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Recycle of Stainless Steel

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Abstract

As a result of mounting interest in global environmental protection in recent years, manufacturing industries are increasingly evaluating the harmlessness of scrap steel during refuse incineration and the recyclability of scrap steel as commercial values. It is commonsense for the stainless steel industry to use scrap as raw material for stainless steel production. The general public does not always understand this fact. Many people who do not handle scrap in stainless steel consuming industries incorrectly think that stainless steel is not recyclable. Using stainless steel railroad cars as an example, the recyclability of stainless steel is introduced here as part of the activities to popularize this excellent property of stainless steel.

1. Introduction

It is still fresh in our memory that the negotiations between advanced countries and between developed countries and developing countries about the gas emission targets to prevent the greenhouse effect at the Kyoto Conference on Climate Change were reported heavily in newspapers. Prompted by the outcome of the meeting, each industry in Japan is carrying out measures to reduce energy consumption and exhaust gas emissions. The general public is greatly interested in these moves and now recognize "earth-friendliness" as one commercial value.

Stainless steel is truly an earth-friendly metal. Although the scrap use rate varies from manufacturer to manufacturer, stainless steel scrap can be reconditioned to prime product by controlling the impurities in the scrap. Up to very recently, stainless steel railroad car manufacturers and designers in the electric railroad industry asked if stainless steel that does not rust and that is highly strong could be really recycled. These people knew that stainless steel is easy to maintain, but did not know as much about the recyclability of stainless steel.

The recyclability of aluminum, a railroad car material that competes with stainless steel, is actively publicized. Some aluminum railroad cars are even running with "recycled car" signs. To publicize the recyclability of stainless steel, a video tape was prepared to demonstrate the recycling of stainless steel railroad cars. This article briefly introduces the recyclability of stainless steel railroad cars and reports the recyclability test results of stainless steel railroad cars.

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2. Raw Material Situation of Stainless Steel

The production of stainless steel has grown five times in the past 30 years at an annual rate of 5.5%. The production of its main raw materials, ferrochromium and ferronickel, and the generation of stainless steel scrap are also increasing. The supply rates of ferrochromium, ferronickel, and stainless steel scrap in Japan are shown in **Figs. 1** to **3**, respectively. The supply of raw materials has increased with increasing production of stainless steel. The

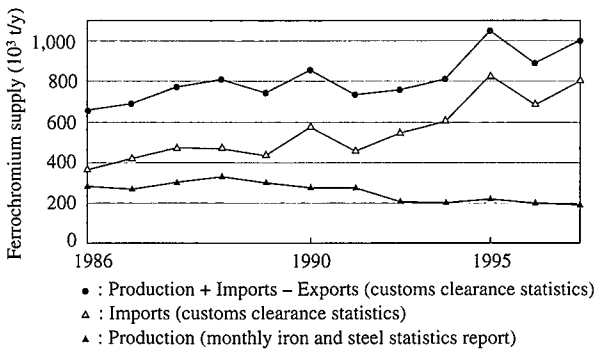

Fig. 1 Supply of ferrochromium in Japan

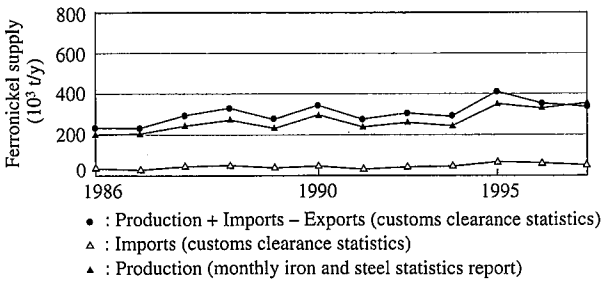

Fig. 2 Supply of ferronickel in Japan

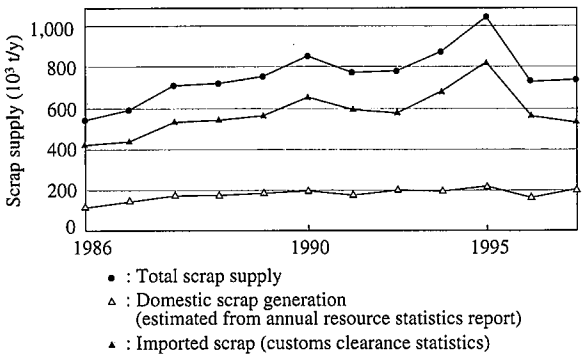

Fig. 3 Supply of stainless steel scrap in Japan

imports of ferrochromium have increased, but the imports of ferronickel have not increased as much. The imports of metal nickel have been increased to make up for the low import rate of ferrochromium. The decline in the amount of imported stainless steel scrap is countered by the increased collection of domestic stainless steel scrap. Ferrochromium contains about 50% pure chromium, and ferronickel contains about 20% pure nickel. The average composition of stainless steel scrap is unknown, but SUS 304 accounts for the majority of stainless steel scrap.

3. Recovery of Scrap

Stainless steel scrap is recovered through different routes, depending on its form. Stainless steel scrap is mainly divided into the following types.

(1) Home scrap

Home scrap refers to the scrap generated by stainless steel manufacturers as they produce stainless steel sheet, wire, tube, shapes, and so on. The home scrap is classified, recovered, and melted by their mills.

(2) Prompt industrial scrap

Prompt industrial scrap refers to the scrap left after stamping, cutting, drawing, or otherwise processing to the desired final size or shape by steel fabricators or assemblers. The prompt industrial scrap is classified at each plant, recovered by scrap collectors, and supplied through scrap dealers to stainless steel manufacturers.

(3) Obsolete scrap

Obsolete scrap includes worn-out or broken products of end users. This is generally what is simply called "scrap". When a plant is demolished, the generated scrap is classified by type of stainless steel. Electric products and other obsolete products are collected as incombustible sold wastes from households and are supplied from collectors through processors (having shredders and other equipment) to stainless steel makers.

4. Utilization of Scrap

In the steelmaking process, the collected scrap is classified and stored by composition. The scrap is blended with ferrochromium and ferronickel to achieve the target composition of the stainless steel to be made and is charged into the melting furnace.

The molten heat is decarburization refined in a vacuum or pseudo-vacuum process like VOD (vacuum oxygen decarburization) or AOD (argon oxygen decarburization), and is then finish refined (reduced, deoxidized and desulfurized) and adjusted as to composition using reducing agents. Carbon, lead, tin, and zinc are gasified and removed. Sulfur is incorporated into the slag and discharged. Impurities are not completely removed, but the composition of stainless steel is designed to take account of the impurities that are contained. The scrap of SUS 301L for railroad cars, for example, can be regenerated to SUS 301L for the same railroad car application or to SUS 304 for the kitchen application.

5. Recycle of Railroad Car Body Shell

Tokyu Car Corporation introduced technology from Budd Corporation of the United States and delivered Japan's first all-stainless steel cars to Tokyu Corporation in 1962. Stainless steel cars were then adopted by Nankai Electric Railway and Keio Electric Railway and by Japanese National Railways (JNR) in 1985, and became the mainstream of suburban commuter train cars. As shown in **Fig. 4**, the total number of stainless steel cars manufactured in Japan is estimated to have exceeded 12,000 in 1998. As shown in **Fig. 5**, almost a half of the railroad cars produced in recent years are stainless steel cars.

Stainless steel cars corrode little and need no painting, so that their life cycle cost, including maintenance, is evaluated to be the lowest. In fact, Japan's first stainless steel car is still running satisfactorily. Its life cycle cost is not yet confirmed as a result.

The 3000 series operating on the Inogashira Line of Keio Electric Railway are stainless steel cars in production since 1962. To increase the transport capacity, present 18-m long cars with three doors per side are being replaced by 20-m long cars with four doors per side. The replaced cars are re-utilized by other electric railway companies to the maximum possible extent. An intermediate car was left out of a train set and was about to be discarded. Taking this opportunity, we verified whether or not the car would be difficult to demolish, cut and separate in cooperation with Tokyu Car Corporation, and produced a video tape for the publicity of stainless steel recycle.

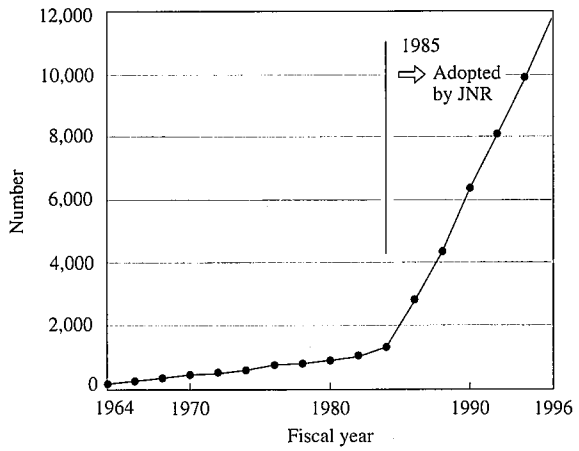

Fig. 4 Number of stainless steel railroad cars produced in Japan

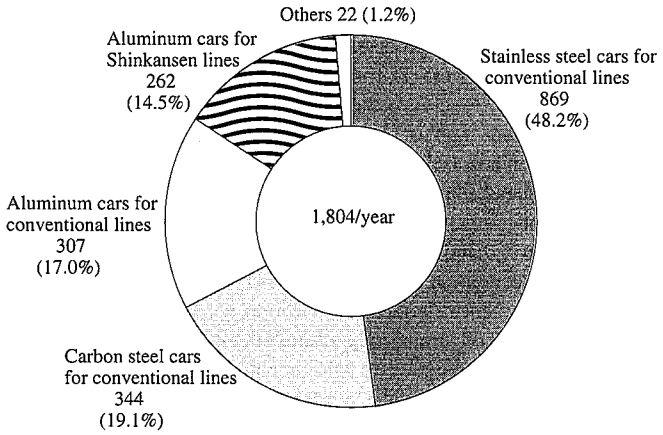

Fig. 5 Number of railroad cars produced by type of material in Japan (average data from 1993 to 1997)

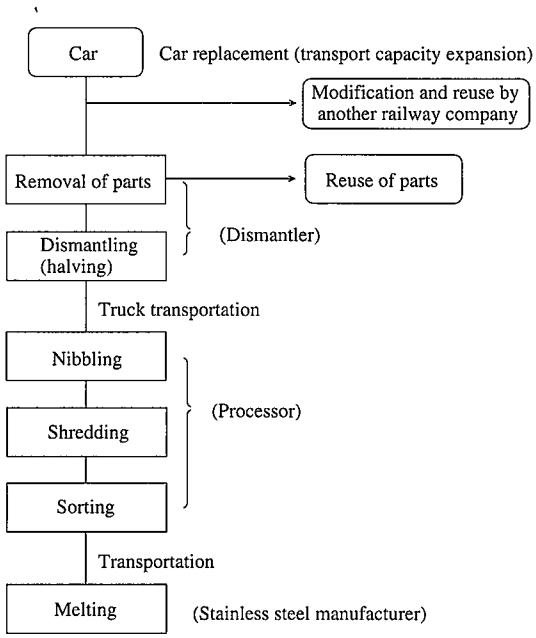

Fig. 6 Car recycle task flow

Fig. 6 shows the flow of the car recycle tasks. The dismantler removes reusable parts from the car with a plasma cutter or the like, and divides the car body shell into two. This was the first work of its kind for the dismantler, but was completed in a half day. The car body shell halves (see **Photo 1**) were carried by truck to the processor, divided by a nibbler (see **Photo 2**), shredded, and separated. The separation flow on the shredder line is shown in **Fig. 7**. Plastics and other dust are sucked by vacuum, and metals are separated by magnets into magnetic and nonmagnetic portions. Nonmagnetic metals are put in a liquid of appropriate specific gravity and separated according to their difference in specific gravity. Of course, this method does not ensure an accurate separation and recovers pieces of stainless steel scrap with paint deposits. Since stainless steel scrap goes through melting and refining processes including impurities, this degree of separation accuracy is practically acceptable.

Based on these dismantling and processing results, the recycle

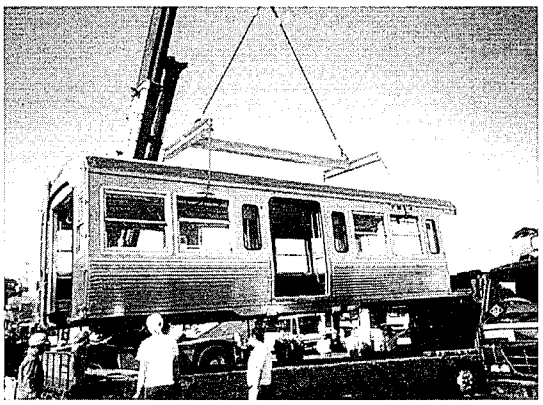

Photo 1 Removal of parts and division of car body shell into two

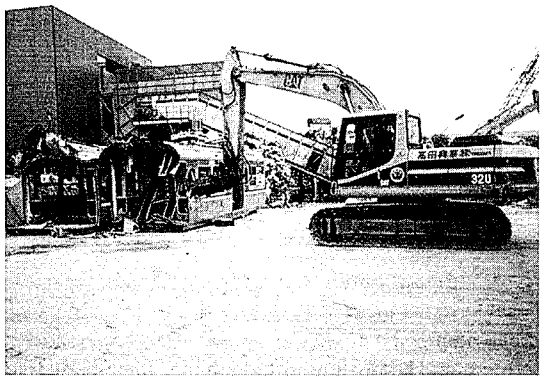

Photo 2 Nibbling of car body shell

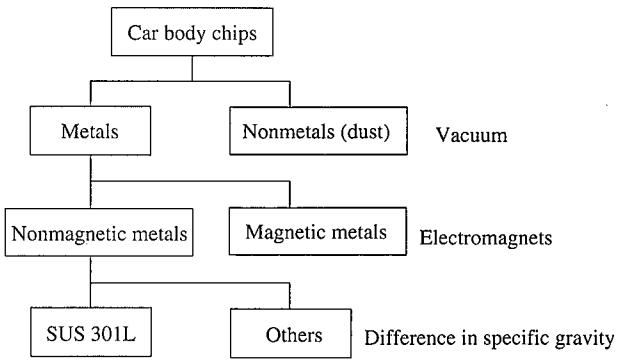

Fig. 7 Material separation flow after shredder

cost (= dismantling cost – scrap value) was calculated by Tokyu Car Corporation. The recycle cost of stainless steel cars is compared with that of railroad cars made of other materials in **Fig. 8**. Since the aluminum car has different aluminum alloys used in different parts, its dismantling and separating cost increases if the scrap value is sought. Since the stainless steel car is mostly built of SUS 301L, there is no need to separate the scrap into grades. The scrap value is so high that the dismantling cost is offset by the income from the sale of the scrap, making the recycle cost almost zero. As a result, stainless steel was confirmed to be superior in the economics of recycle.

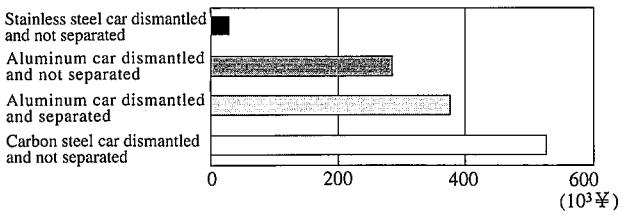

Fig. 8 Recycle cost (Source: Uchida and Matsuoka, Technical Report of Tokyu Car Corporation)

6. Conclusions

No methods are established yet for evaluating stainless steel from the large viewpoint of contribution to global environmental protection. The survey reported here has confirmed the recycle advantage of stainless steel in the railroad car sector.

The video prepared for introducing the recycle of stainless steel cars was awarded a recommendation prize by the selection committee of the Japan Stainless Steel Association (JSSA). Formerly, stainless steel products and structures were only selected for JSSA prizes. The fact that the video was awarded the JSSA prize means that its publicity of stainless steel recycle is evaluated to be effective in increasing the demand for stainless steel.

If those concerned agree, stainless steel may be evaluated some day as to the impact on the global environment of the energy, and interleaving paper, rolling oil and other materials consumed in the entire stainless steel production process from rolling through annealing to shipping. When compared with carbon steel, stainless steel is low in production efficiency and high in material consumption. That is, the manufacture of stainless steel consumes larger amounts of energy and materials than that of carbon steel. Given the long life imparted by high corrosion resistance, however, stainless steel will be more highly rated for its life-cycle contribution to the global environment.