DISPOSITION AND RECYCLING OF PLASTIC PRODUCTS INCLUDING USED NETS

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ABSTRACT

Disposition and recycling technologies of various plastic wastes are reviewed. The technologies employed vary by material and type of waste.

Case studies were carried out at Akkeshi and Wakkanai ports in Hokkaido, which are major base ports of Japanese salmon fishing vessels. Some used nets are recycled into nylon pellets; others are incinerated or landfilled.

BACKGROUND

Recycling technologies in Japan have been developed because Japan is poor in some natural resources. Japan must import most raw materials needed to produce industrial goods, and there exists national recognition of the necessity to make the utmost of raw materials through recycling and other means.

Japan is also a small and densely populated country. It is not easy to find places for waste disposal, and the environment tends to be susceptible to damage from waste disposal practices. Thus, Japan finds it necessary to develop effective recycling technologies. To date, effective recycling technologies have been developed mostly by small- and medium-scale enterprises, rather than by public research institutes. Thus, these enterprises tend to be small in scale and of great variety.

There are two principal methods of recycling used fishing nets--pelletization and reutilization. Both methods have problems. Pelletization as a recycling business requires profit stabilization, while reutilization of nets requires further development of recycling methods in order to increase demand.

PLASTIC CONSUMPTION IN JAPAN

The output of primary products of plastics in Japan reached 4.77 million tons (MT) in 1987, an increase of about 12% over the 4-year period

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from 1984. Responsible for this increased production is the continuous development of new plastic products, progressive development of synthetic technologies of resins, and the easy-to-process nature and low prices of plastics.

The lifespan of plastic products from marketing to disposal varies according to the resins and their products. The life of packaging materials and disposable containers, which together account for some 40% of plastic products, averages 1 to 2 years; on the other hand, sundry goods for household use and toys last for 3 to 5 years. As a result, 55% of plastic products are discarded within 5 years after their production. Pipes and other plastic products used in construction last for more than 10 years, but they account for only 20% of the total.

The most notable characteristics of plastic products are durability and low prices. The low prices, however, have brought about the "throw-away" practice; thus, the useful life of the products themselves is much shorter than that of plastic as a substance. The present problem is that the disposal of plastic is difficult, the difficulty stemming from its high durability.

CASE STUDIES OF RECYCLING WASTE PLASTICS

Introduced here are some Japanese technologies for recycling waste plastics. In recycling waste plastics, effective classification and separation of various plastics are essential to maintain good quality of recycled products and to lower production costs.

Plastic products are being used in almost every field, often in combination with wood, steel, or other materials. As a result, discarded plastics are mixed in with other waste material. Moreover, even if plastics are grouped by kinds at the time of refuse collection, they are usually covered with dust, earth, or sand, in which case additional processing is required.

Various techniques for classifying municipal refuse have been developed. They include techniques developed under the "Stardust '80 Project" conducted by the Agency of Industrial Science and Technology of the Ministry of International Trade and Industry in 1972-82 with the aim of turning such refuse into new resources.

There are two ways to recycle waste plastics--one is using it in new plastic products and the other is reducing the plastic as a material. Although in both cases quality control is a difficult task, this has developed into a new business in which 88 companies are already engaged throughout Japan. Recycled plastic products include manhole covers, piles, and flowerpots. The Ministry of International Trade and Industry has established the Japan Industrial Standard as guidelines for uses and quality control of such recycled products.

The pyrolytical method converts organic substances of high molecular weight into those of low molecular weight by use of heat energy. Suitable

substances for this process are waste plastics, used tires, and waste oils. As opposed to incineration, pyrolysis needs not only strictly controlled operations, but must also meet two conditions:

- Waste plastics as materials must be even in quality and available steadily and in large quantity.
- A reliable supply system of recycled products like oil and gas must be established.

TECHNOLOGY FOR SORTING MUNICIPAL WASTES (STARDUST '80 PROJECT)

This system is designed to sort municipal refuse into two or three groups by applying both the pulverizing and sorting processes simultaneously. These processes utilize the principle that different materials can be crushed into different sizes in accordance with their resistance to shock, compression, and shearing stress.

One such group is composed of kitchen garbage, fragile paper, and other goods which can be easily reduced to small pieces and passed though small screen holes. Another group is made up of plastics, metals, fibers, stronger paper products (cardboard paper and laminated paper), and other things which cannot be broken easily and are extracted from the machine almost in their original sizes. When compared with conventional pulverizing machines, this system has the following advantages:

- Pulverization and sorting are possible in one process with a small amount of power.
- As metals, plastics, and other items can be selectively broken almost in their original forms, the system faces less wear and therefore entails lower maintenance costs.
- Owing to its slow speed, the device produces less noise, vibration, and dust.
- A special anticoiling device prevents long objects from wrapping around the rotating shaft.
- It is possible to easily discharge overloading objects such as metal blocks, bulk waste, etc., out of the system through adjustment of its rotating speed.

TECHNOLOGY FOR SORTING AGRICULTURAL FILM

This system is capable of sorting and utilizing soil-smeared agricultural films without resorting to a washing process.

Films are first roughly crushed (about 40 mm) and then sent to a heavy, oil-fired stirring dryer where the material is dried with 110°C hot air. Soil and sand are loosened from the films and discharged from the

screen at the bottom of the drying chamber. Iron elements are eliminated by the use of magnets. The films are further crushed and once again dried (air drying) so that their quality is improved. After this, iron pieces are again removed by magnet and the films recovered in the form of fluff.

Recovery costs, excluding those of pelletization, amount to about ¥37.5/kg.

TECHNOLOGY FOR RECYCLING FOAMED STYROL FISH BOXES

Foamed styrol is used to make fish boxes and package cushioning, the latter used extensively in business offices and households.

Fish boxes are first used in fishing ports and later accumulated in markets and retail stores. Of the fish boxes handled in central wholesale markets throughout Japan in 1979, 42% were incinerated and about 22% were recycled.

Fish boxes to be recycled must be relatively clean. After being cut, they are heated and melted at 270°-280°C and molded into blocks weighing 8 kg each. These plastic blocks are exported through chemical companies to Southeast Asia, where they are used as raw materials for toys and re-exported to Japan, the United States, and elsewhere.

Such boxes were initially sold at ¥25/kg but their current price is ¥5/kg; the decline resulting from the price competition with virgin materials produced at low cost reflecting the current stagnant oil prices.

RECYCLING WASTE PLASTICS INTO ARTIFICIAL FISH REEFS

In Japan, the establishment of artificial habitats for fish has been promoted under a long-term national project designed to increase fish resources along the coasts.

Man-made waste plastics fish reefs are made of recycled polyethylene, polypropylene, and other polyolefin plastics derived from the plastic films used for packaging foods and other purposes.

In order to strengthen artificial fish reefs, various measures are taken, such as mixing ferro-oxide into the melted plastic to substantially increase density and building structural-use steel pipes into props. Between 1972 and 1988, a total of 250,000 m^3 of fish reefs weighing about 18,000 MT, were installed on the seabeds around the Japanese coasts. These artificial reefs have the following characteristics:

- There is no limit to their durability.
- As they are made of assembling units, it is easy to adjust their shapes and sizes.
- Easy to assemble, the time needed for installation is short.

- As they do not exude alkali elements, a variety of seaweed and shellfish can safely attach to the artificial reef.

TECHNOLOGY FOR RECYCLING FISHING BOATS OF FIBER-REINFORCED PLASTICS

About 1965, fiber-reinforced plastics (FRP) began to be used for building fishing boats. Easy to mold, lightweight, durable, and economical, FRP fishing boats have been used widely in the coastal fisheries. In Japan the number of powered FRP boats reached 290,000 in 1984. The earliest of these vessels have reached "retirement age," and safe disposal is now a major problem.

In 1985 and 1986, the Fisheries Agency developed an FRP boat disposal system. The disposal procedure is discussed below.

Chosen for the experiment was an FRP vessel from the set net fishery; the vessel weighed 3.42 MT and measured 9.86 × 2.6 × 0.59 m. The vessel was first crushed by a hammer crusher into 10 to 20 cm^3 pieces. These pieces were carbonized in a batch-type pyrolysis incinerator which measured 3.4 cm^3. Waste tires were used as fuel for the carbonization process.

The plastics decomposed in the pyrolysis were gasified and recovered in the form of oils, which were further separated into water, tar, pitch, and waxes and stored as reprocessed oils. Glass fiber residue was burned in the pyrolysis furnace.

Recovered were the following substances:

- Oils--For reasons of smell, low calories, and irregular viscosity, the recovered oils were traded as products below C-class fuel oil (heavy oil).

- Glass fibers--Recovered glass fibers were utilized as composite plastics for compound plastics called AMC or FMC. Pending further research, they may be usable as molded products for automobiles. Their utilization as powdered glass may also be possible.

- Carbons--They are a mixture of products from FRP and waste tires. It is possible to market those sifted through an 80-mesh screen.

TECHNOLOGIES FOR RECYCLING AND INCINERATING USED FISHING NETS

Used fishing nets can be utilized in their original form for applications other than fishing or they can be reprocessed into basic material and used to produce other things.

Recycling of Used Fishing Nets in Their Original Forms

There is a wide range of purposes for used fishing nets other than fishing. These include:

Collection of Planktonic Larvae of Scallops

When used for catching planktonic larvae of scallops, one-sixth of a unit (about 100 m/unit) of nylon monofilament driftnet used in the salmon fishery is packed in one onion bag. Salmon driftnets are used and not squid driftnets; the latter are unsuitable because they are smeared with squid ink. Scallop fishermen buy used nets from net-weaving companies at a price of about ¥1,600 per unit (including shipping costs) in Hakodate, Hokkaido.

Protection of Trees From Deer

In 1986, in order to protect trees in the training plantation of Kyoto University in Shibecha, Hokkaido, a reforested area within the plantation was surrounded with nets 1.4 m high that had been used previously for salmon fishing. Before such protection, 79% of the 86 trees in the area had been damaged by deer, *Cervus nippon esoensis*. No further damage has been reported since the installation of the nets.

Although such protective nets can be considered effective for preventing deer from harming trees in Hokkaido, this method is costly and labor intensive. In Chiba Prefecture located east of Tokyo, a deer was reported to have died when its antlers became entangled in a net.

Drying Tangle

In Japan, tangle is usually dried on pebbles after it is gathered from the sea. In some regions, trawl nets are used instead as drying racks.

Antibird Nets at Garbage Collection Sites

In Wakkanai, Hokkaido, used trawl nets cut into 2-m squares are spread over garbage cans at community garbage collection sites so that crows cannot scatter the garbage.

Reprocessing of Used Fishing Nets

Since 1988, three factories (two in Akkeshi and one in Hakodate) have been in operation pelletizing used nylon monofilament salmon and squid driftnets. The companies collect nets from various ports in Hokkaido. The pelletizing process is similar at all the companies and total production is an estimated 700 MT a year. The pellets are sold to chemical companies at a price of about ¥210/kg (1988) for the manufacture of electrical equipment for automobiles, bicycle saddles, electric fans, and other kinds of goods. When compared to virgin pellets, however, the tensile strength of recycled pellets is reported to be weaker by 10%.

One of the problems concerning pelletization lies in the great effort required in washing nets or otherwise removing impurities from them. Trawl nets are more likely to retain soil and trash at their webbings due to the method of fishing. As far as we are informed, there is practically no reprocessing of trawl nets at this time, presumably due to the cost of preparation.

Economically, the competitive advantage of reprocessed pellets over virgin pellets is very unstable; the price of the latter being subject to the price of petroleum.

Incineration of Used Fishing Nets

In Japan, as a means of reducing the volume of bulky fishing nets, high heat incineration, which is effective in minimizing harmful substances and ash, has been under study. Under consideration are batch-type pyrolysis furnaces (0.7 to 50 m^3 in size) placed underground and designed to attain complete combustion through use of water-gas reactions.

This furnace is constructed so that combustion may take place using an air intake from above. This also makes it possible to adjust the supply of air so as to prevent unburned soot and dust from being discharged. The chimney flue helps combustion by serving as a secondary furnace.

When burned, plastics generally give off black smoke and, in some cases, harmful gases. No noxious smell or black smoke is produced, however, in this particular type of incinerator, even if used fishing nets, tires, foamed styrol, or lumps of plastics are burned.

RECYCLING OF USED FISHING NETS IN HOKKAIDO

Information regarding recycling of used fishing nets in Hokkaido was obtained from oral surveys conducted among staffs at government offices, fishing operators, net-weaving companies, and other related industries in Akkeshi and Wakkanai in 1988. Akkeshi is one of the five main ports in Hokkaido engaged in medium-sized salmon driftnet fishing operations. It is also known as a port for the squid driftnet fishery. Wakkanai, on the other hand, is a port mainly supporting a trawl fishery.

Akkeshi

Use of Fishing Nets

As of 1987, fishing operators in Akkeshi owned 13 fishing boats authorized for use in salmon and trout fishing with medium-sized driftnets. Six of them were also engaged in driftnet fishing for squid. In addition, 10 other boats from other ports landed their catch at Akkeshi; these vessels were not involved with the disposition of fishing nets.

Medium-sized salmon driftnets in use at Akkeshi mostly measure about 100 m in length. When the salmon and trout fishing season using medium-sized nets comes to an end around July, some nets are used again for squid

catching and then scrapped. Nets aboard boats used exclusively for salmon and trout fishing are transported to net-weaving companies. About 50% of the nets need no repairs and are used again the following season; 30 to 40% of the remaining nets are repaired and used again. About 20% of the salmon and trout fishing nets are scrapped each year, and almost all nets used to catch both salmon and squid are scrapped after the cuttlefish season ends. The lifespan of nets averages from 2.5 to 3 years.

Disposal and Recycling of Fishing Nets

For lack of landfill space and to avoid pollution, Akkeshi Town does not incinerate used fishing nets or discard them in landfills, although it discards foamed plastics like fish boxes as "incombustible refuse." Fishing operators burn their ropes and buoys separately.

In Akkeshi, there are two companies that reprocess nylon monofilament salmon and squid driftnets into pellets. Used nets are either brought to the processors by fishing operators and net-weaving companies or gathered without charge at port collection sites. Nets purchased from net makers and repairmen cost the processors ¥20/kg. It is estimated that about 600 to 900 MT of used nets are collected within and from outside Akkeshi annually. Among them, those unfit for recycling are incinerated by the reprocessors. The rest are melted and pelletized into an estimated 450 MT at the two reprocessing companies. Before 1987, some used fishing nets were exported through trading firms to China and Taiwan to be made into valves and other products. Such exports are not carried out today because of the unfavorable prices of petroleum.

One of the two pellet processors in Akkeshi is capable of producing 1.5 MT a day in a 9-h operation, but such facilities are in operation for only about one-third of the year. The company spent ¥14 million on a washing machine and another ¥13.5 million on a machine for melting and pelletizing plastics, with the total investments estimated to be some ¥60 million, including the land and building. The monthly production of 15 MT of pellets requires ¥740,000, including ¥200,000 for fuel and electricity and ¥520,000 for 100 man-days of labor.

Wakkanai

Use of Fishing Nets

As of 1987, Wakkanai had 19 boats which were allowed to fish in the offshore trawl fishery. On an average there are about 10 fishing nets for each boat; usually 2 or 3 nets are loaded on the boats, and also on board are 1 or 2 nets to be repaired. The remainder of the net supply is stored in warehouses or other locations of the fishing operators or net-weaving companies.

Damaged nets are repaired aboard the fishing boats when the damage is slight. Major repairs are made either in the fishing operators' own net-weaving shops or shops of independent net-weaving companies. Repairs usually become necessary after six or seven fishing operations; repairs

mostly concern the dislocation of rope from net mesh. Net webbing usually lasts for 2 years. Torn webbing is usually not mended, but replaced with a new section of webbing. Fishing operators spend about ¥10 million each year for net-repairing purposes.

Scrapping of Fishing Nets

Scraps of trawl webbing are accumulated during the process of repairing by net-weaving companies and fishing operators. About 15 to 18 MT of scrapped webbing is accumulated by net-weaving companies; the total excludes webbing used for heating purposes during winter. The amount of scrapped webbing accumulated by fishing operators is estimated at 17 MT per year.

Disposal and Recycling of Fishing Nets

Scrapped nets not used for heating or recycling are brought to garbage disposal plants in Wakkanai. An estimated 700 MT of fishing materials are brought to landfills annually, accounting for 1.6% of the municipal total in 1987. Of the 700 MT, nets made up 80% and ropes, 20%.

Some of the scrapped nets are incinerated at establishments of net makers and fishing operators. Here, stoves used as heaters during winter burn nets exclusively (or together with waste oil). This is probably the most popular method of used trawl net recycling practiced in Wakkanai.

Between 1982 and 1987, a producer of animal feed in Wakkanai used scrapped trawl nets as an auxiliary fuel in its coal boiler. To operate the boiler the company burned 30 used 12-MT truck tires every day and burned 2 to 3 MT of scrapped fishing nets every year. The feed producer obtained these nets free of change at net-repairing shops.

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