Recycling of Waste paper By Flotation Deinking Technology

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SUMMARY

Recycling of waste paper is playing a very vital role in the production of paper and paper boards in many countries. Our country is lagging far behind in this respect and recycling of waste-paper is still in its infancy and has not been able to assume any significant role. The deinking process of different countries are surveyed and their progress and most recent developments are discussed. Approaches for collection of waste paper which have yielded fruitful results in other countries are indicated in light of the prevailing conditions of our country.

Flotation deinking technology, in general is discussed briefly. The deinking process and flotation cell adopted by this laboratory are also described in a nutshell.

INTRODUCTION

The first recorded attempt to recycle printed paper by deinking was in 1695 in Denmark. As early as 1800 a patent was granted to Mathias Koops that related to deinking technology[1]. There was no substantial growth in deinking until World War II. Advances in equipment and systems design today, make the deinking process an economic and viable alternative to conventional manufacture of paper from virgin materials.

Deinking has gained the momentum recently. In some countries like USA it is for ecology movement and for others like West Germany, Japan and England, it is for the simple reason — they do not have the natural resources to make paper and boards.

Table—I indicates the role of recycled paper in the supply of pulp in some selected countries of the world[2].

Total installed capacity of flotation deinking plants in the world by the end of 1980 has reached about 3.13 million tons per annum. Table II indicates some of the leading countries in flotation deinking. Much of this growth is in Japan where

TABLE—I WASTE PAPER RECOVERY FOR SELECTED COUNTRIES (1975-77)

Country	Collections (10^3m tons)			Recovery rate (%)		
	1975	1976	1977	1975	1976	1977
USA	10,391	13,985	14,852	20.4	24.0	24.7
Japan	5,162	6,198	6,602	46.1	41.4	42.3
Austria	191	213	243	35.8	30.0	34.6
Sweden	450	490	505	27.1	28.8	34.1
Norway	112	121	110	24.0	25.1	22.6
Finland	161	149	172	25.2	22.4	28.9
UK	1,700	2,000	2,100	28.2	29.1	30.4
Netherland	706	911	891	41.8	46.7	45.5
Italy	1,256	1,236	1,343	35.8	27.7	31.7
Germany Fed. Rep.	2,289	2,698	2,809	33.1	33.1	33.2
France	1,800	1,924	1,919	38.2	34.4	34.3
Belgium	329	400	377	33.4	32.4	31.3

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the installed capacity has reached about 1.25 million tons per annum. Japan alone now has almost as much deinking capacity as all of Europe. The Oji Paper's Tomakomai mill is now the world's leading mill in deinking with a total installed capacity of 860 tons per day (bone dry).

Table II
Leading countries in flotation deinking in 1980
(Capacities in 10^3 air-dry metric tons/year)

Name of the country	No of mills	Capscity
1. Japan	24	1,252
2. Germany Fed. Rep.	10	256
3. Sweden	4	254
4. United States	10	214
5. United Kingdom	5	163
6. South Korea	2	91
7. Austria	4	85

In USA the predominant deinking process is the washing type and the capacity is of 1.6 million air-dry m. tons/annum. The reasons for less enthusiam for flotation deinking in that country are lower final brightness, difficulty in handling sophisticated offset inks and ineffective removal of clay.

General interest for deinked pulp has increased over the last few years, because of the difficult wood supply situation and the cost for electrical energy. A Number of major mills in Europe are seriously planning to have deinking systems as the cost of pulp is rising and energy crisis is aggravating. Energy cost development appears to impact favourably on deinking in general. An energy consumption of about 300 KWH/ton of deinked pulp is required in a voith system, compared to 1500 KWH/ton of stone groundwood[3].

The EEC countries lie in a deficit zone in so far as the supply of virgin pulp is concerned. The paper and board import into the community in 1976 was about 11 million tons which has grown up considerably since then. Even France which produced 1.9 million tons of pulp, imported 0,9 million tons of paper and board and 1.1 million tons pulp. Similarly Fed. Rep. Germany and U. K. imported 1.8 million tons and 2.8 million tons of pulp and paper & board respectively.

Since not enough virgin fibre is available in the community to make a significant difference to this picture, waste paper is the only possibility. In the last 15 years there has been a steady progress in the consumption and recovery rates of waste paper in these conntries.

The Table-II on waste paper recovery shows only two countries with a recovery rate of more than 40%, the Netherland with 45.5% for 1977 and Japan with 42.3%. These two countries share a number of charcteristics which encourage the collection of waste paper. They have very little raw material of their own, suitable for paper making. Nearly all of it has to be imported. They have very high concentration of population. The urban areas that go with high population density make recovery easier.

There are, at present two deinking plants in India viz. M/s Rajendra Paper, New Delhi and M/s Sri Venkatesa, Udamalpet. The start up date for the first was 1978 and that of the latter in 1980. Both are based on Voith Flotation deinking system. The capacities are 10 tons/day. M/s Rajendra Paper has a plan to produce writing and printing paper while the other one for producing Newsprint by using Newsprint and Magazine paper as the base paper.

The estimated requirements of cellulosic raw material in India during 1981 and 2000 are shown in Table—III[4].

TABLE—III ESTIMATED REQUIREMENTS OF FOREST RAW MATERIALS AND SECONDARY FIBRES (1976–2000) IN INDIA.

Year	Capacity (10^6m. tons)	Forest raw materials and secondary fibres (10^6m. tons)
1981	1.68	5.88
1986	2.20	7.70
1991	2.80	9.80
1996	3.50	12.25
2000	4.25	14.87

As bamboo available at best cannot be more than 4 million tons, it is ovbious that the future requirements of cellulosic raw materials of the country will have to come from mixed hardwood to a large extent, will have to be supplemented to a significant extent by increasing the use of agricultural residues such as cereal straw, sugarcane bagasse, jute sticks ete. This uncertainty of supply of raw materials is acting as a severe constraint on the growth of the industry. That apart, reliance on bamboo as raw material involves deforestation which has its own adverse effects on ecology. So, the possibilities offered by waste paper recycling must not be ignored. Countries like Japan and South Korea have met a large part of their cellulosic raw material by waste paper recycling Last year there was some decrease in the production of paper and paper board in our country. It has come down to 0.971×10^{6} metric tons from 1.108×10^{6} metric tons during the year before last. The reason given for this drop in production figure is mainly power shortage. Secondary fibre mills are reported to have a distinct advantage over virgin fibre mills in energy consumption, since less energy is required to produce a ton of secondary fibre than a ton of equivalent virgin fibre. The electrical and steam requirements for producing newsprint at Garden State Paper Company was detailed by F.W. Lorey for both virgin newsprint and recycled newsprint. Electrical requirements for producing virgin newsprint is 90-100 H P. Day ton whereas for recycled newsprint it is only 31-32 H.P. Day/ton. Another United States study[22] states that conversion of waste paper into usable paper saves 15-16% on water consumption, 60-70% energy, 60-73% atmospheric pollution, 13-44% BOD, around 25% suspended matters in water and 39-100% solid waste. Our paper and Board industry should not overlook this aspect of lower energy and water consumption in case of recycling of waste paper to sustain the rate of production.

A comparison of the figures given in Table-IV will indicate that most of the countries have increased production including those which are considered as deficit zones for cellulosic raw materials. Japan is the second largest producer of paper and board. This has been possible because that country uses a large quantity of waste paper for recycling which has reached 1.25×10^{6}m. tons in 1980. Similarly the growth of Koreas paper industry would have been impossible without a heavy reliance on waste paper. The industry in that country started to take waste paper seriously when the energy crisis struck in 1974. The ratio of waste paper used in total raw materials was only 29.8% in 1971 which jumped to 69.6% in 1978.

In order to increase the production of paper and paper boards, therefore, one of the alternatives is to increase the capacity of waste paper recycling.

COLLECTION OF WASTE PAPER FOR RECYCLING

One of the major problems of recycling of waste paper is the collection of waste paper at an economic price. This depends to a large extent on a constructive joint effort by households, authorities and the paper industry. The amount of waste paper that can be recycled depends on the willingness of the household to take the trouble to sort out these wastes to be collected by some agents of the paper industry. The paper mills must invest in sorting and in processes that make it possible without a detrimental effect on the environment, to destroy the printers' ink recyclable waste papers and screen out plastics, wax, bitumen and other substances. Compared with other grades of waste paper, a relatively large fraction of the used containers can be collected with only small quantities of other fibre impurities, because relatively large fraction of the used containers end up as commercial and industrial waste, is usually more concentrated and hence, easier to collect, presents fewer sorting problems and is less likely to be contaminated with the undesirable materials as compared to other post-consumer grades of waste paper.

In the U.K. waste paper is available to mills from several sources. The largest waste paper using mills have associated paper merchants, and two companies, Thames Board Mills and Reed Paper & Board use about 40% of the waste paper consumed by the industry. On the local level, Thames Board has put forth a great deal of effort in encouraging local authorities to collect waste paper. The company has provided both financial assistance to enable authorities to set up viable collection system.

The collection of waste paper in Japan is in the hands of many thousands of small companies, most often with two or three people working in each. This is for the household and office collection. The collection of industrial waste paper from corrugated box plants, department stores and printers is handled by small special firms.

Similarly South Korea is making tremendous efforts to increase the share of domestic paper in waste paper recycling. Consumption of domestic waste paper in that country has increased from below 1×10^{5} m. tons in 1971 to above 5×10^{5} m. tons in 1979.

The volume of waste paper collected naturally depends on the quantity available; but a country like India, where per capita consumption of paper is so low cannot expect to collect and recycle as high a percentage that Japan and some European countries do. It requires many years to develop a network of collectors and dealers, and, even more important it necessitates the education of the population to a collected philosophy.

In order to make the waste paper collection industry a viable one it would have to be modernized. Positive propaganda will be necessary to let all households understand the value of waste paper as a resource and to cooperate in the collection. Films may be prepared for showing in schools, colleges and communities with the theme "Recyle and recovery

TABLE—IV. PRODUCTION OF PAPER AND BOARD IN DIFFERENT COUNTRIES OF THE WORLD (10^3 metric tons)

Name of the country	1974	1976	1976	1978	1979
USA	55,994	54,470	55,099	57,809	58,882
Japan	15,645	15,394	15,702	16,499	17,525
Canada	13,220	11,784	12,249	13,592	13,490
USSR	8,196	8,916	9,090	9,400	8,800
Germany F. R.	6,523	6,394	6,603	6,850	7,444
Sweden	5,510	4,946	5,060	5,702	6,280
Finland	5,573	4,550	4,629	5,130	5,738
France	4,785	4,611	4,722	4,963	5,261
U. K.	5,548	4,098	4,083	4,152	4,198
Korea	739	955	1,170	1,436	1,630
Australia	1,253	1,189	1,229	1,232	1,310
Taiwan	609	876	966	1,159	1,336
India	880	1,002	1,213	1,108	971
People Republic China	6,350	7,450	7,350	8,125	5,000

waste paper because the alternative is a dirty environment." Only and only when the people become conscious and cooperative, India can expect to have a waste paper collecting system as in Japan and some European counteris.

DEINKING TECHNOLOGY

Until the late forties, recycling of waste paper was a simple and straight forward recovery process. However, technological advances in adhesives, paper coatings, printing inks, polymer coatings and other materials difficult to eliminate have created many problems in deinking waste paper today. Papers are often subjected to a myriad of treatments and finishes which prepare them for the consumer. Rosin sizing improves the resistance to wetting and writing quality, UF resins are added to improve paper wet strength, clay fills the fiber surface filling voids resulting in a smoother surface to improve the printing characteristics of the paper, starch is used extensively as the adhesive in the fabrication of corrugated box board and many other ingredients are added for the production of speciality papers. Most of these manufacturing processes and additives result in paper stock which has a high resistance to water penetration resulting in difficulties in subsequent recycling. The development of various wettability techniques however, has caused the situation. Most modern deinking processes utilise surface active agents to help remove and emulsify the printing inks on waste paper.

The deinking process adopted by this laboratory has been based on flotation principle with aeration flotation cells.

The flotation deinking process normally starts with an alkaline repulping stage performed at 3.5% consistency at a pH of 9-10, at temperature of 35-40°C during which the waste paper is reduced to as table pulp suspension. Following various cleaning operations, the pulp is then diluted to 0.6-1% consistency and in the presence of insolubilized soap particles, the printing ink particles are surface collected as a foam/scum when the suspension is aerated. Countinuous removal of this scum effectively separates ink from fibre and thus forms the specific basis of the flotation deinking process.

CHEMICALS REQUIRED FOR DEINKING

Chemicals are required at the waste paper repulping stage to produce and maintain the necessary degree of alkalinity. The conventional chemical system consist of a mixture of polymeric sodium sillicates (also called metasilicates) and sodium hydroxide. These chemicals are normally supplied as concentrated solutions, which can be metered into the pulper from storage tanks. Usage rates are typically 3.5-5% sodium silicate and 1.5-2% caustic soda by weight of waste paper.

The alkalinity, which is highly effective in distintegrating the waste paper into a stabilized ink-pulp suspensions, could be achieved by using caustic Soda alone. However, under such operation the pH drops to undesirably low values and hence the use of a buffering system is desirable The role of buffer is adequately performed by sodium silicates allowing the pH to be maintained in the range 9-10. For wastes of high mechanical pulp content, the pH must be kept below 10 to avoid ecxessive yellowing of lignin

The role of the alkali is effectively restricted to producing the stablized ink-fibre suspension. It appears highly unlikely that any significant degree of ink-vehicle saponification occurs even at the substantially higher pH's upto 11.5, that are often used in deinking wood free wastes. The printing ink pigment particles are therefore removed with their mineral oil or resinous binders from their fibrous supports during repulping. As such ink-fibre release has been fully obtained on repulping; ink fibre separation can then be achieved at the flotation stage.

Flotation chemicals are required to extract the ink particles from the ink-fibre suspension, and, under aerated conditsons, carry the ink particles to the surface to be suitably removed. Such chemicals called collectors, consist insolubilized soaps.

Two basic techniques are widely used in flotation plants to produce these insolubilized soaps. The utilization of either the sodium soap or the fatty acids ultimately achieves the formation of the required insolubilized soap system. The fatty acid systems are liquid, normally based on technical oleic acid, and required pulper neutralization before the waste paper is repulped. The sodium soaps can be pulper solubilized or reconstructed as solution concentrates.

The chemical bases of the soap systems are mixtures of vegetable oil derived fatty acids and tallow derived acids. By suitable selection of these raw materials, collector soap system can be prepared to maximize the efficiency of a wide range of deinking systems utilizing various waste feeds For newsprint based waste feeds the soap utilization rate is normally 0.8 1% based on fibre, but for wood free deinking, because of the reduction in the number of ink particles in the system, soap utilization rates may be as low as 0.5%.

It is vitally important, however, that neither inadequat nor excessive soap addition levels be used. Low soap levels lead to ink carry-over ultimately to the paper machine, while excessive levels can easily lead to felt blinding during dewatering on the machine.

The function of the soap is purely as an insolubilized surface collector and has no role to perform as an emulsifier. As such the calcium ion concentration in the process water needs to be sufficiently high to achieve total soap insolubilization. Occasionally it is necessary to add extra calcium ions to the system by using calcium chloride solution to generate the desired level of foam on flotation. Providing a suitable waste feed has been selected, the operating pH and calcium ion level can be adjusted to provide the required foaming level in the flotation cells Under such condition excellent ink removal is achievable with suitable collector system.

In some specific systems, conventional detergent systems are added to promote fibre wetting and foaming usage rates are of the order of 0.2% only.

The fundamental requirement of a deinking system is to eliminate from the waste paper the colour that the ink imparts to the cellulose fibre. For the most part pigments are generally inert to alkalies. In this category are carbon black, phthalocyainineblues, ultramarine, titanium dioxide, and many others, whilst iron blues including prussian blue, are decomposed into a colourless ferrocyanide and the residues are ironoxide and hydroxide.

Pigments are, however, a secondary consideration in a deinking process as the binders assume the principal role by strongly attaching themselves to the fibres. Only by detaching the binders the pigments can be released into suspension. Commonly used binders are listed in table V that can be categorized as easy to treat or difficult to treat.

TABLE—V CATEGORIZATION OF BINDERS COMMONLY USED IN PAPER INDUSTRIES

Sl. No.	Easy to treat	Nos.	Difficult to treat
1.	Natural resin	7	Asphalt
2.	Modified resin	8	Cellulose derivatives
3.	Turpentine resin	9	Synthetic latices
4.	Petroleum resin	10	Phenol & Urea resins
5.	Alkyd resin	11	Melamine resins
6.	Drying oil	12	Polyamide, epoxys

Because the more difficult to treat binders tend to be used on the better quality wood free papers, more, power, chemicals and heat are required than lower quality wood containing papers A high brightness is obtainable with a yield at about 70% because of the high filler content. Wood containing papers, such as news. magazines, books, advertizing etc. are treatable at a lower cost and have a higher associated yield. There are no standard conditions for deinking and widely different practices are followed in different mills. The process may be broadly divided into two major steps.

A) The paper has to be disintegrated and simultaneously the ink particles have to be detached from the fibres.

The condition for this varies widely. In general there are three different methods.

i) Disintegration of the stock in a pulper followed by cooking in a separate digester.

ii) Disintegration on the stock in a pulper followed by cooking in the same pulper.

iii) Cooking in digester without previous disintegration followed by refining the pulp.

Either high (20-35%) or low (4-10%) consistency disintegration is used. The temperature maintained for digestion of waste paper is usually 38-93°C. The time required for pulping varies between 30 minutes to 8 hours depending upon the consistency, chemical, temperature and other process conditions.

Cleaning of the stock is generally done by screening unit such as vortex cleaner. It is also done by removing coarse impurities by a high consistency purifier and subsequently de-specking the pulp in a high speed deflaker.

B) After the disintegration of the pulp and release of the ink particles the detached ink particles have to be separated and eliminated from the pulp suspension. The removal of the ink particles is then performed in a flotation deinking cell.

The removal of ink particles from the waste paper pulp suspension by the application of flotation technique has been reported as early as 1933, but only recently it has been successfully adopted in commercial practice. Kowleski[6] described the chemicals and the type of flotation cell required for the removal of printing ink in the form of a froth with the help of flotation agents. Amongst the floattion agents he mentioned are turpentine, petroleum, fatty and rosin soaps.

In 1956, J M Voith G.m.b.H.[7] caught up the idea of the removal of printing ink by employing the flotation technique. After much research and development work, has devised a successful process for the removal of printing ink from waster papers and also the flotation cell required for the purpose.

Voith[8] has the largest share of flotation deinking system in operation. Voith recently introduced its ATS-N high consistency deinking system in which the waste paper is treated in a high density storage tower (20% consistency) for about 3 hrs. after leaving the pulper but before flotation. Voith claims that the new ATS-N system yields higher brightness with the same chemical usage rate.

Escher Wyss[9,10] G. m.b.H. recently developed the FZ-U Unicell, a single large cell instead of multiple smaller cells. The Unicell is dimensioned in length and breadth to suit capacity and site conditions. Two tier arrangements are possible, and the floor space requirement is said to be only 0.6 m^2/ton of output. The Unicell is also said to save upto 40 KWH of energy per ton of bone dry stock compared to conventional cell. In 1978, Escher Wyss introduced Cassette form design for its cells stationery aeration system. This is said to improve maintenance. The Borch-Madsen process is another new proposal which claims to have lower running cost.

A new deinking systems has been proposed from Poland[11]. This is based on the coagulation of ink into granules that are then removed by hydrocyclone. The OY Tampella AB, Finland process can deink all the difficult inks-offset, UV dried inks, Xerox copies and carbon-less copy papers.

Swemac SA, Belgium entered the flotation deinking field only in 1977 and its first commercial installation started up earlier in 1979 at the Katrinafos mill of Eiskeby AB, Sweden.

The Swemac Hellberg cell differs from other flotation cell in that it is cyclinderical. Advantages claimed for this new design are that it is self cleaning, fully enclosed, has low space requirements and extracts ink rejects in highly concentrated form. Air is introduced through a bronze plup in the special mixing chamber and this is claimed to give accurate control of bubble size and consequent good mixing and chemical action.

The process developed at Regional Research Laboratory, Jorhat, for deinking of printed papers is schematically represented in the flow sheets (Fig. I & Fig. II). The design and other parameters of the flotation cell developed are described elsewhere The flotation cell consists essentially of a rectangular tank made of M. S. plate equipped with a mechanically driven stirrer. The stirrer consists of a shaft to the bottom of which the blades, made of aluminium, are fitted. The stirrer is surrounded by a perforated jacket which is fastened to the base of the cell. The air inlet is at the bottom together with the inlet of the stock to be deinked. The tank is provided with baffles for the movement of the froth in the proper direction. The froth is skimmed off with a mechanical scraper.

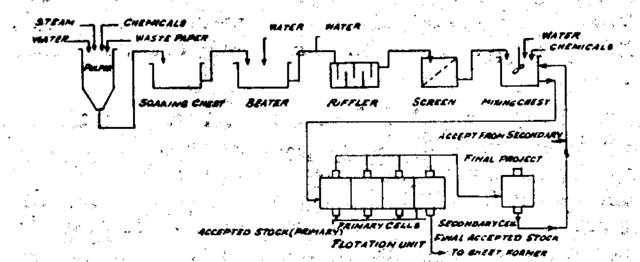

FIG. 1 FLOW SHEET FOR DEINKING OF WASTE PAPERS CONTAINING GROUND WOOD PULP BY FLOTATION.

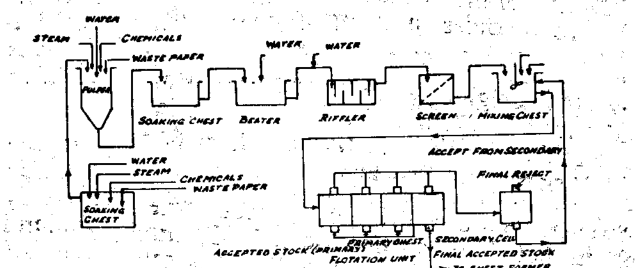

FIG. 2. FLOW SHEET FOR DEINKING OF GROUND WOOD FREE WASTE PAPERS BY FLOTATION.

In this process, waste papers are agitated in a pulper for about 1 hr. at a consistency of 5-6 percent. Chemicals are added in the pulper and a temperature of about 50-60°C is maintained. The defibrised waste paper is stored in a tank for about 2 hours at a temperature of 50-55°C, so that the pulp swells due to the chemical-thermal action. As a result a portion of the ink particles is loosened or released from the fibres. The fibre suspension is then run in the beater for 20-30 minutes at a consistency of about 3-4 percent with the beater rolls sufficiently raised so that the mechanical stress exerted by it is extremely mild and there is no appreciable decrease in the freeness of the pulp. Due to the bruising action of the beater the fibre clusters are removed from the stock. The stock is then diluted to acon sisrency of 0.6% and flotation chemicals are added. The stock is now ready for the next operation flotation.

FLOTATION SYSTEM

For the removal of printing ink by the flotation technique, air is introduced into a properly treated waste paper suspension when the ink particles preferentially adhere to the bubbles to remove this material from the surface of the cell in the form of a froth.

The flotation cell employed essentially consists of a tank with a mechanical stirrer. The stock to be deinked is fed from the bottom and at the same time air is also introduced judiciously from beneath. Due to the action of the stirrer and air, the stock is thoroughly mixed and distributed uniformly. The ink particles, are separated from the pulp and carried to the top, which is skimmed off mechanically. The accepted stock is drawn from a lower levels.

The flotation system employed consists of 5 cells; 4 primary cells and one secondary cell. The primary cells operate in series i.e. the accepted stock from the first cell goes to the second and so on to the fourth eell. The rejects i.e. the foam carrying the particles together with a small proportion of fibre from all the four cells goes to the secondary cell. The accepted stock from the last primrry cell is neutralised to the desired pH and used for sheet formation.

The reject from the secondary cell mainly consists of carbon particles, fillers, fines and minor quantity of fibres and is discarded.

The strength and other properties of the deinked paper are summarised in Table-VI[12]. The brightness of sheets made of deinked stock is almost similar to that of the original waste paper. Table-VII[13] shows the properties of the deinked groundwood free waste paper when the raw material used are waste papers like letter heads, records, ledgers etc.

DISCUSSION

McKee[15] found substantial changes in physical strength properties after several recycles when beating to a consistent freeness. He observed that sheet properties which are a direct function of fiber-to-fibre bonding and fibre strength decrease markedly with the number of times repulped, with the loss in bonding potential having a greater effect than the loss in fibre strength. In addition, he observed that the greater the degree of refinement of the virgin fibres, the lower are the recovery potentials of those sheet properties which are a direct function of fibre bonding. Brecht[16] compared the handsheet properties of regenerated pulps with those of the original beaten pulps to determine the influence of freeness. Breaking length, folding endurance, and tear were lower than their original values except in the case of a slow draining pulp

TABLE—VI CHARACTERISTICS OF ORIGINAL AND RECLAIMED PAPERS OF DIFFERENT GRADE

	Original newspaper	Deinked newspaper	Original magazine	Deinked magazine	Deinked 50% news 50% magazine.	Deinked mixed waste paper
Ash	6.42	2.98	9.26	4.38	8.21	3.12
Freeness of the pulp (°SR)	—	62	—	66	58	44
G. S. M.	55.6	59.07	54.3 (av.)	54.1	57.21	61.02
Thickness (mm)	0.8	0.8	0.9 (av.)	0.9	0.9	0.9
Breaking length (m)	1242	946	1410	1220	1296	1944
Folding endurance (Double fold)	2	2	4	2	3	6
Stretch %	1.2	1.2	2.1	1.8	1.9	2.4

TABLE—VII PROPERTIES OF DEINKED PAPER MADE FROM GROUNDWOOD FREE WASTE PAPER

	Original office records	Deinked	Original Books 50%(+)office record 50%	Deinked
Ash	13.23	4.25	15.08	7.33
Freeness of the pulp (°SR)	—	37	—	36
G. S. M.	—	66.0	—	67.7
Thickness (mm)	—	1.1	—	1.1
Breaking length (m)	2479 (av.)	2566	3052 (av.)	2354
Strength %	2.6	2.7	2.7	2.4
Folding endurance (Double fold)	7	9	15	7

where the changes in strength properties were small, Brecht associates strength losses with the loss of fines during sheet formation, a decrease in the relative proportion of fines to fibre corresponding to a loss in the strength and degree of fibre bonding. He claimed that fines losses increased with the slowness of pulp and that the original strength properties could be maintained through several recycles if small amounts of fines were returned to the stock each time.

Klye[17] found that handsheets from beaten eucalypt Kraft pulp successively air dried and reslushed showed progressive strength losses. Tear and burst decreased and approached the values of the unbeaten original pulp.

Wahren & Berg[18] in compering recycled sulphite and sulfate pulps at constant density, found that elastic properties and tear remained relatively constant while breaking length decreased slightly. Bovin et. al.[19] found that recycled chemical pulps showed strength losses when beaten to constant freeness, but that when beaten to constant breaking length, density and tear remained constant. Cildir & Haworth[20] found that both tensile and tear decreased with recycling, tear passing through a minimum. They attributed the strength loss to a reduction in bonding.

Cardwell & Alexander[21] determined the strength properties of recycled pulp and found no significant decrease in strength properties, such as burst, tear, zerospan, tensile strength and internal bond.

The study of deinking of waste paper carried out at RRL, Jorhat, using the flotation proccss shows that there is very little change in strength properties after recycling The overall stock loss is also low. It depends mainly on the grade of waste paper used. With old newspapers either alone or in combination of magazines (50 : 50), the stock losses are below 10% based on the raw material. In case of ground wood free waste papers such as books, old records etc. the loss is slightly higher (5-15%). This is due to the presence of higher filler content in the original waste paper, which is also removed together with the ink particles.

The consistency of the rejects from the secondary cell is about 1-15 percent. The rejects mainly consists of printing ink, fillers, fines and minor quantity of fibres. Due to high ink content the colour of the rejects is almost black. The ash content varies with the types of waste papers used. With 50 percent old news papers and 50 percent magazine stock, the ash of the rejects is found to be 44.6 percent.

Comparative results summarised in Table-VI and Table-VII as to the qualities of the basic fibre material and those of the deinked waste paper stock show that there is no adverse effect of the process. Table-VII shows that better results are obtained with a mixture of 50 percent magazines. The product has higher strength than original newsprint. Mixed type of waste papers also produce sheets of quite satisfactory strength properties. It has been observed that the handsheets made from the deinked mixed waste papers have superior qualities than the normal newsprint.

Table-VII shows that the process (B) for the removal of printing ink from groundwood free pulp can be used without affecting the properties of the basic fibre material.

Deinked waste paper stock is always superior to mechanical pulp due to presence of certain percentage of chemical pulp fibres. With higher percentage of chemical pulp fibres in the stock, the strength of the paper also increases.

The conclusions of this study do not necessarily apply to more complex recycling processess where additive mechanical and chemical treatment may be required and when paper making additives or contaminates are also present. For example, some types of mixed waste and fibre recovered from municipal waste contain appreciable proportions of low strength groundwood and significant quantities of dirt and grease which hinder interfibre bonding. In addition, such secondary fibres often require deinking and bleaching before reuse. After such treatments, the reclaimed fibres have variable strength properties dependent on their sources.

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