Recycling Technologies for Promoting Recycling-oriented Society

Hirohisa Hotta*

* General Manager, Planning & Administration Dept., Recycle Business Center

NKK has developed a number of recycling technologies to recycle wastes as raw materials in iron and steel making processes. In response to the enactment of a series of recycling laws since 2000, NKK started new businesses of recycling waste plastics, used home electrical appliances, and waste PET bottles. Further, R&D on recycling construction and demolition debris and used motor vehicles is ongoing. This paper outlines the new businesses and technologies NKK has developed for recycling resources.

1. Introduction

Alongside efforts to prevent global warming by reduc-

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2.2 Recycling of waste plastics

2.2.1 Recycling as blast furnace feed material (chemical recycling)

(1) Treatment of industrial waste plastics at Ohgishima

In an ironmaking blast furnace, coke is gasified into CO, and used for reducing iron ore (oxidized iron) into iron.

2.2.2 Recycling of waste PET bottles

Based on the Containers and Packaging Recycling Law, several companies have already started the business of recycling waste PET bottles since 1997. PET bottles are widely used as containers for soft drinks, soy sauce, and alcoholic drinks. Domestic consumption of PET bottles in Japan is increasing each year and reached almost 400000 tons in 2001, of which about 170000 tons were collected by municipalities. The current collection ratio is 44%, far surpassing the 1997 ratio of 10%, and is expected to increase further in future.

The NKK Group constructed a waste PET bottles recycling plant with an annual capacity of 10000 tons at the Mizue area of Keihin Works, and commenced operations in April 2002.

The process flow of treating waste PET bottles at this plant is shown in **Fig.4**. This plant processes transparent waste PET bottles into PET resin flakes. Waste PET bottles collected by municipalities contain colored bottles, caps, and labels. The most important issue in this operation is how to remove these foreign objects efficiently and accurately. This plant employs a combination of mechanical sorting, manual sorting, automatic bottle sorting, and label and cap separation. The separated foreign objects are sent to the adjacent plant that recycles waste plastics into blast furnace feed material.

This plant recycles waste PET bottles into useful resources while generating almost no other wastes, thanks to its advantageous location in the steelworks.

In the past, recycled PET flakes were mainly used for

2.2.3 Waste containers and packaging pretreatment by PFI

The Containers and Packaging Recycling Law obligates

After used appliances are manually dismantled and major component parts removed, the remaining parts are charged into the crusher and then mechanically sorted. Heat-insulating urethane in refrigerators is separated by wind sorting, compressed, and used as blast furnace feed material. Heat-insulating urethane contains fluorocarbon used as a foaming agent. In this plant, fluorocarbon released from the crushing and compressing processes is adsorbed by activated carbon in the foaming-agent recovery device, thus avoiding further damage to the ozone layer and global warming. Iron and nonferrous metals are recovered by the magnetic sorting machine and nonferrous sorting machine respectively, and used as iron and steel making materials.

A feature of this appliances recycling plant is that most of the recovered materials are effectively used in adjacent iron and steel making facilities. Its unique advantage is that the recovered plastics, which account for nearly 30% of home electrical appliances, are directly used in the blast furnace waste plastic feeding operation. As a result, the recycling ratio at this plant currently exceeds 80%. R&D is continuing, aiming at raising this recycling ratio to more than 90%.

3. Future recycling technologies toward establishing a recycling-oriented society

3.1 Expansion and upgrading of blast furnace feed technology

3.1.1 Blast furnace feeding of PVC by removing chlorine

paddles. The thermally decomposed substance can be fed into a blast furnace after being cooled and granulated. Hydrochloride is generated at a comparatively low concentration, and will be treated by neutralization.

When the plastic is solely composed of PVCs or contains more than 50%, the thermally decomposed substance does not have sufficient fluidity and so thermal decomposition needs to be carried out in an externally heated rotary kiln while agitating and mixing with a certain medium. The thermally decomposed substance will be fed into a blast furnace after being cooled and pulverized. A candidate medium is powder coke used as a material in a steelworks. Powder coke is used to prevent thermally decom-

In order to solve the problem, NKK has developed an innovative system for recycling shredder dust as shown in **Fig.8**. In this process, shredder dust is quickly separated into plastics, metals, and inorganic substances by dissolving it in a coal-tar-based heat medium bath heated to around 300°C.

Plastics such as polyethylene and polypropylene float up to the surface of the heat medium bath. They are recovered, granulated into designated sizes, and used as a reducing agent in a blast furnace. PVCs and halogen-containing plastics are thermally decomposed, and their halogen contents are removed. The decomposed substances also float up to the surface, are recovered, and used as a reducing agent. Urethane is degassed by thermal decomposition, compressed, and used as a reducing agent as well.

On the other hand, iron and copper sink to the bottom of the bath along with glass and sand, and are recovered as deposit, from which iron and copper are separated for use as recycled resources for iron and steel making and other purposes.

The heat medium method is expected to boost the motor vehicle recycling ratio to more than 95%.

3.3 Recycling of construction and demolition debris and used motor vehicles

As stated before, R&D on using construction waste wood as blast furnace feed material is ongoing. In addition, the gasifying and melting furnace is expected to play an important role in recycling construction and demolition debris. This type of furnace can turn the non-combustible components in the construction and demolition debris into molten slag and metal, and combustible components into gaseous fuel.

Yet another new law, the Motor Vehicles Recycling Law, is planned to be enacted in 2004. The Law requires that the motor vehicle recycling ratio be raised to 95% and the ratio of shredder dust disposed of by landfilling be reduced to less than 1/5 by 2015. This goal cannot be achieved without widespread application of the gasifying and melting furnace and heat medium method, and so expectations are high for the gasifying and melting furnace.

4. Conclusion

NKK's business development and R&D activities on resource recycling were outlined. NKK's recycling businesses are making the best use of the advantage of its steel works located in the urban area where huge amounts of industrial and municipal wastes are generated, thus providing the urban steelworks with new social value. Existing facilities are being effectively used to turn wastes into

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Fig.8 Heat medium bath for treating shredder dust