Recycling of Waste Paper

JAYA KRISHNAGOPALAN, SANDHYA BAPNA AND KULKARNI A. Y.

INTRODUCTION

With the progress of civilization, the paper and board consumption has increased tremendously over the years resulting in increased waste papers called "*urban forests*", making the recycling technology more and more complex and important. Public attitudes have also been stimulated by a growing awareness for control of environmental pollution and have as a result chnged more towards conservation of natural resources. There is now an awareness that recycling conserves natural resources and reduces the solid waste burden. In the developing and third world countries, recycling of waste paper becomes an absolute necessity due to scarcity of raw materials.

Paper is one of the major components of urban solid waste (houshold and commercial waste) and has a potential resource value when collected and reused. The recycling and reuse of paper may be for various reasons viz.

(1) Recycling of the waste paper has been a practice that has prevailed in the paper industry since its inception and therefore continues.

(2) Use of the organic content in solid waste for its energy values.

(3) Production of non-paper products with extended life, (e g.) building materials.

(4) Chemical or biological conversion, new compounds such as protein .

The use of waste paper in non-paper fibres products has a relatively limited application Some of them are — particle boards, bricks, insulation, pipe, hardboard, simulated wood and cement panels. Expansion of markets for products crrrently made from recycled fibres will provide only a fraction of the desired recycleing increase. This is the reason why the development of new products which can be made from reclaimed fibres is so essential.

The reuse of waste paper in the manufacture of paper and board is not new and the first recorded report of recycling of waste paper dates back to 1695, at the George Bathasar IIIy Mill in Denmark. Over 100 years later, a British patent was granted in the name of Mathias Koops on a process for the utilisation of waste paper.

There are three major factors which favour utilization of waste paper for recycling to paper products.

(1) Worldwide shortage of raw materials.

(2) Increasing consciousness for cleaner environment and control of "Solid pollution".

(3) Valuable benefits of recovering a ready made fibre from waste.

At the same time, there are factors which discourage the use of waste papers beyond certain levels. They are—

(1) Virgin fibres is a more versatile raw material than waste paper and is preferred due to its uniform characteristics. Waste Paper is heterogenous, its market is fluctuating and complex in terms of processing due to the presence of contaminants and has limitations of availability in very large quantities.

(2) Due to this reason, larger production units with economic production of virgin pulp are favoured to smaller waste paper mills.

(3) Forest resources may be owned and managed to provide long term stability; which is difficult to realise in waste paper reutilization.

(4) End-uses in which recycled fibre has been used widely have not grown at the desired rate so as to consume all the waste paper generated with some exceptions such as newsprint and corrugating medium. Competitive materials also have displaced some of these products.

Traditionally, it has been a practice to use the waste paper in boards and corrugating medium. But presently, many other products apart from these two are manufactured using varying proportions of waste paper. They are newsprint, printing and

writing papers, tissues, etc. Newsprint from recycled newsprint has become technically feasible, so is printing and writing paper with 50 to 80% recycled fibre. In tissues manufature, there are no technical limitations to the amount of recycled fibre used.

The economics and technology of recycling differs from country to country. The various factors that influence the economics are—

1) Virgin material availability.
2) Cost of virgin raw materials (Vs.) waste paper and
3) Market values of virgin papers and waste recycled papers.

Table-1 gives the collection and consumption figures of waste paper for various countries.

In some countries, paper collection and recycling is engaging the attention of Governments too.

Sweden has established a 'Paper Collection Act of 1975' by which collection is organised by the local authorities under the municipality. Separation is done at the source. Except for offices, shops and other firms, waste paper can be removed only by those specially engaged for this purpose.

The European Economic Community (EEC) has formulated multinational research projects and funding is from all the countries of EEC. Each area is headed by one country and the Chairmanship for 'Recycling' is given to Belgium.

TABLE—I WASTE PAPER RECOVERY AND CONSUMPTION AROUND THE WORLD

(Source : PPI, July 1980, Annual Review Number)

Figures for '79

Sl. No.	Country	Per capita consumption (Kg)	Total Paper & Board Prodn. (1000 T)	Waste Paper (1000 Tons)		% Production	
				Recovery	Consumption	Recovery	Consumption
1.	Fed. Rep. Germany	155	7444	3268	3198	43.9	43.0
2.	Sweden	213	6280	509	634	8.1	10.0
3.	Finland	165.4	5738	216	202	3.8	3.5
4.	Italy	92	5101	1339	2096	26.2	41.1
5.	France	117	5261	1956	1863	37.2	35.4
6.	Spain	61	2251	911	1073	40.5	47.7
7.	U.K.	134	4198	28*	2184*	0.7*	52.0*
8.	Netherlands	148	1704	935	886	54.9	52.0
9.	Austria	103	1565	n.a.	458	n.a.	29.3
10.	Norway	136	1400	123	112	8.8	8.0
11.	Poland	41	1248	462	443	37.0	35.5
12.	Ger. Dem. Rep.	81	1217	578	565	47.5	46.4
13.	Belgium	145	863	430	234	49.8	27.1
14.	U.S.A.	289	58882	16330	14152	27.7	24.0
15.	Canada	215	13488	n.a	n.a.	n.a.	n.a.
16.	Japan	151	17861	7732	7830	43.3	43.8
17.	Taiwan	80	1336	600	1050	45.0	78.6
18.	India	2	971	300	300	30.9	30.9
19	Brazil	26	3002	n.a.	1070	n.a.	35.6
20.	Mexico	29	1731	n.a.	1006	n.a.	58.1

*Unusual high inventeries from previous few years.

n.a - not available

WASTE PAPER SOURCES

Usually waste paper is available as—

1) Pre-consumer wastes like press cuttings, converting wastes, etc.
2) Post consumer wastes like books, stationary, office and shop waste, household waste paper, street sweepings, etc,.

Ideally paper manufacturers would prefer to have the wastes which are clean and uniform in characteristics. In practice, however, they contain many undesirable elements other than fibres which are called 'contaminants' and contraries' Additives (fillers, dyes, wet strength resins) printing inks, varnish, wax, etc. are added during paper making or in converting. Many other contaminants like metals, strings, wood chips dirt, etc., enter the stream during collection, packaging and transportation. All these have to be removed in order to obtain a clean pulp. An initial sorting either at collection point (source) or at the mill removes heavily contaminated wastes and impurities. Many processing steps like screening, cleaning, washing and some special treatments are given to remove most of the contaminants. Each contaminant depending on its physical and chemical nature, requires special technology and equipment.

THE WASTE PAPER RECYCLING SYSTEM

Some of the general processing steps in any waste paper recycling system are :

Collection
|
Sorting
|
Pulping
|
Screening (Removal of heavy and large size contaminants)
|
Cleaning (Removal of grit and heavy small size contaminants)
|
Special methods of removal of contraries (Deinking, etc,.)
|
Dispersion of some contraries.
|
Washing
|
Bleaching or Whitening.
|
Beating or Refining.
|
Additives (Size, alum, dyes, etc.)
—
Papermaking.

More steps may be added depending on the waste stock and final product. Seven basic parameters have been defined for the evaluation of the waste paper system.

1) End Product Quality

a) Defibering index (%)
b) Classification of fibres
c) Freeness (°SR)
d) Ash Content (%)
e) Efficiency of removal of impurities (%)
f) Optical properties
g) Strength properties

2) Yield %

3) Cost of Installation

4) Operating Cost

a) Power consumption
b) Water consumption
c) Steam consumption
d) Cost of chemical additives

5) Quality of Effluents

6) Runnability of technological cycle.

7) Reliability of the Machinery

IMPORTANT TECHNOLOGISTS AND SYSTEMS DEVELOPED FOR WASTE PAPER RECYCLING

1) Dispersion of Contaminants

Inks, colours, wax, bitumen, etc., are dispersed finely and thoroughly so that they do not give specks and patches on the paper Except for hotmelts like wax, bitumen, varnish, etc., pulping at slightly higher temperatures with chemicals and a mild refining disperses most of the contaminants. The hot-melts or stickies are very problematic. They have either to be removed or dispersed finely. If not they tend to stick to paper machine felts, wires, etc., and cause operational problems. These are effectively dispersed by refining a high consistency stock at temperatures above 100°C with some pressure. Some of the popular hot dispersion systems are available from Voith, Beloit-Jones, Maulay, etc.

2) Removal of Contaminants

This is a better alternative for dispersion, as the product becomes cleaner in quality, since otherwise of impurities have a cumulative effect in the waste paper market.

a) **Printing Inks** are removed by three progressive stages of the deinking process—

i) Ink removal from fibre (with chemical addition)

ii) Ink removal from pulp (washing or froth flotation

iii) Ink removal from effluent (clarification)

Ink must be first removed from the fibres and dispersed. This is achieved by shear forces encountered in pulping and by the addition of deinking chemicals. Once separated from the fibres, ink has to be removed from the pulp slurry. There are two basic approaches to this : *Dilution washing* is a mechanical process of rinsing ink particles from the pulp. *Froth flotation* utilizes the different behaviour of fibres and ink pigments when wetted with water. When flotation chemicals and finely dispersed air bubbles are introduced into the suspension of ink and fibres, the ink pigments adhere to the bubbles and rise to the surface and form a layer of froth that is removed by skimmers.

Clarification of the inky effluent using flocculation is very important in any commercial deinking process.

b) **Chemical Treatment** for contaminant removal are not too plentiful, but these are becoming increasingly important. e.g., Treatment of plastics and wax coated carton stock using trichloroethane to dissolve these materials leaving white paper.

c) **Mechanical Treatments**

i) Pulp-Polyethylene suspension is diluted to allow floating of the pieces of polyethylene, which are mechanically raised out of the suspension by way of a conveyor.

ii) One method describes the removal of bitumen from waste paper slurries by agitating the slurry in the presence of plastic materials at a temperature above the softening point of the bitumen. The bitumen adheres to the plastic and the bitumen-coated-plastic is then screened out of the waste paper stock at the end. Addition of surfactants enhances the adhesion of bitumen to plastic.

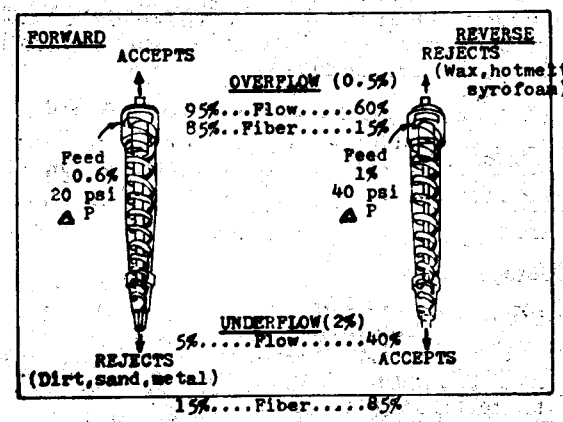
A FEW IMPORTANT AND NOVEL TECHNIQUES/SYSTEMS

1) Reverse Cleaning (Fig. 1)

In a conventional forward centri-cleaner, heavy contaminants like grit and coarse fibres are

FIGURE 1

PORWARD (CONTENTIONAL) AND REVERSE-FLOW CENTRIFUGAL CLEANERS



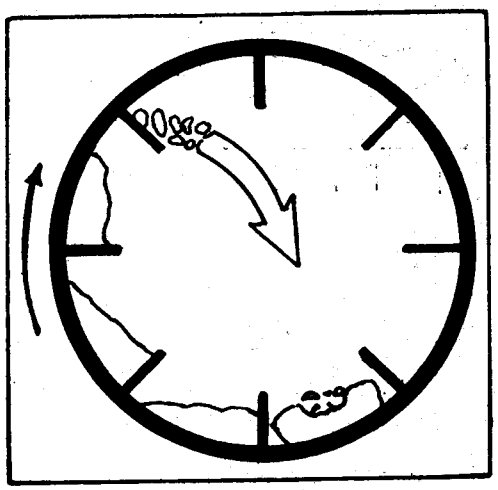
rejected through the apex end. Only 5% of the flow and 15% of the solids are rejected. In a reverse cleaner, the proportions are somewhat changed by different orifice sizes and/or value action. 45% of the flow and 85% of the solids (mostly good fibre) are accepted through the apex and the rejected (lightweight contaminants like hot-melts, wax, plastic bits and fibre fines) via the vortex end.

2) Ahlstrom—Fibre flow System (Fig. 2)

Waste paper is wetted to a consistency of about 15% with water and some wetting and swelling chemicals and repeatedly dropped on to a

FIGURE 2

AHLSTROM FIBREFLOW SYSTEM



CROSS SECTION OF THE DRUM

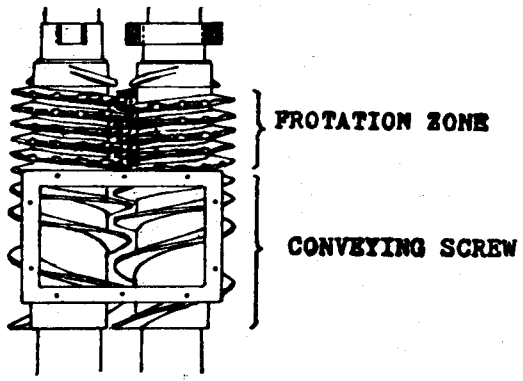
hard surface. This action fibrizes the wet paper, but does not break up bits of plastic, string, etc.. A rubbing effect is added when a rolling motion is applied between drops. Ink, size, laminates and hotmelt substances are loosened from the fibres.

After the high consistency zone, the stock is diluted and individual fibres pass through the perforated drum. The rejects (wires, plastics, etc.) eventually find their way to the end of the drum and are removed.

3) **Frotapulper** : (Fig. 3)

Major principle of the system is that treatment of fibres at low consistency should be minimized, as it creates a lot of fines which increase the drainage resistance. High consistency treatment utilizes the energy more efficiently and leads to increased temperature of the pulp which is necessary for dispersion of hotmelts like wax, bitumen, etc.. The 'Frotapulper' consists of two intermeshing screws rotating synchronously against each other. The paper flakes (30-35% consistency) are sheared between the flanks of the screws, which leads to a complete separation of fibres; plastic coating (Polyethylene) is rolled into spirals which can be easily removed by screening.

FIGURE 3
WORKING ZONE OF THE FROTAPULPER



(4) **Dry-sorting**—is based on a differential mechanical fragmentation and screening of feed material into 3 fractions-Mechanical fibre enriched, intermediate, and chemical fibre-enriched. The quality of separation is dependent upon the differences in strength properties of the furnish components as well as upon process operating variables. The strength of a sheet of paper or board is indicative of the quality of its consistent fibres. The sorter consists of a longcylindrical rotor with parallel blades extending radially from its surface. The rotor is either partially or entirely covered by a screen made by heavy wiremesh and spaced some distance from the rotor. Waste paper is fed from one side, subjected to intensive mechanical treatment by the blades as they rotate. Weak components breakdown first and pass through the screen. The fractions passing through the last screen sections are made of the strongest fibre in a given mix.

THE INDIAN WASTE PAPER RECYCLING INDUSTRY

In India also, waste paper is recycled extensively and more than 30% of our paper and board production is from waste paper. Even husnehold waste gets sorted and ends up in a board mill as "street sweepings".

While the waste paper dealers and collectors find good profits in this trade, environmental protection aspect also gets satisfied indirectly. Moreoever, our acute raw material shortage makes recycling a necessity.

Our end-uses of waste paper differ much from those of other countries. The good quality waste papers like imported kraft waste, press trimming, cuttings, etc. end as kraft, liners for duplex boards and in printing and writing papers. The inferior quality wastes like duplex and grey board cuttings, office waste, street sweepings, etc., are mainly used for corrugating medium and filleqs in duplex and grey boards.

The technology and equipment required for upgrading these wastes for the manufacture of higher grade products is expensive. Moreover, the waste papers available in the market are highly heterogeneous. There is considerable variation between consignments from the same supplier or between suppliers on account of various grades of paper and board manufactured in the country and the numerous agents supplying waste to the wholesaler. Table 2 gives the present approximate prices of a few varieties of waste papers, virgin pulp and raw materials.

Sorting is done both at collection points and at the mills, but more so at the mill site. A good and thorough sorting is very costly and after a certain limit becomes prohibitive. Inspite of visual sorting sometimes mistakes happen.

Bitumen and wax embedded between layers of kraft board, plastic in between layers of paper in duplex cuttings are some of the hard to sort out cases. Our processing has to overcome such mistakes and guarantee clean products. For the range of products so far manufactured in India, the follo-

TABLE—2 APPROXIMATE COSTS OF VARIOUS WASTE PAPERS AND RAW MATERIALS

Sl. No.	Item	Cost (Rs./Ton.)
1.	Street Sweepings	900 – 1000/–
2.	Grey board cuttings	900 – 1100/–
3.	Mill Board	1200/–
4.	Duplex Board cutting	1500/– – 1900/–
5.	Imported kraft waste	1800/– 2200/–
6.	White cuttings	2500/– 3000/–
7.	Kraft waste (Indian)	1500 – 1900/–
8.	Computer, Cards, Tag cards	2000 – 2500/–
9.	Book, stationary & mixed waste	1800/–
10.	Imported wood pulp bleached	6000/–
11.	Bleached CPM pulp	5000/– – 6000/–
12.	Bamboo	350 – 400/–
13.	Hardwoods	300 – 350/–
14.	Wheet straw and rice straw	100 – 200/–

wing seqence would ensure good pulp at acceptable prices.

(a) Rapid and efficient difiberation to ensure complete disintegration of the fibres;

(b) good dispersion of contaminants like inks, colours, waxes and varnish.

(c) screening and (d) cleaning.

These basic steps are necessary for all mills–big or small. Government aid by means of subsidies would encourage the recyclers to produce better quality products from waste papers This will ultimately increase the quality of wastes in the country. Government can also control the quality of waste papers and products by standardization and price limitation.

Research in our country should be aimed at improving the present processes without additional machinery or higher processing costs. On the other hand, simple and economic technologies and equipment should be developed for upgrading the waste for the manufacture of better grades.

A CASE STUDY

A project was undertaken using minimum equipment (hydrapulper, beater, sheet making and pressing apparatus) to process both sorted and unsorted waste paper with relevance to the manufacture of duplex and grey boards. The major objectives of this project were to—

(a) obtain good defiberation;

(b) obtain good dispersion of some selected contaminants such as printing inks, varnish, wax, bitumen and colours; and

(c) upgrade the waste pulp.

In this study differents chemicals which act as swelling and wetting agents were evaluated at various concentrations and temperatures, based on economy, final pH and quality of the pulp obtained. It was found that small quantities of sodium silicate and sodium carbonate are very effective even at room temperature.

While treating contaminated waste, ideally they should be removed if the final product is to be clean and of good quality. However, removal of contaminants is rather complicated and requires special techniques and equipment. Hence, a good dispersion of the contaminants was sought. Printing inks and varnish were found to disperse well by he addition of small amounts of sodium carbonate and sodium silicate in the hydrapulper. Wax also disperses similarly if present in small amounts. Colours if present in light weight papers, disperse easily by the same method. Coloured board cuttings, which are also varnished resist easy defibration and dispersion.

The most problematic contaminant is 'bitumen'. It does not disperse easily, being a hotmelt, at room temperature. Most bitumen contaminated boards and papers are easily recognisable and therefore can be sorted out. Any unsorted bitumen that gets into the system has to be monitored by means of occasional sampling of the hydrapulper stock and increasing the pulping temperature when necessary. The system of 'reverse cleaning' may be installed, if the problem is acute and constant.

Many mills do not refine or beat the pulped stock It was observed that a mild beating enhances the uniformity of the pulp to a great extent. Bleaching of waste paper pulps is very common in many countries using peroxides and sodium hydrosulfite, both being excellent agents for bleaching without degrading the pulp in any way. Unfortunately, both these chemicals are very expensive in

India. Sodium hydrosulfite is quite effective even in small amounts and the manufacturers claim that subsequent washing is not necessary.

In this study, sodium hydrosulfite and calcium hypochlorite singly and in combination were evaluated for brightening the waste pulp. The latter is relatively cheap and the brightness gained is also more. Inspite of the proven advantages of hydrosulfites and peroxides, their high costs are prohibitive.

It is generally felt by the waste paper processers in India that presence of large amounts of newsprint in the furnish decreases the strength properties of products made from recycled pulps because of its high groundwood content.

The effect of varying amounts of newsprint on the strength properties of waste paper was evaluated. It was found that 30 to 40% addition of newsprint waste to chemical waste, does not bring down the strength properties (tensile and burst and tear) noticeably. These three properties were evaluated with reference to board manufacture. Mention has to be made, that newsprint made from 100% virgin pulp and 100% recycled newsprint (deinked) are technically comparable, especially in two critical factors—brightness and tear factor. This has been established by the Garden State Paper Company in USA.

In India, recycling of waste paper, though popular in quantity, still lacks quality. We cannot blindly follow the technologies of developed countries, as they are both advanced and expensive. What we need is to develop our own technology and equipment to suit our waste paper market, our economy and our final product requirements. Research and development should be aimed at the following —

1) Economic means of contaminant removal.
2) Screening and cleaning methods.
3) Post-treatment of pulped stock like refining, beating, bleaching etc..

Products from waste paper should be made cleaner and better as this has a long range affect on the waste paper available for re-use of recycling eventually. Efforts and resources should be pooled to get the maximum results from such research activities.