UDC 628.4:629.012.5

Waste Tire Recycle and Its Collection System

Yasuyuki NAKAO*1 Kunihiro YAMAMOTO*1

Abstract

It is the most important problem for the continual expansion of the Japanese economy that we abandon the type of economy based on large-scale production, consumption and waste and that we construct for our economy a circulatory system comprising the theme of 3Rs (namely, reduce, reuse and recycle). Nippon Steel Corporation Hirohata Works is playing a part through using 6% of waste tires that are discarded all across Japan. This paper discusses waste tire recycling and a system for their collection.

1. Introduction

With the diversification of economic activities and consumers' daily lives in recent years, an increase in the amount of wastes discharged has become a serious global environmental issue. With the intention of preserving the living environment, the Japanese government has also been taking necessary measures, for example, to revise the Waste Disposal Law so that waste can be controlled and recycled and that the appropriate disposal can be promoted.

In this context, the Hirohata Ironworks of the Nippon Steel Corporation has been using cut waste tires amounting to a little over 5,000 tons monthly for its SMP (Scrap Melting Process) as a substitute for part of the coal and iron scraps since 1999. More concretely, when cut waste tires are charged into the SMP, the steel cords contained in the tires are melted and recycled into steel, while the carbon contained in the rubber is utilized as a component of melt pig iron. Furthermore, those tires burnt as a substitute for coal are utilized as a heat source for melting along with the use of a hydrogen-rich gas that evolved as an energy source in the ironworks.

This paper introduces waste tire recycling and the collection system thereof.

2. How waste tires are released

The domestic production of tires rapidly increased in parallel with full-fledged motorization in the 1960's, and sharply from 64 million in 1960 to 124 million in 1970. Even in terms of the number of tires for replacement, a substantial increase was observed from 22 million in 1960 to 41 million in 1970.

The number of waste tires released, however, also increased from 0.36 million tons in 1970 to over 1 million tons in 1997, posing a serious problem related to the preservation of the environment (**Fig. 1**). This has prompted a social need for waste tire recycling.

3. Physical properties of a tire

As **Fig. 2** shows, a tire is composed of a rubber portion, a belt, a carcass, and bead wires. As **Table 1** shows, rubber accounts for about 50%, carbon black, about 25%, steel, about 15%, and other blend-

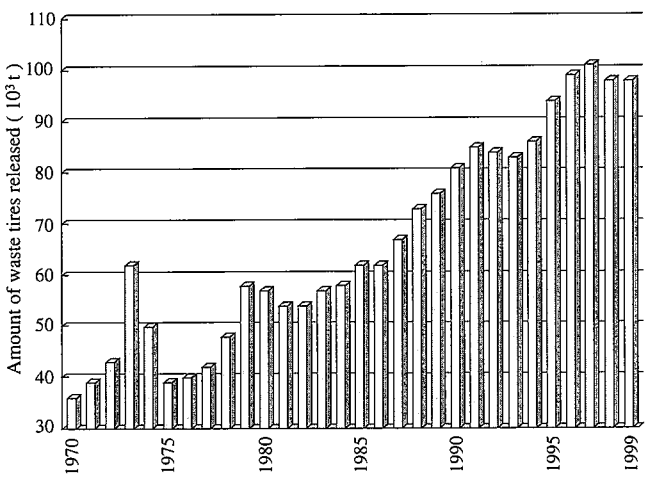

Fig. 1 Transition of the amounts of waste tires

*1 Hirohata Works

Table 1 Tire components (wt %)

	TB Bias	TB radial	PC bias	PC radial	Radial tire for lightweight trucks	Radial tire for lightweight automobiles
Rubber	40 - 55	40 - 50	30 - 55	35 - 55	40 - 50	35 - 55
Carbon	15 - 30	15 - 30	20 - 35	20 - 30	22 - 30	20 - 30
Sulfur	0.5 - 1.5	0.5 - 1.5	0.5 - 1.5	0.5 - 3	0.5 - 1.5	1 - 3
Softener (petroleum oil, etc.)	2 - 10	1 - 5	7 - 20	3 - 12	2 - 11	2 - 12
Zinc oxide	1 - 2.5	0.5 - 2.6	1 - 1.5	1 - 4	1 - 2	1 - 4
Curing auxiliaries and others	2 - 13	3 - 10	2 - 8	1 - 7	1 - 7	1 - 7
Fiber (Nylon, polyester)	7 - 15	0 - 4	5 - 18	2 - 10	2 - 10	2 - 8
Steel	3 - 10	15 - 40	2 - 10	5 - 16	5 - 17	5 - 16

	For two-wheeled motor vehicles	For scooters	No-puncture tire	Construction vehicle tire		Flap
				Bias	Radial	
Rubber	30 - 50	35 - 55	45 - 60	40 - 55	40 - 55	35 - 55
Carbon	25 - 35	25 - 35	10 - 30	20 - 30	20 - 30	20 - 35
Sulfur	0.5 - 1.5	0.5 - 1.5	0.5 - 2	0.5 - 2	0.5 - 2	0.5 - 1
Softener (petroleum oil, etc.)	7 - 22	6 - 22	3 - 10	2 - 20	0 - 10	8 - 24
Zinc oxide	1 - 2	0.5 - 1.5	1 - 2.5	1 - 3	1 - 3	1 - 2
Curing auxiliaries and other	1 - 5	1.5 - 5	1 - 25	2 - 16	2 - 16	1 - 15
Fiber (Nylon, polyester)	5 - 11	3 - 10	0 - 15	5 - 25	0 - 20	0 - 2
Steel	3 - 12	2 - 6	3 - 10	0 - 5	0 - 30	0

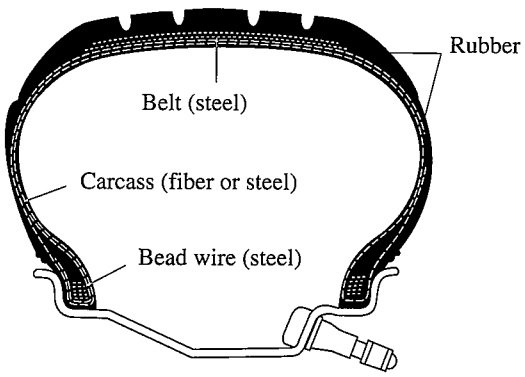

Fig. 2 Tire composition

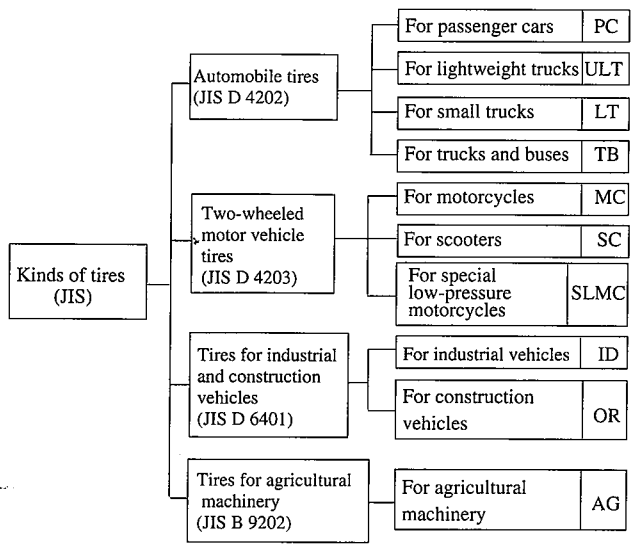

Fig. 3 Kinds of tires

ing, about 10% in terms of the composition of the weight of the raw materials. Since the raw materials of a tire depend about 60% on petroleum, it is a great task to recycle waste tires to the society as a valuable resource, particularly domestically with scanty resources.

As **Fig. 3** shows, the tires are mostly used for PC (passenger cars), LT (lightweight trucks), and TB (trucks and buses). As **Table 2** also shows, respective fundamental weight units (weight per tire) differ greatly: 7 to 8 kg for PC against 30 to 50 kg for TB.

A tire is characterized by its reuse in the end as a high-calorie heat source even after it has seen service and has been recycled. When a tire burns, it evolves large amounts of energy, large enough to be used as a substitute for fossil fuel. Therefore, tires have long been used as fuel. **Table 3** compares heat values of tires with those for fossil fuels.

Table 2 Basic weight units by tires

Kind	Size, construction, etc.	Basic weight unit (kg)
For truck and bus	Bias	37.0
	Radial	45.0
For small truck	Over 7.50 to 16 equivalent	16.0
	Under 7.50 to 16 equivalent	9.0
	Total	12.5
For lightweight trucks		5.1
For passenger cars		7.4
For lightweight passenger cars		4.3
For construction vehicles		102.5
For industrial vehicles		8.3
For agricultural machinery		5.0
For two-wheeled motor vehicles		1.5

Table 3 Comparison of heat value

	Heat value (kcal/kg)	Index
Heavy oil C	9,200	100
Petroleum	6,000	65
Radial tire for passenger cars	8,100	88
Radial tire for trucks and buses	7,500	82

4. How waste tires are recycled

Fig. 4 shows how waste tires were utilized for respective applications in 1999. About 50% of the total is for thermal recycling with about 20% each for reuse and material recycling. The rate of recycling in 1999 (except for the unknown) is 88%, equivalent to 860 thousand tons in weight.

The end users of the recycled waste tires, except for those reclaimed, are mostly cement and paper manufacturers with 31% and 20% for cement and paper industries, respectively. However, the problems related to the product standards and the disposal of residue in each industry limit the amount to be used. In other words, the presence of iron and zinc in the product and the residue is said to be responsible for limited use. On the other hand, based on the findings of the trial calculation of the rate of material recycling by the corporation Japan Automobile Tires Association, that for the cement factories is 21% against 45% for that of the SMP .

5. How waste tires are collected

5.1 Outline of the waste tires collection system

In the case of waste tires directed to recycling, the amount one business establishment could use so far fell mostly below 1,000 tons/month because of the foregoing reason. This means that the amount of 5,000 tons/month, used by Hirohata Works, can be considered the largest figure one business establishment can use throughout the country. **Fig. 5** shows a flowchart for collecting waste tires for recycling. Waste tires released from general consumers or tires selling shops, truck, bus, and taxi companies or automobiles dismantling companies are turned to material recycling, thermal recycling, and reuse through collection companies and intermediate processing companies.

When waste tires are recycled, they are used as is, in most cases. However, they are generally cut for ease of transport and handling

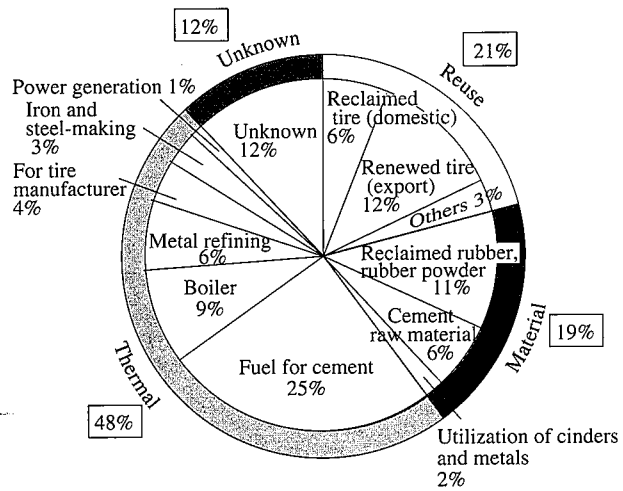

Fig. 4 Ratios of recycling by applications

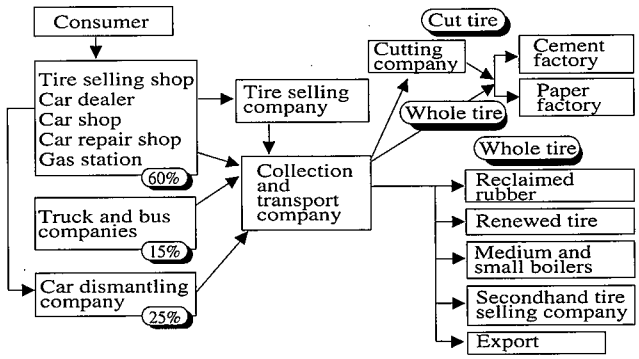

Fig. 5 Flowchart of recycling waste tires

and for sanitary reasons, as well. This also applies to Hirohata Works. **Figs. 6** and **7** show a tire cutter and cut tire pieces, respectively.

In the case of cut tires, one cutting company is capable of cutting 100 tons/month at best. This means that some 50 cutting companies are required to meet 5,000 tons. It therefore becomes necessary to expand areas for collection if it is expected to satisfy this amount with any stability. Through the cooperation of the corporation Japan Automobile Tires Association, a system was structured, on a trial-and-error basis, by which cut tires in the quantities required could be collected from all over the coun. This has the stable collecting thereof by overland transportation from neighboring areas along with marine transportation at a unit of 1,000 tons/ship, a volume scale-merited. **Table 4** shows the ratios of collection by areas.

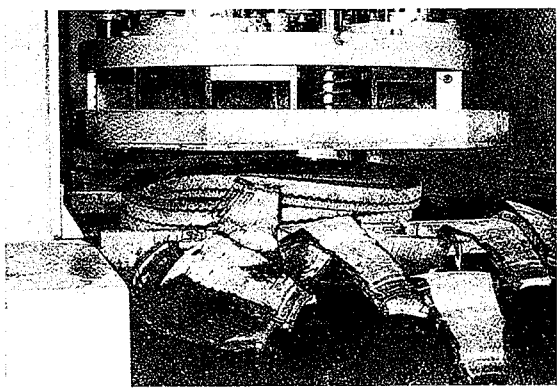

Fig. 6 Tire cutter

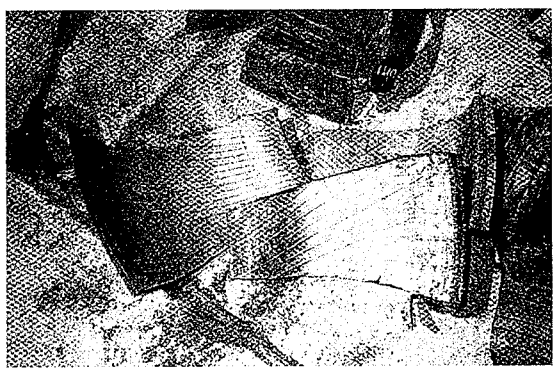

Fig. 7 Cut tire pieces

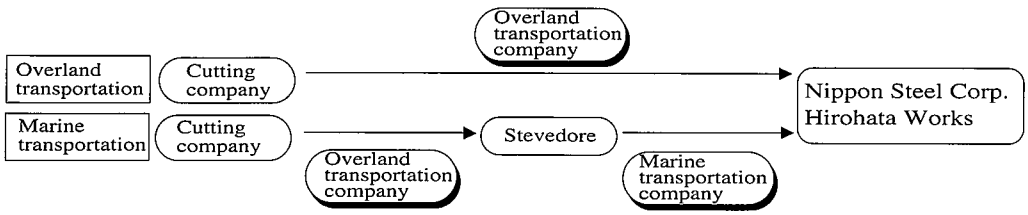

Fig. 8 Flowchart of recycling cut tires

Table 4 Ratios of collection by areas

	Marine transportation	Overland transportation	Total
Hokkaido	4%	0%	4%
Kanto	21%	1%	22%
Chubu	20%	7%	26%
Kinki	0%	33%	33%
Chugoku, Shikoku	0%	14%	14%
Total	44%	56%	100%

5.2 How cut tires are transported

The following describes in detail how cut tires are transported (**Fig. 8**).

Waste tires discarded from general consumers or tire selling shops, truck, bus, and taxi companies or automobile dismantling companies are collected by collection-and-transport companies, which in turn bring them to tire cutting companies, where they are cut and delivered directly to final disposal companies when handled by overland transportation, and to harbor yards when marine transportation is used. In both cases, tires are delivered aboard the company's own or licensed, hired vehicles. With regard to marine transportation, the goods are transported by ships registered by shipping companies licensed to transport.

5.3 Characteristics of overland and marine transportation

5.3.1 Overland transportation

A transportation lot is 10 tons/car at most, even when a large trailer truck is used because of a bulk density of 0.3 to 0.5 even when tires are cut. Accordingly, 200 trucks are required monthly to transport 2,000 tons overland. If goods are accepted only on weekdays, 10 large trailer trucks should be used regularly. Due consideration should therefore be given to stable delivery.

5.3.2 Marine transportation

When loading the goods onto a mother ship, it is necessary to leave them temporarily at a harbor stockyard, where they are divided into 500-ton lots, respectively and are enclosed by blocks in accordance with the Fire Services Act. In some harbors, the goods are covered with vinyl sheets. The ship is mostly of type 499 (for loading 1,000 to 1,200 tons) for bulk cargoes. Grab buckets are used for handling the goods.

Marine transportation is very advantageous for mass transportation, but disadvantageous partly because of the necessity of securing a receiving yard. Attention should be paid for securing receiving yards and shipping schedules.

6. Conclusion

The greatest task for us to sustain the growth of our economy in the 21st century is to discover how to emerge from an economy that has been dominated by mass production, mass consumption, and mass disposal since the middle of the 20th century. In other words, it is urgently required to "structure a recycling-oriented society".

Under the circumstances, Hirohata Works of Nippon Steel Corporation, where a system of collecting goods from all over the country has been established, can be considered to be responding to the social need of utilizing a large quantity of waste tires effectively. In the future as well, we will promote the utilization of recycled goods in terms of the use of low-cost fuel.

Reference

1) The Japan Automobile Tire Manufacturers Association, Inc.: Tire Recycling Handbook