Efficient Utilisation of Secondary Fibres

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ABSTRACT

The recovery of secondary fibres i e wastepaper and its recycling as a rawmaterial in paper industry is increasing all over the world. The Indian paper industry is also facing tremendous pressure to conserve and efficiently utilize its conventional rawmaterials. With this in view, paper industry in the country is very much attracted to use the secondary fibres to substitute, to some extent, the conventional rawmaterial and also to meet their demand of rawmaterial.

One of the major problems in recycling of wastepaper is its collection at an economical price. This would depend to a large extent on joint and constructive efforts of households, government authorities and paper industry. Presently imported wastepaper is available for recycling by the industry. The efforts are needed to use both local and imported wastepaper efficiently.

This paper delas with the various sources of secondary fibres. the contaminations therein and their effective removal. A broad outline of various practices followed for the use of wastepaper have been highlighted particularly those which would be feasible under our conditions. An experiment was conducted for effective utilization of one of the better quality wastepaper i e. computer printouts, for different grades of paper. The results indicate that this wastepaper does not require the same chemical and mechanical treatment for different end uses. The mode of treatment may be selectively based on the quality and grade of end product desired. Apart from these, this paper also deals with the impact of secondary fibre utilization on paper quality, energy and pollution aspects.

The increasing demand of paper and paperboard and non availability of conventional raw materials paper industry in India is forced to search for suitable long term fibre resources to meet the requirement. The recycling of secondary fibres has got tremendous potentialities to partially substitute the conventional raw materials. The use of wastepaper is of considerable economic benefit to both industry and community-to the industry, by recycling, the amount of expensive virgin-fibre to the community, by mitigating the problems of solid disposal and by providing funds to the persons involved in collection.

The problems of recycling of wastepaper in Indian context are many. The economic manufacture of paper to meet the specifications required is not easy, as there is lot of variability in wastepaper and moreover, newspapers, magazines etc. are used secondarily for the domestic purposes. Most important fact is that the philosophy of recycliyg of wastepaper has not yet reached the mass. Indian environmental groups are also quite behind in bringing the recycling concept as a means of decreasing waste disposal to consumer level.

Hence, one of the alternatives is to import wastepaper from other countries. But most of the mills can not afford to buy good quality wastepaper, some times due to lack of incentives and uncertainty of its supply. Often the cost of imported wastepaper is high due to handling and transportation.

This paper deals with a few aspects of efficient utilization of wastepaper. The effects of wastepaper utilization on energy, pollution and paper properties are discussed. The paper also includes the various experimental results on better utilization of good quality wastepaper e.g. imported computer printouts.

TYPES OF WASTEPAPER

Wastepaper varieties are numerous at the base level. There are two ways of grading wastepapers. One is on the basis of their source and the other is on the technical disparities, i. e. specificities in their constituting factors. Commonly used grading is based on scurces i.e.

— Domestic refuse: Newspapers, magazines, board cartons

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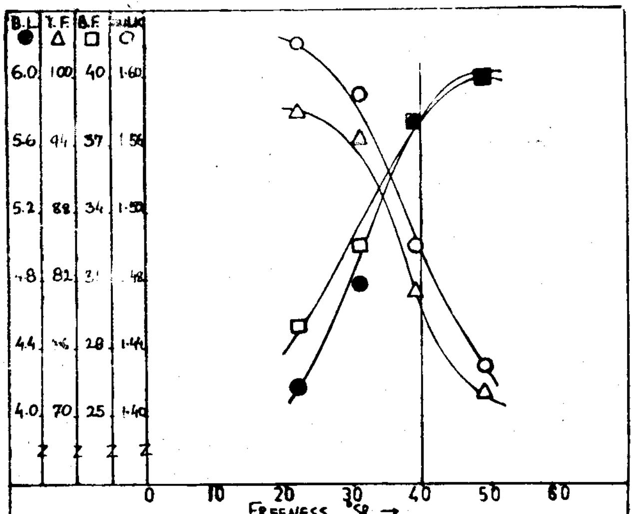

FIG. 1 FREENESS Vs STRENGTH PROPERTIES OF COMPUTER PRINTOUT.

- Industrial and trade refuse: Corrugated board, solid packaging board, duplex board, trimmings from converters and packaging manufacturers, paper sacks, paper savings from printers
- Office refuse: Ledgers, files and papers from Government offices, Universities and large business organizations
- Street sweepings: Contains all sorts of papers and boards.

CONTAMINANTS AND REMOVAL

Many different materials other than ink are laminated to paper in order to obtain the end product requirement. The presence of these contaminants bring in decrease in quality and unavoidable problems in processing. Broadly contaminants can be ctegorised under two heads.

Heavy contaminants include materials such as glass, metal fragments, sand, paper-clips, staples etc. These materials are of substantially higher density than cellulose and consequently can be removed quantitatively by screening and centrifugal cleaning. Low density contaminants are of two types. One type consists of materials easily freed from the fibres, such as string, cellophane, wood slivers, excelsiors, rags and wet strength papers. Secondly, the difficult to remove are plastic contaminants of infinite variety and complexity which have been added to the original paper or package to give its functional properties superior to those of untreated paper and board.

The screening process begins in the raw material handling zone. This is the best possible place for rejecting contaminants as this is the area in which they are found in their largest form and therefore easiest to remove. The separation procedures depend on the type of unwanted materials present in wastepaper chosen for recycling. The common separation procedures are:—

- Exceptionally big size contaminants can very well be separated by manual picking.
- Materials susceptible to magnetic force of attraction can be separated by the use of magnet.
- Heavy particles such as glass, rocks, staples, paper-clips etc. can be separated by screening cylinder with replaceable perforated screen plates where centrifugal force act to separate.
- The considerable difference in densities between contaminants and pulp or water some times helps in separation of those materials.
- A modified centrifugal cleaner is in use now-a-days where light weight particles can be separated from heavy rejects and accept. Even the cleaner is helpful in removing small pieces of polystyrene, low density waxes and hot melts, plastic contaminants (which originate from plastic marker tags in logging operation) and above all small particles developed during pulping which have escaped the conventional cleaning operation and later cause machinery damage and impair the product quality.
- By agglomeration i.e. gathering of small particles, an improvement in screening efficiency is achieved. A separation, using screens, also possible according to the shape of the stock impurities. Cube, shaped particles can be separated in fine-slotted screens with high degree of efficiency. Flat particles such as film and foil fragments, varnish particles and oblong particles like flakes are better retained by perforated screens with small holes.
- Some times the laminates are selectively dissolved by some chemicals. For example polyethylene separation from paper is being done by treatment with trichloroethylene or perchloroehtylene on hot condition where chemicals dissolve the low

density polyethylene as well as any wax coatings. Excess solvent can be steam distilled off the paper product. The separated wax and polyethylene can also be recovered.

DEINKING OF WASTE PAPER

One of the major contaminants is the ink in the paper. There are two basic steps in deinking :—(1) dissolving or loosening the ink by chemical means and (2) removing the ink from the pulp by mechanical washing. All deinking systems have the following stages :—

a) Pulping or defibering in the presence of chemicals.

b) Cleaning and screening.

c) Washing.

d) Dewatering and thickening.

Pulping :

The fibre furnish of wastepaper is one of the important parameters guiding chemicals to be used for pulping. Ground-wood is difficult to deink, it turns yellow during deinking.

Wells observed that for deinking six additives are necessary :

(1) An alkali to saponify the printing ink.

(2) A washing material e.g. a sodium soap of a fatty acid, sulfonated oil and fat alcohol as well as complex phosphates.

(3) A dispersing agent e.g. sulfonated products to separate the pigments adhering to the fibres and agglomerate the particles, also to emulsify the mineral oil or wax in the stock.

(4) A softner to dissolve synthetic resins if present.

(5) A medium for selective absorption of the pigment after separation from the fibres and to prevent re-adhesion to the fiibres e.g. loading materials like china clay serve this purpose. This is one of the main reasons why in a deinking process-generally certain percentage of magazine paper is added to incorporate fillers into the suspension and thereby achieve a better end whiteness of the stock.

(6) Chemicals like sodium pyrophosphate or sodium hexmetaphosphate to prevent the formation of calcium or magnesium soaps and also to dissolve the salts of these metals formed with hardwater.

For coloured ledgers, tab cards, computer printouts and other selected clinical fibre waste, some typical chemical formulae for pulping are :

(1) Sodium hydroxide, 4%

(2) Sodium hydroxide, 2.5% plus 2.5% sodium silicate plus 3% sodium carbonate.

(3) Sodium hydroxide 3% plus 2% sodium silicate.

(4) Sodium hypochlorite, 0.8% expressed as chlorine plus 4% sodium hydroxide.

Paper containing groundwood can be treated with 1% H_2O_2 plus 2% sodium hydroxide plus 3% sodium si icate. In all these cases dispersing agents and absorbing agents should be added for better efficiency of the system.

The batch pulping is preferred to that of continuous system. Most deinking is done in open pulpers at temperature of 50 to 82°C and a retention time of 30 minutes to 1 hr. 30 minutes. Pulping consistency vary from 7 to 25%. Some of the most undesirable materials are ink balls, plastic, particles, latex or oxidized rubber particles, asphalt, undispersed paper particles and hot melt adhdsives.

Centrifugal cleaners are generally used. The stock enters the top of the cleaners. The cleaner stock returns up through the centre area of low or no

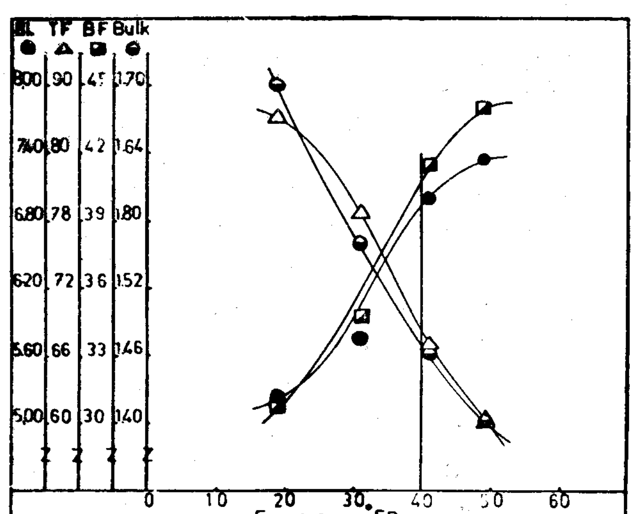

Fig. 2 Freeness Vs. Strength Properties of Bleached Pulp (Sulphate)

pressure and is discharged at the top of the separators The heavy contaminants separate at the bottom of the cleaners and are removed. Then, the stock is screened before washing. Pressure screens having small holes or slots are used either single or in series. Mostly primary screening is done at 1.0 to 1.5% consistencies. Fine screening is by means of rotary vibratory screens that vibrate at high frequency.

The cleaned and screened stock is washed to remove dispersed inks, clays and chemicals. The type of washing depends on individual preference, water availability. effluent handling system and initial investment limitation. Washing processes are based on the simple principle of draining or pressing the water in the stock through a screen. Success depends upon how finely divided and dispersed the ink is in the stock. The ink particles are fairly large and tend to become entrapped by the fibres during washing stage. Another effect is redeposition of the ink particles on the fibres surface.

FLOATATION CLEANING

To avoid some of these problems floatation washing system is followed. The system consists of a tank, and agitater, an overflow for froth removal, a mechanical paddle for removing the froth and a discharge pipe to pass the stock to the next cell in the floatation line. The high speed agitator induces a partial vacuum, which. in turn. uses air to enter the system and combine with the stock and floatation agents to form small air bubbles. The chemicals are used for suitable environment for the attraction of the ink particles and pigments to the air bubbles, which are generated at the bottom of the cell and pass upward through the stock slurry to become froth at the surface. As the ink-laden air bubbles reach the surface they are swept into a separate chamber by means of two armed rotating paddle that ensures the removal of a uniform volume of froth from each revolution.

Floatation systems are considered better due to higher yield of pulp, no absorption of ink Particles on fibre and reduced BOD load in comparison to washing system.

EXPERIMENTAL RESULTS

In the laborotory experimentation a detailed investigation on the fibre furnish of the imported computer printouts has been studied and was found that this sample constitutes softwood and hardwood fibres and the pulp is free from groundwood pulp. The ash content of the paper was 8.9%.

As the paper was free from groundwood special treatment with H_2O_2 was not essential. Computer printouts were completely defibrated at a constant revolution after soaking at a 1.2% consistency. Disintegrated pulp is evaluated for pulp and papermaking properties as control. Different pulpings were carried out with different chemical treatments at 50°C for 30 minutes at 5% stock consistency. Pulps were washed with constant volume of water. For comparison purposes the disintegrated pulp was further washed with the same volume of water. Handsheets were made as per the standard methods and evaluated for paper properties. Cleanliness of the handsheets were evaluated on relative basis based on visual observation. The lower numerical used indicates relatively low cleanliness of the handsheets (Table-1). In another set of experiment disintegrated pulp was beaten to about 40° SR and paper properties were evaluated (Table—2).

These results indicate that non beaten pulps recovered from disintegrated washed and different chemical treatments have considerable higher strength and can be used for better grades of paper. Further improvement in strength, if required, can be achieved by mild beating of the pulp. However, the cleanliness of the pulp and brightness are two significant parameters to be considered for good quality papers. Based on the requirement in the end use any one of these cooking conditions can be selected.

For optimisation of chemical concentration in pulping three different combinations of sodium hydroxide and calcium hypochlorite solutions were tried and CPN was pulped under identical conditions. The results showed that (Table—3) the improvement in the yield i.e. reducing the loss of fillers and fines from the deinked stock, can be achieved by reducing the chemical requirement for pulping and accordingly decreasing the wash water volume. However, the brightness and cleanliness of paper are not to be ignored. Floatation deinking method may substantially reduce the yield loss as well as remove ink and

TABLE—1

COMPARATIVE EVALUATION DATA FOR C P O PULP WITHOUT AND WITH CHEMICAL TREATMENT

Particulars	Disintegrated pulp	Disintegrated and washed pulp	Pulping Under Selected Condition 1	2	3	4
Chemicals for pulping	—	—	NaOH—4%	NaOH—3% Sodium silicate 2%	NaOH—4% Hypo—0.8%	NaOH 2.5% Sodium silicate-2.5% Sodium carnate-3%
Cooking condition						
Temperature, °C	—	—	50	50	50	50
Time, minutes	—	—	30	30	30	30
Consistency, %	—	—	5	5	5	5
Yield, % (on O.D. wt. of sample)	100	82.7	80.5	80.6	79.5	80.1
Final Wash Water pH,	6-0	6.7	6-7	6-7	6-7	6-7
Shrinkage, %	—	17.3	19.5	19.4	20.5	19.9
Brightness, % (Elrepho)	69.3	71.0	73.0	76.3	80.0	74.0
Bulk, cm³/g	1.66	1.75	1.59	1.60	1.63	1.68
Burst factor	26.3	28.1	34.8	31.5	32.2	29.9
Tear factor	109	101	107	99	99	104
Breaking length, m.	4040	4310	4870	5050	4800	4440
Cleanliness (Ascending numericals for increasing cleanliness given on visual observations)	1	2	3	5	6	4

Note : Handsheets were made at initial freeness (22-23 °SR).

TABLE—2

PHYSICAL STRENGTH PROPERTIES—UNBEATEN AND BEATEN COMPUTER PRINTOUT PULP

Particulars	Disintegrated CPO Sample	Beaten CPO Sample
Freeness, °SR	23	40
Bulk, cm³/g	1.66	1.47
Burst factor,	26.3	39.8
Tear factor,	109	82
Breaking length, M.	4040	5733

TABLE—3

CHEMICAL OPTIMISATION IN PULPING

Particulars	1	2	3
Chemicals for pulping	NaOH —4% Hypo —0.8%	NaOH 2% Hypo —0.8%	NaOH 1% Hypo —0.8%
Cooking Condition			
Temperature, °C	50	50	50
Time, minutes	30	30	30
Consistency, %	5.0	5.0	5.0
Volume of water used for washing, L/100g.	50	22	14
pH, (Final wash water)	6—7	6—7	6—7
Yield, % (on O.D. wt. of sample)	82 5	84.7	87.0
Shrinkage, %	17.5	15.3	13.0
Ash in pulp, %	5.3	3.5	2 6
Brightness, % (Elrepho)	80.1	80.7	81 4

other particles giving a brighter and cleaner sheet of paper. Further work in this area in selecting required chemical and following floatatation method is in progress. Beating behaviour of optimized CPO pulp is quite comparable to beaten bleached bamboo and mixed hardwood (90-10) pulp (Table—4). However, the brightness of the CPO pulp at all stages of beating is considerably higher than the beaten sulphate pulp. It is interesting to note that brightness of the beaten CPO pulp drops remarkably from a very high initial brightness to a law brightness after beating to higher degree of freeness. Hence, care should be taken to give mild beating to CPO. Blending of different proportion of CPO with bleached sulphate pulp can be done (Table—5) depending on the end product requirement. If high brightness and high tear strength in paper are required higher proportion of CPO in blending is recemmonded. Most importantly the economics of different combinations of blending of CPO with beaten sulphate pulp has to be worked out for different grades of paper.

TABLE—4

BEATEN PULP PROPERTIES OF CPO AND BLEACHED SULPHATE PULP (BAMBOO : MIXED HARDWOOD : 90 : 10)

Particulars	C P O, 100%				Bamboo : Mixed Hardwood 90 : 10			
Freeness, °SR	22	31	39	49	19	31	41	49
Bulk, cm³/g	1.62	1.59	1.50	1.43	1.70	1.56	1.46	1.40
Burst factor,	29.0	32.5	38.0	40.0	30 8	34.7	41 4	44.0
Tear factor,	97	95	81	72	87	79	67	60
Breaking length, M.	4184	4786	5741	6000	5238	5748	6995	7329
Brightness, % (Elrepho)	41.4	77.8	76.1	73.3	73.8	72.9	72.4	72.0

TABLE—5

HANDSHEET PAPER PROPERTIES OF BLENDED PULP

Particulars	BSP 100%	BSP : CPO 90 : 10	BSP : CPO 80 : 20	BSP : CPO 70 : 30	BSP : CPO 60 : 40	BSP : CPO 50 : 50	CPO 100%
Freeness, °SR	40	40	41	41	42	43	40
Bulk, cm³/g	1.47	1.47	1.48	1.47	14.8	1.47	1 50
Burst factor,	41.0	40.5	39.6	39.4	37.7	37.0	38.0
Tear factor,	68	69	72	74	78	79	80
Breaking length, M.	6920	6960	6590	6260	5870	5710	5760
Brightness, % Elrepho	72.4	73.0	74 2	75.0	75.5	76.0	76 1

N.B :—BSP = Bleached Sulphate Pulp (Bamboo : Mixed Hardwood : 90 : 10)

REFINING AND ENERGY CONSUMPTION

The power requirement for sucondary fibres refinining are low sinee they were refined earlier in the manufacture of paper. The properties of these fibres can be preserved by maintaining gentle conditions. In high consistency refining, where fibre to fibre rub action dominates, the pulp develops better strength at lower power consumption levels. Better energy requirement is about 25-30% of the conventional refining energy required.

Separation of fines from the pulp stock yields a fibre stock relatively free from fines. Fibre fines separated may either be rejected or fed to the board machine without refining. Fibre fraction free of fines can be used in the manufacture of better quality papers. The economic viability of the fibre fractionation process depends on operating costs of fibre fraction as compared to the enhanced value of the pulp.

The energy consumption in wastepaper based board mills is 30-40% that of an integrated paper mill.

EFFLUENT

The affluent from the wastepaper board mills has 80-120 ppm BOD, 250 ppm COD, 100-500 ppm suspended solids and pH 6-7. Fines present in the effluent pose some problems in the clarifiers.

Conversion of wastepaper for usable papers saves 15-16% on water consumption, 60-75% atmospheric pollution, 13-44% BOD, around 25% suspended solids in water and 39-100% solids waste.

PAPER PROPERTIES AND ITS BEHAVIOUR AFTER REPEATED RECYCLING

Pulp can be recycled without significant decrease in strength properties such as burst tear, zero-span tensile energy absorption and internal bonding characteristics provided the pulps are beaten to a constant breaking length instead of freeness.

Depending on the types of wastepaper and its processing the basic quality of the paper changes. The tear index is highest with washing than with floatation because this property depends essentially on long fibre content. With floatation and low ash starting material there is no significant difference in strength properties between the rawmaterial and dinked pulp.

The recycled pulp suffers some mechanical attrition, as evidenced by fibre classification and drainage time data but such attrition was not so severe as to prevent recovery of the initial strength.

When repeated recycling is done for the same stock, strength properties decreases if compared at the same freeness level. Each time as the fibre is pulped it is subjected to mechanical attrition, swelling and deswelling as the fibre is dried. This hardens the fibres and as a result the interfibre bonding properties diminishes.

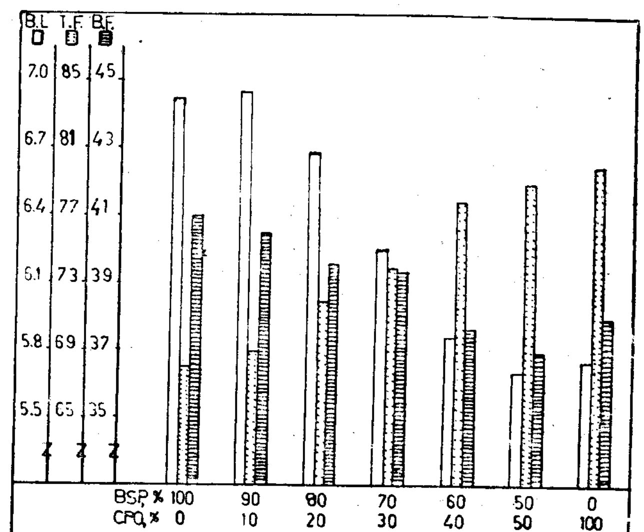

FIG-3 EFFECT ON STRENGTH PROPERTIES DUE TO BLENDING (BSP&CPO)

Box compressive strength and other properties of combined liner board and corrugating medium were all lower when virgin pulps were replaced with 100% recycled post consumer corrugated containers. Recycling clean corrugated fibre board resulted in losses in such properties as flat crush, burst and compressive strength-loses with generally increases as the percentage of recycled fibre increases.

CONCLUSION

The scarcity of natural fibrous source and increasing environmental consciousness in people have broght-up the necessity of recycling of wastepaper not only in countries where there is lack of wood but also in countries rich in forests. In future increased quantity of wastepaper are expected to be used all over the world in manufacturing quality papers, writing printing and newsprints. The initial sorting of the wastepapers, detection and removal of contaminants are very important and needs proper technology to ensure qnality of the end-products. Chemical treatment in the hydrapulper and subsequent floatation deinking system can achieve higher financial return by using the good quality of wastepaper pulp in quality papers rather than lower grades. The pulping conditions and washing system can be optimized depending on the end uses considering pulp yield, brightness and cleanliness of the pulp and above all on the cost of processing. If the supply of wastepaper can be maintaned, it will not only benefit the partial substitution of the rawmaterial but also in saving energy and reducing pollution load of the mill which will outweigh-extra investment required for the process.

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