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At the Frontline of Plastic Recycling

Dyeing, Paper, and Lime Industries in Japan Turn to RPF as an Alternative to Fossil Fuels

Plastic Waste and Used Paper Become Raw Materials for Fuel

A variety of recycling laws are starting to take hold in Japan with the aim of creating a recycling-oriented society. The recycling of plastic waste, for example, is making steady progress, and energy recovery based on a new technology has grabbed the attention of various industries. This new technology is called refuse paper and plastic fuel (RPF).

The use of RPF is a form of energy recovery.It is a fuel provided in solid form using non-reclaimable used paper and plastic waste as raw materials, and it is in high demand from the dying, paper, and lime industries as an alternative to fossil fuels such as coal, coke, and oil. The use of RPF is also receiving high marks from the production industry. The annual demand for RPF has increased from 83,000 tons in 2002 to about 450,000 tons in 2004, a dramatic rise of 5.4 times.

This report explains the difference between RPF and Refuse Derived Fuel (RDF) ,describes how RPF is used, and examines the prospects for supply and demand of RPF in the years to come.

I.Development of Environmentally Conscious RPF in Plastic Recycling

As an alternative to fossil fuels such as coal and coke, RPF has attracted the most attention from the paper-manufacturing industry. The idea here is to reduce manufacturing costs by using RPF instead of coal as boiler fuel, an essential element of paper-manufacturing plants. With RPF, the same calorific value as coal and coke can be obtained at one-third to one-fourth the cost, so it is not surprising that RPF should attract such interest.

Against the above background, Sekishouten Co., Ltd. (Headquarters: Kuki City, Saitama Prefecture, Japan) has been exploring ways of energy recovery the huge volumes of paper products and plastic waste that cannot be used in mechanical recycling. The company has already completed a RPF manufacturing plant as a culmination of several years of study and research, and has secured a stable calorific value by limiting constituent materials to used paper and plastic waste. This, and the fact that Sekishouten's RPF can reduce costs in the production industry, decrease processing expenses of local governments, and extend the life of final disposal sites (landfills), has made RPF all the more appealing.

In contrast, the main constituent of RDF is household trash (combustible trash) collected by local governments. This trash consists of kitchen garbage and some plastics, which makes for high water content and low calorific value compared to that of RPF.

Differences between RPF and RDF

RPF

This is a solid fuel consisting mainly of used paper obtained as a result of sorted-discharge standards, industrial waste such as plastic waste (excluding vinyl chloride products), and domestic waste. Although RPF does not have a long history, it is already known for its stable quality, the ability to control calorific value, and its use as an alternative to coal. It features a calorific value of 5,000 — 10,000 kcal/kg for one type of. energy recovery.

RDF

This is also a solid fuel consisting of trash collected by local governments. It is used mostly as a fuel for generating electricity. Since its main constituent is household trash, its water content is high resulting in a calorific value of 3,000 — 4,000 kcal/kg, which is low compared to RPF.

An explosion at a RDF power-generation plant in Mie Prefecture in the summer of 2003 has led to a call for a more robust RDF management system.

The following table summarizes the main differences between RPF and RDF.

RPF Development Begins with Appearance of Laminated Paper

In the paper-products market, high-strength, high-water-resistant products began to appear about 20 years ago. These products, which employ laminated paper, have been expanding steadily since then, and this expansion brought to mind a question that had been asked in the past about iron products: "Why is it that we have an "arterial" supply industry for iron but no "venous" industry for reusing (collecting) used iron?" It was found that the same issue could be applied to laminated paper, and it was this realization that suggested the development of solid fuel (RPF).

The next 6 or 7 years was spent collecting information both inside and outside Japan, and 1990 saw the establishment of a supply system and the start of RPF manufacturing. The availability of a new solid fuel that could be used as an alternative to coal caught the attention of related industries, and the annual production of RPF has since risen to about 96,000 tons.

Main Differences between RPF and RDF

Fuel Type		RPF	RDF
Sorted-discharge method		Based on sorted discharge performed by private enterprises (following pickup instructions given to source of discharge)	Collection performed by local governments (mixed trash included in sorted collection)
Material properties	Composition	Used paper and plastic waste (mainly industrial waste) excluding vinyl chloride and thermosetting resins that cannot be used for mechanical recycling	Probability of chlorine concentration is high since sorting by households is imperfect (trash, incombustibles, vinyl chloride, etc. become mixed together)
	Water content	Water content of waste discharged by private enterprises (process and distribution systems) and general households is low	Water content is high since garbage from kitchen is included
Product properties	Calorific value (kcal/kg)	5,000—10,000 kcal/kg (can be adjusted by varying paper content)	3,000—4,000 kcal/kg (cannot be adjusted)
	Size	Diameter of 6—50 mm (supports small diameters capable of air transport)	Diameter of 15—50 mm (small diameters are difficult to manufacture)
	Ash content	7% max.	20% max.
Incidental equipment		Ash collector	Ash collector Deodorizer Exhaust-gas processor for desiccator Anti-decay-additive supplier
Applications		Boiler fuel RPF power generator Lime-burning fuel Desiccator fuel	Boiler fuel RDF power generator (use as fuel is limited)

Foundation of Japan RPF Association Centered about Sekishouten

As operations at Sekishouten Co., Ltd. began in earnest, it gradually became known that a practical alternative to coal was available. The need was consequently felt among concerned enterprises for the drafting of specific policies regarding RPF manufacture, sale, raw-material collection, quality control, etc., and the sharing of technical data and other information all with the aim of contributing to the formation of a recycling-oriented society. In response to these needs, the Japan RPF Association was formally established in March 2003 (consisting of 8 companies and 9 plants).

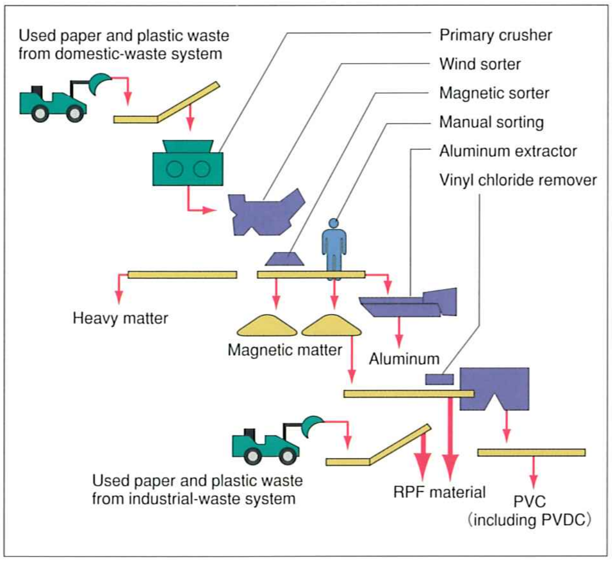
The Japan RPF Association has reported that actual demand for RPF was about 450,000 tons in 2004 and about 685,000 tons in 2005 with demand in 2006 expected to double to about 1,210,000 tons. The annual amount of RPF that can actually be supplied, however, is only about 250,000 tons at present. While annual production could possibly rise to about 500,000 tons in the future under existing conditions, the RPF industry must nevertheless find ways of securing more raw material while increasing manufacturing capacity to meet this growing demand. These are the major issues surrounding the RPF business at present.

80% of RPF Supplied to Paper Companies

Refuse paper and plastic fuel is currently being supplied for use in paper-manufacturing boilers, lime burning, and dyeing boilers. Here, the greatest demand is being generated by paper companies that absorb about 80% of all manufactured RPF. Next in line are the lime industries and dyeing industries that account for 15% and 5%, respectively, of purchased RPF. The chemical industry may also generate some demand in the future.

There are several reasons why RPF is proving to be popular. For one thing, the calorific value of supplied RPF can be set to either 6,000 kcal/kg (that of coal) or 8,000 kcal/kg (that of coke). The solid, high-density form of RPF also makes for ease of use and storage, and RPF emits almost no chlorine gas or dioxins.

Sekishouten Co., Ltd., Ibaraki Plant (Plant No. 2)



RPF Manufacture Flow

RPF products (diameters of 40 mm)

RPF products (diameters of 8 mm)

II. Oji Paper: Using RPF as an Alternative to Fossil Fuels

Environment Charter Promotes the Use of Recyclable Resources

Oji Paper Co., Ltd. (Headquarters: Tokyo, Chuo-ku) and its Tomakomai mill in particular are taking a proactive role in using RPF as an alternative fuel as described below.

Recycled Pulp Makes Up 60% of Newsprint Supplied to Newspaper Companies Throughout the Country

Oji Paper supplies about 30% of all newsprint used by newspaper companies in Japan, and newsprint makes up about 80% of the paper manufactured at the Tomakomai mill, which boasts the largest facility layout and capacity for the manufacture of newsprint for a single plant. Producing newsprint consisting of 60% recycled pulp made from collected used newspapers (a system begun in 1975) and 40% fresh pulp (made from wood chips), this mill is one of the most advanced in the recycling industry.

The Oji Paper Environment Charter was established in 1997. The Basic Concept section of this charter states that Oji Paper is committed to observing environmental regulations and improving the environment, and that corporate activities shall be centered about the "promotion of forest recycling" through the development of tree-planting projects and "promotion of paper recycling" through increased use of used paper. The charter also calls for expanded use of fuels made from plastic waste and used paper difficult to reclaim as paper (RPF) to decrease dependency on energy generated from fossil fuels.

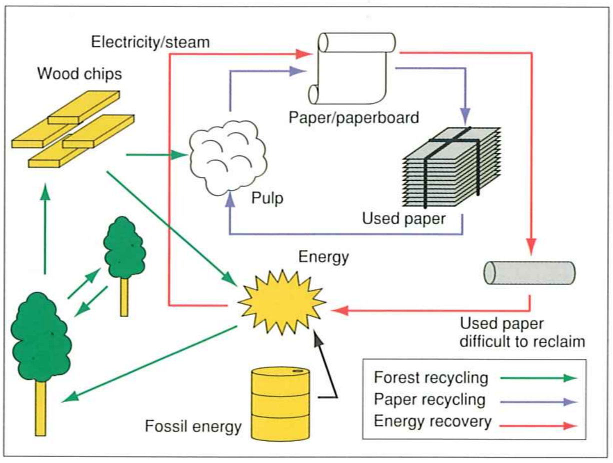
Paper production at the Tomakomai mill (FY2003 status report):

Newsprint: 960,000 tons/year
Medium-/low-grade paper for printing : 199,000 tons/year
Total : 1,159,000 tons/year

What does the "promotion of forest recycling" actually mean? The idea here is to restore ecosystems by tree-planting projects that can regenerate forests in denuded lands wherever they may be. This process involves the selection of trees appropriate for the soil in question (such as broadleafs like eucalyptus and acacia trees and conifers) and the maintaining of a balance between consumption (conversion to pulp) and production (tree planting). In addition, waste fluid generated in the manufacturing of fresh pulp (see explanatory note) can be reused as a fuel (energy recovery) and combined with forest recycling to construct a comprehensive resource-recycling system.

Waste liquid = "black liquor," a black vegetable residue resulting from the extraction of pulp from wood chips. In concentrated form, the organic portion of black liquor is used as fuel in a special (recovery) boiler, and the inorganic portion remaining after combustion is recovered and reused as a chemical for the formation of wood chips into pulp. The calorific value of black liquor is 12.5 — 15.0 MJ/kg (3000 — 3600 kcal/kg).

View of Tomakomai mill



Conceptual Diagram Relating Forests, Paper, and Energy Recovery

Similarly, the "promotion of paper recycling" means the collection of post-use paper and its recycling as paper and paperboard. We note here that "energy recovery of used paper" refers to the collection of used paper that is difficult to reclaim and its use as a heat source (thermal energy), which reduces the use of fossil fuels and the amount of trash to be disposed of.

In contrast to fresh pulp, used paper generates nothing equivalent to "black liquor." As a result, the energy needed for the pulp-formation process here would normally have to come from outside fossil fuels, but the use of RPF can help reduce this dependency.

A plan formulated by Oji Paper calls for the use of new boilers and the promotion of energy-reduction techniques at Tomakomai and three other mills in the Oji Paper Group. For the same amount of produced paper as FY2003, this plan forecasts a 20% reduction in unit fossil energy [amount of fossil energy used) / (amount of paper and paperboard produced)] and unit CO_2 emissions [(amount of CO_2 emitted by use of fossil energy) / (amount of paper and paperboard produced)] by FY2010 relative to 1990.

Adoption of Cogeneration for More Efficient Use of Energy

The paper-pulp industry uses both electricity and large amounts of steam. To raise energy efficiency here, the steam employed for generating electricity can be reused as a heat source for drying paper, for example, in a firmly established process called "cogeneration." Energy efficiency can be raised to about 70% in this way.

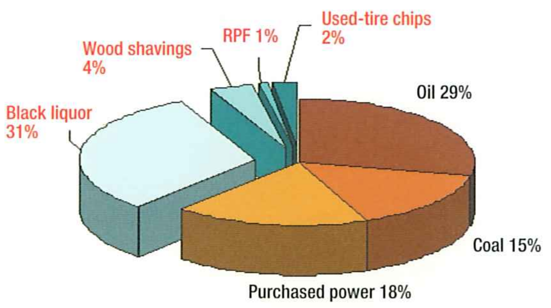
・Cogeneration: As this compound word (co+ generation) implies, a method for extracting several types of energy from one type and using them simultaneously. For example, exhaust heat (steam) used for generating electricity in the paper-pulp industry can subsequently be used as a heat source.

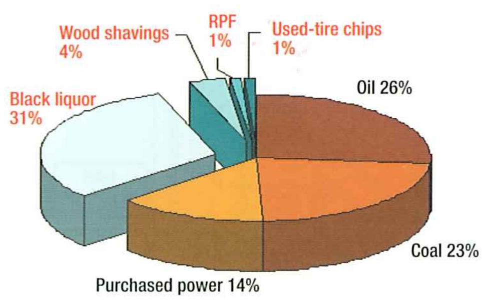
This high efficiency is achieved by cyclic reuse of energy. Here, the high-temperature, high-pressure steam created in a boiler can first be used to turn a turbine generator. It can then be used as a heat source for drying paper and as a means of heating wood chips or pulp in the paper-making process, and it can finally be returned to the boiler to complete the cycle. Furthermore, the electricity generated by the turbine can be used to power paper-manufacturing facilities and incidental equipment in the mill and even office equipment on the same premises. This cyclic reuse of steam combined with effective use of electricity is what makes an energy efficiency of 70% possible.

It should be mentioned here that, for FY2003, the ratio of non-fossil fuels such as RPF, black liquor, paper sludge, and used tires in the fuel supplied to boilers in the Oji Paper Group was high at about 40%. In addition, RPF-dedicated boilers have been operating at two mills (Tomakomai and Oita) in the Oji Paper Group since 2004 marking further progress in the cyclic reuse of resources.

Expanded Use of RPF Toward Zero-use of Coal

At the Tomakomai mill, most of the power used within the plant is self-provided, and the fuel for producing this electricity and steam consists not only of fossil fuels but also renewable fuels (like black liquor





FY2003: Fuel breakdown (ratios based on calorific value)

Fossil energy : Oil,Coal,Purchased power
Renewable energy : Black liquor,Wood shavings
Waste energy : RPF,Used-tire chips

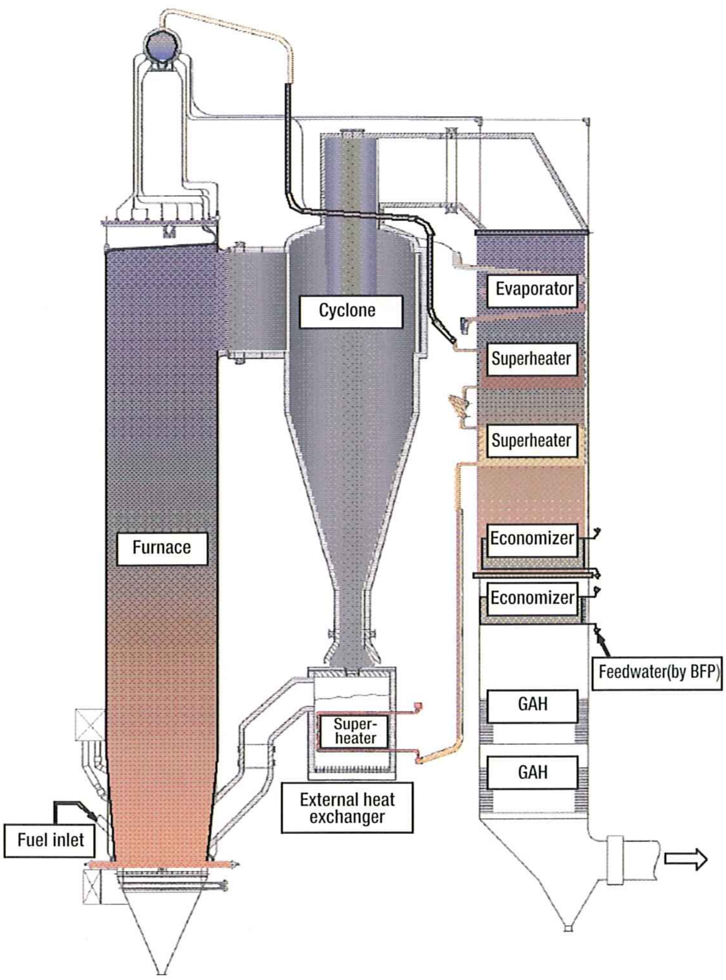
→ Non-fossil energy makes up about 40%

and paper sludge) and waste fuel (like RPF and used-tire chips).

The fuel used by the dedicated boilers mentioned above consists mostly of RPF with another portion made up of waste fuel like used-tire chips, paper sludge, and wood shavings and the remainder occupied by coal. The plan set forth by the Oji Paper Group is to eliminate the use of coal by increasing the annual use of RPF to about 600,000 tons.

Main features of RPF-dedicated boiler (boiler No. 6 at Tomakomai mill)

- Combustion air entering from the bottom of the boiler blows fine particles (about 200 tons of sand or similar) upward to the top of the main boiler unit (furnace) where they enter the cyclone for collection and eventual return to the furnace resulting in the formation of a "circulating fluidized bed."
- Circulating particles make for long residence time.
- Combustion takes place throughout the furnace.
- Circulation and agitation produces brisk heat conduction.
- An hourly steam-generation rate of 260 tons at a steam pressure of 12.3 MPa and temperature of 569° C corresponds to the industry's top class of waste-fuel boilers.
- After being subjected to continuous high-temperature combustion (850 — 900° C) during a sufficiently long residence time, the gas exhausted from the furnace passes via the cyclone through an evaporator, superheaters, and other equipment to be rapidly cooled (below 200° C) and emitted (at 55° C) from a chimney via a bag filter resulting in almost no resynthesis of dioxins.
- Chlorine components in RPF are strictly controlled to prevent external corrosion of water pipes. Standard value is under 0.3%.
- The boiler also supports biomass fuels.



Structure of RPF boiler

RPF

Paper sludge

III. RPF Supports Color Creation in Knitwear and Other Products in the Fashion Industry

Benisan Database Stores More Than 500,000 Colors

The Benisan Ashikaga Plant (Benisan Co., Ltd., Headquarters: Koto-ku, Tokyo; plant: Ashikaga City, Tochigi Prefecture) was the first plant in Japan to deploy a RPF-dedicated boiler to promote energy recovery. This plant uses from 8,000 to 10,000 tons of RPF annually as a heat source for the dyeing of sportswear and casual wear sold by domestic and international designer brands. As a member of the Asikaga area, Benisan views its introduction of a RPF-dedicated boiler as a way of doing its part to deal with global warming and the scarcity of landfills and to ease the load on the global environment.

Construction of Japan's 1st RPF-dedicated Boiler

Founded in 1875, this year marks the 130th anniversary of the Benisan company. Though suffering much damage in the Great Kanto Earthquake of 1923 and the Pacific War, the company has never strayed from the dyeing business. Having been a witness to many eras of "color variation," Benisan has come to pursue the development of dyeing technology.

The original facilities of the Ashikaga Plant were completed in 1964, and the plant has gone through several periods of expansion to become the main Benisan plant incorporating the functions of the Tokyo headquarters plant. It is involved with much dye processing for top designer brands both in Japan and overseas and has reached a level on a par with Italy and France, the traditional world leaders in color for the fashion industry.

The main source of heat at the Ashikaga Plant is a RPF-dedicated boiler constructed in 1991 as Japan's first boiler of this type. Before that time, the plant used fossil fuels (A-grade oil), but as social awareness of global warming and diminishing space at final disposal sites began to grow, a decision was made to employ RPF. This technology could provide plastic waste that would normally be disposed of in landfills and used paper that could not be reclaimed all in an easy-to-use solid form. The Ashikaga Plant uses from 8,000 to 10,000 tons of RPF annually having a calorific value of 6,000 to 6,500 kcal/kg.

The deployment of this RPF boiler also came out of a realization that "to coexist with the local community, it was extremely important that local residents understand Benisan's corporate stance of reusing the heat source (energy recovery) required for the dying of knitwear and other familiar products and of contributing to a reduction in environmental load."

Collecting and Reusing Heat from Used Steam

Given that plastic is made from fossil fuels, it was natural that certain industries would start to note the

View of Ashikaga Plant. The RPF-dedicated boiler is located in the top-center part of the photo.

View of boiler at Ashikaga Plant

calorific value of plastic waste and the possibility of constructing dedicated boilers for reusing (recycling) that waste much of which was being disposed of in landfills.

A boiler of this type has a "fluidized bed" structure that produces steam by arranging four layers of water pipes (whose surfaces are specially treated to prevent bodily injury) at the bottom of the boiler and burning RPF supplied from the top of the boiler to raise the temperature of the sand in the boiler. The inside of the boiler is kept at 850 — 900° C so that the level of toxic substances is minimal and within standard values at all times.

Here, heat from the steam used in the dyeing process can be collected by a heat exchanger and reused for preheating the water used for creating water vapor and the water used in the dying process ("soft water" in either case). This is one example of measures deployed to save on fuel and reduce the load on the environment as much as possible.

A Color Database Storing More Than 500,000 Colors

The driving force behind Benisan's high level of technology is the Technology Group, which has been responsible for all of the company's dyeing and special-processing technologies.

The Technology Group has accumulated a color database in excess of 500,000 colors that are generated through the application of Computer Color Matching (CCM) and an Automatic Dye Matching System (ADMS). About 2500 colors are used every month. This world-class technology enables Benisan to provide Japan and other countries with many products from the world's top designer labels.

RPF stockyard

Example of dying process

Drying process

Dehydration process after dyeing

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