Toward the Establishment of a Recycling-Oriented Society

Abstract

Recent environmental problems cover an extremely wide spectrum of subjects from addressing the preservation of global warming, establishing a recycling-oriented society, to complying with the regulation of chemical substances. With the background of the alarmingly low capacities of landfill sites and the need for recycling brought on by the scarcity of resources, the Basic Law for Promoting the Creation of a Recycling-Oriented Society and other related laws have been enacted. In addition to withdrawing from mass production, mass consumption, mass waste economic system and utilizing the resources effectively by minimizing the waste disposals, the establishment of a recycling-oriented society are urgent. Through the attempting to recycle not only the by-products from its own production processes, but also the by-products from other industries and wastes materials from surrounding communities, Nippon Steel will achieve higher corporate activities by contributing to the establishment of a recycling-oriented society.

1. Introduction

The worldwide trends that have accelerated the structural changes in the domestic social economy during the last decade of the 20th century have been directed toward "Expantion of Information Technology" and "Globalization". Those trends have resulted not only in bringing about the changes in industrial structure and personal lifestyles, but also in implanting a common recognition among the all populations in the world to the new problems including the global environment and waste management.

Since the environment is essential to sustain life it should be maintained so that it can be equally shared by both present and future generations. With this background, the establishment of a full-fledged recycling-oriented society is urgently required so that the socio-economic structure, as characterized by mass production, mass consumption, and mass disposal, can be basically reviewed, waste substances minimized for their effective utilization, and our society changed into "a sustainable one" (Fig. 1).

The steel industry has so far made strenuous efforts to eliminate hazardous emissions by investing continuously in the improvement

Fig. 1 Future image of the formation of a recycling-oriented society

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of operations and equipment and in the development of new technologies so that environmental pollution can be prevented and industrial wastes can be reduced (Table 1).

Steel manufacturers can contribute to the establishment of a recycling-oriented society by recycling iron materials, utilizing recycled resources by taking advantage of the existing infrastructures, and using technologies to eliminate hazardous emissions. It is particularly worthy to note that the present steel manufacturing process has the potential to form a social infrastructure characterized by safety, reliability and high efficiency in the effective utilization of waste substances when deregulation is enforced. More concretely, with the techniques related to high-temperature fusion treatment using blast furnaces, converters, and electric furnaces serving as platforms along with designs for iron manufacturing equipment and operation techniques cultivated thus far, fusion of the application of those techniques into an appropriate interface technology that best utilizes of them can be considered.

It is firmly believed that the high-efficiency production system of which Japanese steel industry can boast will contribute to the effective utilization of recycled resources and the elimination of hazardous emissions in the future to win high praise and interest from among the general public.

This report deals with the total aspect of how Nippon Steel Corporation is taking steps toward establishing a recycling-oriented society.

2. Recent trends of policy on the environment relative to the formation of a recycling-oriented society

2.1 Trends in foreign countries

In Europe, environmental policies have become important political problems since the 1980’s. In Germany, the government enacted an ordinance in 1991 to make self-governing bodies responsible for recycling packaging wastes out of the waste substances treated by the self-governing bodies, enacting further in 1994 the “Cycling Economy/Waste Act” as core to its domestic waste disposal policy.

The environment-related laws in Germany are characterized by three principles: “Principle of hazard prevention”, “Principle of polluters’ responsibility”, and “Principle of cooperation”. In accordance with those basic principles, environment-conscious production processes have been developed with an aim at the symbiosis of ecology and economy so that the additional cost for recycling and the cost for repairing after the occurrence of pollution can be reduced.

The environmental policy in Europe is characterized by a long-term environmental plan formulated by each country for the promotion of comprehensive preventive programs. Those plans are not only requesting the cooperation of those concerned on the mid- and long-term targets, but also encouraging the adoption of an auditing system for grasping comprehensively how the plans are being undertaken and the utilization of economic expertise as an incentive for tackling them. Economic incentives include an environmental levy on products, a deposit system, a preferential taxation system, and an environmental tax. In some countries are taken not only compulsory measures stipulated by laws and regulations but also other measures utilizing an independent agreement with the industry concerned and financial incentives.

2.2 Trends in our country

(1) Basic Plan for the Environment

As a new framework of the environmental policy stemming from the conventional basic law for environmental pollution control, the environmental protection law and the basic plan for environmental pollution control were enacted in 1993 and 1994, respectively. The basic plan for environmental pollution control has declared the four targets. Namely, they are: “circulation”, “symbiosis”, “participation,” and “international activity”. The fundamental principles are stipulated for the environmental policy, for the roles of respective governing bodies, and for the measures for policy making.

(2) Basic Law for Promoting the Creation of a Recycling-oriented Society

The basic law for the promotion of the establishment of a recycling-oriented society was enacted, and fully enforced in January, 2001 to arrange in order the existing method of implementation so that the problems can be quickly dealt with, including a high-level transition of the amount of discharged wastes, the congestion of reuse and recycling, scarcity of final disposal sites, increased illegal waste dumping, and increased use of un-recyclable resources, such as fossil fuel and mineral resources. Central Council for Environmental Pollution Control is now studying a guideline to formulate a basic plan.

This law indicates a basic concept of how basic principles, the responsibility of each self-governing body, and a national policy should be with a view to securing the recycling of social substances, controlling the consumption of natural resources, and reducing environmental load. In addition, the following laws were materialized as the ones by which the ideologics of the laws can be concretely imple-
taking advantage of its technology and infrastructure, with the obvious steps of recycling its own by-products.

3. Movement toward the formation of a recycling-oriented society in the industrial sector

(1) National guideline on the reduction of wastes

The Government decided at the Cabinet conference "A target of waste reduction" in September, 1999 to reduce final disposal amounts by half in fiscal 2010 in comparison with that in fiscal 1996 as a target of promoting recycling.

(2) Voluntary action program of environmental protection by the Federation of Economic Organizations (Keidanren)

The steel industry formulated "Voluntary action program relative to the environmental protection by the steel industry" at the meeting of Keidanren in 1996 and is acting in various ways with a target of reducing 75% of the final disposal amount of slag, dust, and sludge in 1990 by 2010.

Keidanren formulated its independent action program of environmental protection with a target set of reducing industrial wastes in 1997 and is following up its action based on its annual data report (Fig. 3).

(3) Compliance with the waste management law

Pursuant to the enforcement of the basic law for promoting the creation of a recycling-oriented society, the actual results and the plan of collecting wastes - a subject of the law - are reported to each self-governing body. Each self-governing body is expected to decide the details upon consultation. In the steel industry, slag and scale are typical target items.

(4) Compliance with the law for promotion the effective utilization of resources

Appointed as "Specified resource conservation business" on which is imposed concrete responsibility in accordance with the law for promoting the effective use of resources, the steel industry is requested to deal with the prevention of the production of by-products and the promotion of the utilization of the by-products as recycled resources. The steel industry is therefore trying, for example, to prevent the production of slag by elaborating the production process as well as to use it effectively as the raw materials of cement and roadbeds.

4. Activity at Nippon Steel Corporation

Immediately after its start in 1970, Nippon Steel Corporation has set up the Environmental Control section at its head office to be en-

![Graph](https://example.com/graph.png)

Fig. 3 Voluntary action plan by steel industry of reducing industrial wastes
gaged in environmental conservation activity. Its environmental ba-
sic policy, formulated in 1972, was reviewed several times and fur-
ther reviewed in January, 2000 as well. The basic policy comprises
Contributions to the establishment of a society committed to envi-
ronmental preservation, Reducing environmental impact at every
stage of operations, and International contribution through initiatives
for environmental preservation on a global scale. As its mid-term
environmental management plan based on the foregoing, it is devel-
opling a concrete activity by adopting the following platforms: Ini-
tiatives for preservation of the global environment, Initiatives for
creation of recycling-oriented society, Initiatives for contribution,
through products and engineering, to environmental preservation,
energy saving and conservation of resources, and Initiatives for re-
ducing environmental impact. It is actively engaged particularly in
improving the rate of converting by-products, produced in the pro-
duction process, to resources, minimizing wastes, and reusing by-
products produced in other industries and societies as important tasks.

(1) Recycling of steel products

The yield of steel products amounts to about 0.8 billion tons eve-
ery year with some 12 billion tons accumulated now in the society.
Those out of service are collected as iron scrap. The iron scrap makes
up an effective recycling system in which they are used either partly
with iron ore as the main component or mainly for iron manufacture
(Fig. 4).

(2) Recycling of by-products

<Slag recycling>

The slag yielded as a by-product in iron manufacture is mainly
composed of lime (CaO) and silica (SiO₂). Since it contains no other
organic substance, it is used for various applications, such as raw
material for cement, soil conditioners and roadbeds.

It is produced in a blast furnace in the iron making process and in
the steel making process. In the blast furnace, 300 kg of slag is pro-
duced per ton of pig iron, while 150 kg of slag is produced per ton of
molten steel in the steel making process. Since blast furnace slag is
very similar in component to cement, almost 100% of slag is used
for mixing in cement material and as blast furnace cement.

Blast furnace slag in a molten state, when quenched with water,
results in granulated slag that cures with water. Pulverized granu-
lated slag, when mixed in Portland cement, is called “blast furnace
cement”. Since blast furnace cement replaces about 45% of Portland
cement with blast furnace slag, it helps to save the resource of slime.
It is also effective for preventing the temperature-induced cracking
of large structures because of its excellent long-term strength and
small hydration heat. In addition, it is remarkably effective for con-
trolling salt damages and alkaline reactions of aggregates in coastal
structures. It is therefore specified as a “special procurement item”

for public works and also adopted in “Common Specifications for
Construction Work” compiled under the supervision of the Ministry
of Land, Infrastructure & Transport.

Since converter slag is higher in basicity (CaO/SiO₂) than blast
furnace slag, it swells when used as it is. It then becomes necessary
before delivery to stabilize lime (aging) either by storing it for a long
time or by steaming.

<Dust and sludge recycling>

Dust, produced in a blast furnace and a converter in a steelworks,
is already recycled and sold to the extent of 95%. With a view to
increasing further the rate of recycling, however, rotary type reduc-
ing furnaces were installed in three steelworks, namely, Kimitsu,
Hirohata, and Hikari Works, where metals contained in dust and
sludge are reduced and pelletized for recycling in the steel-making
process (Photo 1). With this technology, the dust, hitherto consid-
ered unrecyclable because of the presence of zinc in it, is now recy-
clicable. In addition, the zinc, separated and recovered, can also be
sold.

(3) Recycling of by-products generated by other industries

<Acceptance of waste acid, aluminum dross, and discarded tires>

By-products from other industries and societies are being posi-
tively used as a substitute for raw materials that are purchased in
the steel-making process. Concretely, sludge from the paper industry
and aluminum dross from the aluminum manufacturing industry are
used as insulating material and steel auxiliary, a nickel catalyst used
for petroleum refining and food purification is used as a raw material
of stainless steel, and waste acid from the semiconductor manufactur-
er is used for acid pickling of stainless steel.

At Hirohata Works the method of melting cold iron resources, in
which iron scraps are melted by blowing pulverized coal and oxygen
into a converter, has been adopted since 1993 to secure iron resources
due to the shutdown of the blast furnace. Discarded tires have re-
placed part of this pulverized coal for use as a fuel resource. Steel
wires contained in the discarded tires by about 14% are used as an
iron source, while the gas produced, rich in hydrogen content, is

![Photo 1 Dust recycling plant at Kimitsu Works](image)

![Fig. 4 Reproduction of iron/recycling system](image)
recycled for use as an energy source in the steelworks. In this manner, 57 thousand tons of discarded tires were recycled in 2000, accounting for about 6% of the total discarded tires recycled in Japan (Fig. 5).

(4) New activity
(a) Waste plastics recycling

For efficient use of the infrastructure of its equipment, the steel industry is effectively using waste plastics for a blast furnace and coke ovens as substitutes for coal. Undoubtedly, this serves to solve the problem related to the disposal of waste plastics, save resources by recycling, realize energy conservation, and prevent the global warming by reducing the discharge of CO₂, thus contributing to the creation of a recycling-oriented society.

After a series of tests for effective utilization of waste plastics for a coke oven, Nippon Steel Corporation started recycling waste plastics in 2000 when its technology relative to “the method of recovering chemical materials for a coke oven” was officially authorized in accordance with the law for recycling container packages.

According to containers and packaging recycling law, plastics for container packages, discharged from general households, are classified and collected by respective self-governing bodies, and delivered to a steelworks. Those collected waste plastics are reduced in volume and molded after removing foreign matter to render them suitable in quality and shape for charging into a coke oven, crushing, and removing chlorine compounds. Then, they are mixed with coal, charged into a coke oven, heated to 1,200°C in an enclosed carbonization room to be pyrolyzed. From the high-temperature gas produced then are recovered hydrocarbon oil (light oil and tar), coke oven gas, and a residue from which coke is recovered. The hydrocarbon oil is used as chemical raw material, while the coke oven gas is used at a steelworks as fuel gas and at a power plant. In this system, 40% of charged plastics is recycled as hydrocarbon oil, 20% as coke, and 40% as coke oven gas (Fig. 6).

The waste plastics recovery equipment is expected to run at Nagoya and Kitami Works from October, 2000, and at Yawata and Muroran Works after 2002.

This technology is expected to reduce 1.5% equivalent of CO₂ by accepting 1 million tons in 2010 in the independent action program of the steel industry relative to the global warming problem as well.

(b) Shredder dust treatment

With the recycling-related laws formulated, the movement toward the appropriate recycling of automobiles is actively discussed. The establishment of a recycling system is under discussion relative to the recycling of automobiles with emphasis placed on 1) the prevention of illegal dumping of discarded automobiles, 2) continual recycling and appropriate treatment, and 3) minimizing a final disposal amount.

ASR (Automobile Shredder Residue), a residue with metals, such as iron, removed from an automobile shredded after removing useful and harmful parts, is land filled at a final disposal site. It is requested in the new recycling system, however, to minimize the production of ASR, and take appropriate measures in terms of the reduction of environmental burdens and reduction of a final disposal amount. Nippon Steel Corporation is making headway to respond to the new social need with priority given to the technology of the gasification pyrolysis furnace, well-established already in general waste incinerators.

(c) Environmental solutions fields

Nippon Steel Corporation has developed technologies accumulated in the long history of iron making, offering at home and abroad the technologies related to the environment and energy-saving plant operation. It is also going to offer environmental solutions business that will contribute to the formation of a recycling-oriented society over a broad range from waste disposal to water treatment, energy utilization, and soil purification.

<Gasification pyrolysis furnace>

Since the direct waste melting and recycling system on the basis of blast furnace technology pyrolyzes various kinds of solid wastes, including incombustibles, en boc at a high temperature of over 1,700°C, it is an epoch-making technology for solid waste treatment that prevents the evolution of harmful gases, such as dioxins, reduces wastes for land filling drastically, recovers resources for construction materials from the resulting slag and metals, and utilizes recovered energy for local heat sources. As of November, 2001, the
company has accepted an order for 21 furnaces, accounting for about 1/3 of a total of 66 furnaces throughout the country. There are some 1,500 incinerators of general wastes domestically. It is expected to develop this system as a facility for harmonizing with the environment in the future (Table 2).

5. Future prospects

With various legal systems related in recent years to form a recycling-oriented society, resources are going to be recovered from those items hitherto discarded as wastes in the fields of containers and electric home appliances, and automobiles this year.

Although it is essential to develop the recycling industry as a venous industry for the formation of a recycling-oriented society, management of the venous industry by the collection and delivery of wastes alone will not lead to the promotion of recycling because of the obstacles awaiting in terms of technology development and cost. Since the venous industry has realized continual innovation in the manufacturing process, it may be safe to say that the organic combination of the arterial industry with the venous one can be realized if the latter plays a role as the hear.

The steel industry is capable of contributing greatly to the establishment of a recycling-oriented society by taking advantage of its existing infrastructure to the utmost. Nippon Steel Corporation will therefore try to offer various environmental solutions now and in the future as well.