has positively expanded its overseas technical cooperation, taking advantage of technologies that are useful for global environment preservation, such as energy saving countermeasures, which the company has developed over the course of many years. Examples include the implementation of energy saving model projects sponsored by NEDO (New Energy and Industrial Technology Development Organization) and feasibility studies of proposed projects for joint implementation, among the methods established under the Kyoto Mechanism. In the future, a flexible response will be required, aiming at international implementation of the Kyoto Mechanism based on the results of these efforts.

3 Environmental Preservation

3.1 Activities and Results to Date

3.1.1 Period of high economic growth and uprise of pollution problems

(1) Environmental Efforts and Establishment of Control Organization

Kawasaki Steel's systematized response to environmental problems began from the period when Environmental Control Sections were established in the Head Office and steel works in 1967. This was the period when environmental pollution became a problem throughout Japan accompanying the rapid growth of industry, and the Basic Law for Environmental Pollution Control was enacted. In order to respond to national regulations, Kawasaki Steel strove without delay to introduce environmental protection equipment and develop environmental technologies.

(2) Conclusion of Pollution Prevention Agreements with Local Governments

To enable new construction and expansion of facilities while continuing to improve and protect the regional environment, Kawasaki Steel concluded pollution prevention agreements with local governments. These agreements set standards which are stricter than national government regulations and establish a system of prior consultation when the company plans the installation of pollution control equipment and new construction or expansion of equipment.

Chiba Works: Concluded a basic agreement in connection with facility installation in 1970 and a detailed agreement in connection with the construction of No. 6 blast furnace and its related equipment in 1975.

Mizushima Works: Concluded a pollution prevention agreement in 1971.

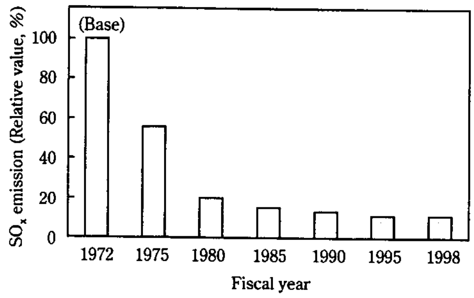


Fig. 2 Reduction in SO_X emission

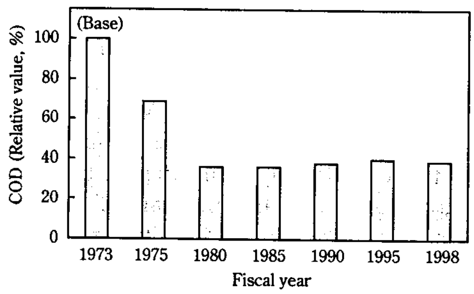


Fig. 3 Reduction in COD at Chiba Works

(3) Installation and Technical Development of Environmental Protection Equipment

The company has also made positive efforts to introduce or develop pollution prevention technologies which are necessary for environmental improvement. The development of technologies for desulfurization of the coke oven gas generated as a byproduct at the site,[7] desulfurization and denitration of sintering plant exhaust gas, the low NO_X burner,[6] dust collecting,[8] and others have been successful in preventing air pollution. As an example of the results of these countermeasures, the reduction in SO_X emissions in Kawasaki Steel as a whole is shown in **Fig. 2**.

With regard to water quality as well, development of technologies for treating coke oven waste water[9] and oil-containing waste water at cold rolling mills was carried out as a COD countermeasure. The reduction in the COD load by implementing these countermeasures is shown in **Fig. 3**, taking Chiba Works as an example.

(4) Amicable Settlement of Pollution Suits

At Chiba Works, amid environmental countermeasure efforts, a primary lawsuit was filed in 1975 on the occasion of the construction plan for No. 6 blast furnace, and was followed by a secondary suit in 1978. Likewise, at Mizushima Works, a suit was filed in 1983 against eight companies with operations in the Mizushima industrial complex, including Kawasaki Steel.

Although the longest of these disputes spanned as much as 17 years, an amicable settlement was reached

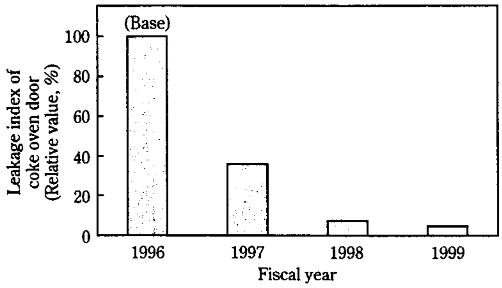


Fig. 4 Reduction in leakage index of coke oven door

in the Chiba Works pollution suit in 1992, and an amicable settlement was realized in the Kurashiki pollution suit involving Mizushima Works in 1996. The resolution of these cases was the combined result of efforts to create friendly relations and establish a relationship of trust with the residents of the areas surrounding the works, and the positive results of environmental measures accumulated to date and ongoing implementation of improvements.

3.1.2 Period of change to urban and household type pollution

(1) Environmental Preservation as an Urban Type Steel Works

In addition to air pollution countermeasures such as SO_X reduction and water pollution countermeasures such as COD reduction, which had been carried out from an early date, the company also took countermeasures against noise and visible smoke affecting the neighboring area. By carrying out multi-faceted activities to reduce the environmental load, the company aimed at creating a steel works which could exist in harmony with the urban environment. As an example of countermeasures against visible smoke, **Fig. 4** shows the reduction in the index of leakage from coke oven doors. This large reduction in the door leakage index was the result of improvements in the door and cleaner[10] and technical development of operational improvements.[11]

While the company is steadily implementing these environmental improvements, it also makes diligent efforts in exchanges with neighboring residents. In addition to introducing an "environment monitor system" and publishing and distributing works' public relations magazines, the company has also held annual "Kawasaki Steel Festivals," which aim at exchanges with the people of the region by opening the works to the general public, at Chiba Works since 1977 and at Mizushima Works since 1979. In 1980, plant visit centers were set up at both Chiba and Mizushima Works.

Socially, concern over conventional type local pollution problems has generally subsided, and attention is now focused on global scale environmental problems. At Kawasaki Steel, a Global Environment Administration Committee was set up in 1991, and a policy entitled "Action Guidelines and Outline of a Plan for Protection of the Global Environment" was established in 1993.

(2) EMS Certification

The idea of global environmental preservation is incorporated in the Basic Environment Law, which was enacted in 1993, and environmental preservation efforts are also now based on international standards. This requires a change from the conventional approaches, which involve mainly conventional environmental control and environmental countermeasure technologies, to EMS, which establishes a system for continuing improvement by including activities extending to management as a whole and to methods of production. Kawasaki Steel's principal works received ISO 14001 certification between 1997 and 1999.

3.2 Future Efforts

The ultimate purpose of EMS is not simply to acquire ISO certification. Rather, the aim is continuing improvement of the environment based on EMS. Because the purpose of EMS is to reduce the environmental load in all the stages of business activities from the purchase of raw materials through manufacturing and transportation to the development of products which consider the environment, it is being promoted with the participation of all departments of the company.

The policy for efforts in this case is voluntary effort by the company, combined with disclosure of information. Together with voluntarily promoting efforts to reduce the environmental load, the aim is to create an urban type steel works which takes a step forward in coexistence with the local community by obtaining the full understanding and trust of the community through the disclosure of information, and further, by contributing to local society through resource recycling and other efforts.

3.2.1 Voluntary activities to reduce the environmental load

Voluntary activities mean that environmental problems are considered to be a basic priority of management, and risk is prevented by taking countermeasures in advance.

(1) Voluntary Reduction and Control of Environmental Load

With regard to dioxin, Kawasaki Steel has already met the national standards which will be applied to steel works incinerators and electric furnace exhaust gas beginning in December 2002. The company is also devoting considerable effort to reducing dioxin emissions in sintering plant exhaust gas by reducing the chlorine content of raw materials and is carrying out research and development of technologies to further reduce and remove dioxins.

PRTR (pollutant release and transfer register) is a system which promotes voluntary reductions of emissions. Under this system, companies report to the national government the amount of releases of substances of unconfirmed toxicity into the environment. Although reporting will become mandatory in FY 2002, Kawasaki Steel is making voluntary efforts to investigate the amount of releases in advance of that date.

In preparation for future conditions in which plants exist in closer proximity to residential areas, beginning with Chiba Works, where redevelopment of the former site of the East Plant is under study, the company is carrying out a multi-faceted study of dust, odor, etc., including a survey of facilities with such efforts, relocation of equipment, and detailed technical development for improvement.

(2) Reduction of Environmental Load from Viewpoint of LCA

Responding to environmental problems on a global scale requires an evaluation not only of the environmental load in production processes, but also the environmental load in all the stages of product life from the extraction of raw materials to product use and recycling. A method of making evaluations of this type is LCA (life cycle assessment), which was developed by the IISI (International Iron and Steel Institute) with the cooperation of member nations. Additional research to reflect this method in product design is scheduled for the future.

3.2.2 Positive disclosure efforts

(1) Manner of Proceeding with Information Disclosure

Information disclosure is linked to the spirit of EMS. Kawasaki Steel has made such efforts to disclose information through exchanges with local residents and other means since an early date. Although the proper form of information disclosure in the future involves a number of issues with which the company has no previous experience, including disclosure items and methods, responsibility to provide explanations, and the evaluation of risk and environmental effects, this is a field in which completion is urgently required, and positive efforts are scheduled in the future as well.

(2) Disclosure Items and Methods

Environmental information, including the company's environmental policy, environmental loads such as SO_X and others, the amount of investments in environmental protection equipment and energy saving equipment, etc., is already being made public in environmental reports.

For the future, PRTR data, environmental information on products, and environmental accounts will also be studied. As methods of disclosure, use of the internet and the creation of an explanation system and locations, etc. are items which should be carried out in the future.

4 Building a Recycling Society

4.1 Zero Waste Activities at Steel Works, Activities and Results to Date

4.1.1 Results of zero waste activities

The modern steel works of the postwar era in Japan were constructed in coastal areas. Not only earth and sand dredged from the coast, but also the slag generated by the steel works, were used as reclamation materials for creating the land on which these steel works were constructed. The useful materials contained in generated dust were recycled as an iron source, and substances which were technically difficult to recycle were buried in final disposal sites prepared by dividing off part of the created site.

As land reclamation approached completion around the middle of the 1970s, Kawasaki Steel positively developed uses for slag in other applications, and beginning in 1990, also began activities to reduce the amount of materials requiring disposal by landfill.

The amount of steel works byproducts generated at Kawasaki Steel per year was 6 056 thousand tons in FY 1998. As shown in **Fig. 5**, 85% of this amount was slag and the remaining 15% was dust and sludge. As can be seen in **Fig. 6**, the byproduct recycling ratio, which was slightly under 94% in FY 1990, reached 99.5% in FY 1998 as a result of zero waste activities.

The amount of landfill at Kawasaki Steel was 391 000 t in FY 1990, but had been reduced to 27 000 t by FY 1998, or a reduction of 93% in comparison with FY 1990. During the same period, the rate of reduction in the steel industry in Japan as a whole was only 56%. Thus, Kawasaki Steel recorded the top class results in the industry.

The voluntary control targets for the industry which were announced by the Japan Iron and Steel Federation call for a 75% reduction, with FY 2010 as the target year. Kawasaki Steel has achieved this goal well ahead

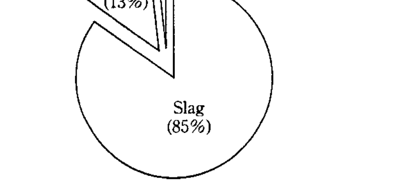
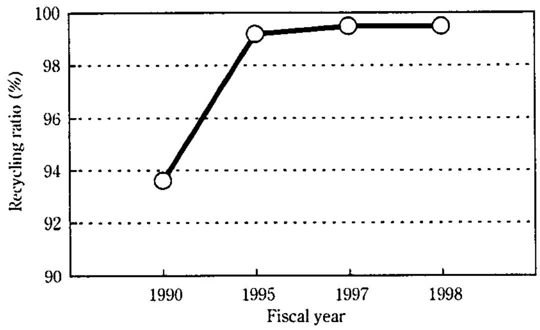


Fig. 5 Composition of by-product from iron- and steelmaking process (FY 1998)



$$\text{Recycling ratio} = \frac{(\text{Amount of by-products}) - (\text{Amount of landfill})}{(\text{Amount of by-products})} \times 100\ (\%)$$

Fig. 6 Progress in recycling of by-product

Table 1 Recycling situation of by-products (FY 1998)

	Amount (kt/y)	Ratio (%)	Landfill (kt/y)	Recycling raito (%)
Slag	5 149	85.0	0.0	100.0
Dust	804	13.3	4.0	99.5
Sludge	31	0.5	16.5	46.8
Others	72	1.2	6.2	91.4
Total	6 056	100.0	26.7	99.5

of schedule. The actual results of the amount of landfill and the recycling ratio at Kawasaki Steel in FY 1998 are shown in **Table 1**.

4.1.2 Recycling technologies

The main content of zero waste activities and the related technologies at Kawasaki Steel are as follows.

(1) 100% Recycling of Slag

Slag accounts for the largest part of the byproducts generated in the steel works, at 85%. As a result of promoting recycling in the works and recycling outside the company by expanding applications, zero landfill disposal of slag has been realized since FY 1995. The main technical development items among uses for slag are as follows.

(a) Recycling to the sintering process and the blast furnace, effectively using the Fe and CaO content of steelmaking slag[12]

(b) Expanded use of water granulated blast furnace slag in cement

(C) Technical development of civil engineering applications for water granulated blast furnace slag, and use of slag as an aggregate for concrete by the hard quality water granulated slag manufacturing process

(d) Technical development for application of steelmaking slag as roadbed material,[13] technical development for application as a soil conditioner for agricultural land, the sand pile construction method, etc.

(2) Dust Recycling Technology

In addition to the conventional method of recycling dust to the sintering process, Kawasaki Steel promoted the use of dust in hot metal pretreatment and developed the STAR furnace (coke packed bed type smelting reduction process)[14] for recovering stainless steel dust as a resource. As a result, the dust recycling ratio improved from 96% in FY 1990 to 99.5% in FY 1998.

(3) Sludge and Others

The amount of sludge generated has been reduced by recovering and reusing waste pickling acid from the stainless steel manufacturing process and by using sludge from pickling water treatment as a kneading material for sintering raw materials. However, the recycling ratio in FY 1998 was only 47%, which says much about the difficulty of recycling sludge in comparison with other substances. The other main material which is disposed of by landfill is ash from the waste incinerators used at the works.

4.2 Response to Recycling Society

Society has begun a large movement toward the construction of a recycling society. Kawasaki Steel's efforts to contribute to a recycling society consist of the following two pillars.

(1) With respect to byproducts generated in the company, zero waste activities.

(2) With respect to materials generated by the local community and other industries, contribution to recycling by using iron- and steelmaking processes.

Zero waste activities are already well advanced in the steel works, as described above. For sludge, which still has a low recycling ratio, recycling technologies are now being developed in response to the exhaustion of landfill disposal sites.

4.2.1 Zero waste activities at steel works

(1) Waste Reduction Targets

Kawasaki Steel has already achieved the voluntary control target set by the Japan Iron and Steel Federation for the amount of landfill. However, considering the exhaustion of landfill sites, the development of recycling technologies which absolutely minimize the amount of waste requiring disposal is now a task. At the present time, the company is carrying out research and development aiming at an 80% reduction in the amount of landfill from the level in FY 1998 by the FY 2005.

The fundamental manner of proceeding with resource recycling is to promote a start of the three Rs of reduce, reuse, and recycle.

(2) Countermeasures Already in Progress

The following may be mentioned as countermeasures which are already being promoted to reduce the amount of waste generated and recycle wastes.

(a) Minimization of amount of slag generated

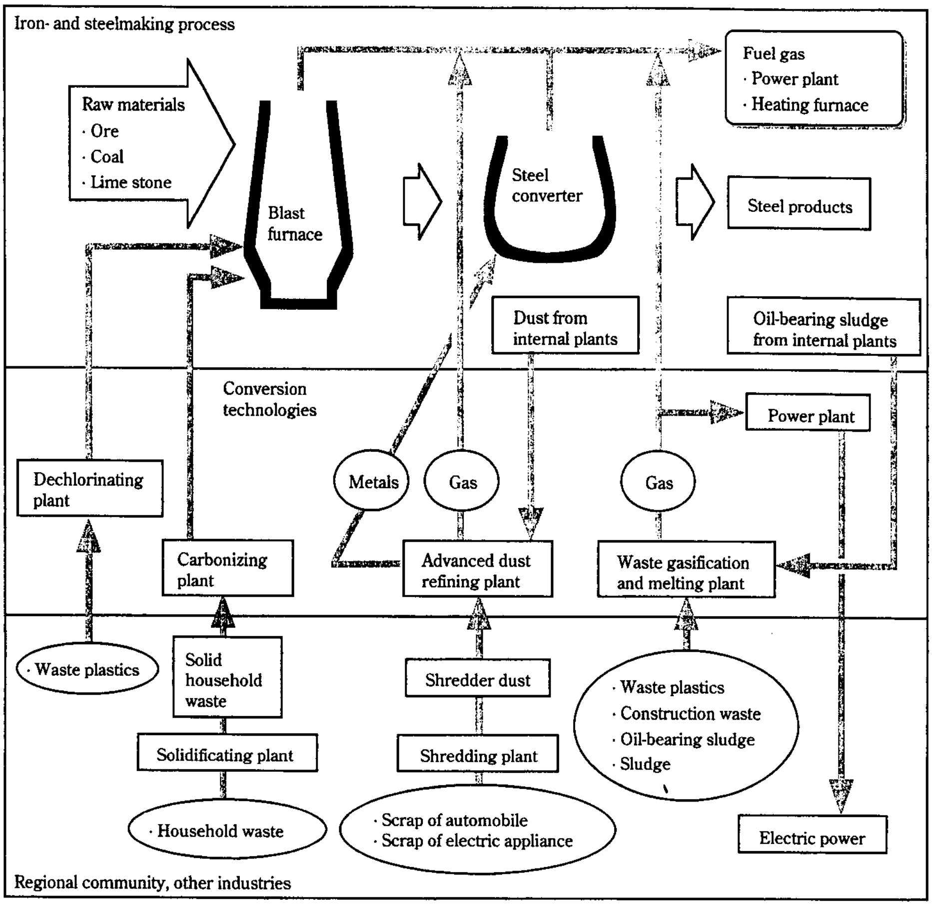


Fig. 7 Recycling system based on iron and steel making process

(b) Reduction of dust generation from the converter by use of the hot cyclone (Started up at Chiba Works No. 4 steelmaking shop in June 2000.)

(c) Waste-free operation using the Kawatetsu Thermoselect method waste gasification and melting furnace[15] (Started up in 1999 at Chiba Works; in the future, other waste incinerators at Chiba Works will be shut down, achieving zero landfill of incinerator ash.)

(d) Recycling of zinc-containing dust by the Z-STAR furnace (advanced dust treatment reactor)[14] (Started up at Mizushima Works in February 2000.)

(e) Sorting of recyclable materials by securing sludge separation areas.

(3) Further Technical Development

Recycling of water treatment sludge has been delayed because the water content is high and the sludge contains substances that are obstacles to recycling. The sludge generated by treating water from steel rolling plants contains oil, and the sludge generated by treating waste water from coating operations contains zinc and tin. The sludge from stainless steel pickling waste water treatment contains fluorine. Considering the different properties of each type of sludge, it is necessary to remove the mixed oil and separate the substances other than iron in order to recycle sludge in the steel works, and methods of recycling the separated substances are also a problem. Research and development with the aim of complete recycling of these types of sludge are currently in progress.

4.2.2 Contribution to recycling society using iron and steel processes

The second pillar or Kawasaki Steel's efforts toward a recycling society is contribution to recycling of wastes generated by the local community and other industries. The company is promoting the construction of a recycling system, as shown in **Fig. 7**, by utilizing recycling technologies developed in the processes of iron and steel manufacturing and steel works processes which effectively use various types of byproducts and energy. The wastes generated by the local community and other industries are treated using various recycling technologies, and the metals, fuel gases, etc. which are recovered are used in the steel works. Resource recycling is already being steadily realized using the technology of the STAR furnace, which treats dust, and the technology of the Kawatetsu Thermoselect process waste gasification and melting furnace. The steel works will contribute to the construction of a recycling society by coexisting with the region through recycling resources in this manner.

5 Conclusion

Kawasaki Steel has actively implemented a variety of measures to prevent global warming, reduce the load on the environment, and contribute to a recycling society. The results of these efforts and tasks for the future have been described herein.

In the future as well, Kawasaki Steel will take the initiative in developing technologies for preserving the global environment, including the manufacturing of products which are friendly to the global environment, and will strive to create an environment-conscious steel works which makes sustainable development possible.

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