Importance of Recycling Through Waste Paper Deinking

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ABSTRACT

The paper describes the importance of methodic waste paper recycling in which emphasis is laid on human behaviour, public awareness and development of deinking technical knowhow etc.

The conventional processes for deinking old waste paper are not fully matured. Therfore, continuous efforts world wide are focussed to modify the technologies so that problematic stickies, non impact inks (Xerox and other electrostatic printing inks), flexographic inks and other difficult to disperse inks are easily removed from waste papers. The paper reviews such efforts and also provides non technical information of a patented process developed by the author, which is based on aquasol technique and works on phase separation concept.

INTRODUCTION

The future demand of raw material can be met by proper recycling of waste paper. The advantages of recycling are many. The reduction of load on depleting forest resources is one of those advantages. The reduction of power requirement/ton of paper produced, environmental cleaning and source of income for the poor are other advantages. But inspite of all these advantages our country presently uses only 10-15% waste paper (mostly imported), compared tp average of 30-40% worldwide. The reasons for such an affair are both social and technical. The social reason is due to improper method of sorting and collection of waste paper, while the technical reason is the unability of removing printed ink from the waste paper and its low fibre strength. The problem of effective ink removal from older waste paper is getting aggrevated world over. The reason is that with the age the ink hardens and in the cross linked form becomes difficult to disperse. Waste paper like electrostatic printed, Xerox and laser printed also contain inks which are difficult to disperse by conventional deinking technologies viz wash deinking & Flotation deinking. In order to meet the quality demands of market and provide the returns needed to keep the recycled writing/printing and light shade paper bussiness attractive, the paper industry must learn how to economically manufacture large volumes of high quality writing printing papers that contain substantial quantities of recycled deinked fibre.

ADVANTAGES OF WASTE PAPER RECYCLING

Utilisation of waste paper is bound to have an impact on environmental cleaning in a big way. When say 50% of the raw material demand is met through waste paper ultilisation and additionally agricultural residues including other unconventional raw materials are in hand, the load on forest based raw materials may be reduced by 60-70%. This in turn will reduce the deforestation and help in preserving the ecology of the forests. We may be able to increase our forest covered area to a near value of 33% with the help of man made forests and afforestation programme in a planned way.

The pollutants generated from various categories of paper mills in India are given in **Table-I.** The reduction of B.O.D. in the case where waste paper replaces agricultural residues from 100-270 to 20-40 kg\ton itself can be taken as the basis of formulating

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Table-I

Type of Mill	Pollutants		
	Suspended solids kgs / ton	BOD kgs O / ton	COD
Large Integrated Mills based on Bamboo & Hardwood	100-150	40-60	150-200
Newsprint Mills	80-100	50-60	130-140
Small Paper Mills based on agricultural residues	100-250	100-270	400-1000
Small Paper Mills based on waste paper	50-90	20-40	50-100

the strategy of making environment clean through recycling of waste paper.

The other advantages are that waste paper is a cheap raw material having higher yield. Properly processed waste paper can be used for making most of the paper grades including writing/printing and light shade grades. As can be seen from the given **Table-II,** a lot of saving in various ingredients like forest based raw material, water, power, steam, coal etc., on one hand and reduction in solid waste disposal and capital investment/ton of paper is possible on the other; if hypothetically 40% pulp is replaced by waste paper pulp. Additionally, the use of waste paper is a better utilisation of waste product and can provide source of income to the poor.

PROBLEMS WITH WASTE PAPER RECYCLING

Inspite of so many advantages of waste paper recycling, its present recovery in our country lies in the range of 10-15% compared to average 40% world around. Some of the reasons for that are:-

(a) Improper and unorganised method of waste paper gradation at the time of collection.

(b) The paper industry mainly depends upon the imported waste paper. Our attention to indigenous waste paper due to low strength and other reasons remained negligible.

(c) Waste paper is used for only cheap grades of paper. Very little efforts have been put to make high quality papers from waste papers.

(d) We have never taken waste paper recycling seriously. No worth mentioning research work has been carried out to develop an indigenous process technology suitable to Indian waste paper, equipment and environment.

(e) The paper industry neither had, nor have a good guiding force to streamline the process technology for effective utilisation of waste paper.

Table-II (1)

Savings by way of using waste paper (Basis one ton of paper) Figure of 1985-86

Sl.No.	Particulars	Unit	100% mill pulp	60% mill pulp + 40% waste paper	Requirement reduction %
01.	Raw material consumption (Bamboo & hardwood)	Tonnes	2.7	1.62	40
02.	Water	M^3	272	206	24
03.	Power	KwH	1,500	1,308	13
04.	Steam	Tonnes	11.0	8.3	25
05.	Coal	Tonnes	1.32	1.13	14.4
06.	Solid wastes disposal	Tonnes	2.2	1.43	35
07.	Capital investment Rs/annual tonnes of paper	Rs. 24,000		Rs. 20,2000	16

(f) Human behaviour

The human behaviour, in the wake of need of waste paper utilisation, has to be turned more positive and realistic. One and all, starting from individual consumer upto collector, supplier, technology planner, scientist, equipment supplier and even Government has to play a role in the best possible way.

(g) Development of proper technical know how

Unfortunately, till date, no concentrated research work has evolved an indigenous technology for removing printing inks from waste paper so that it could be used for producing lighter shade grades of paper, writing printing papers for example. The two main techniques developed by foreign companies like Voith, Beloits and Black Clawson etc. are wash deinking and flotation deinking. The development of printing inks for better printing art has introduced a lot of technical bottlenecks for the successful utilisation of printed waste paper. Such inks are cross linked heat set inks, Xerox and other photostatic inks, etc.

(h) Efficient sorting of waste papers

No doubt, sorting at the source is the best possible choice for producing consistent grades of waste paper throughout. The indiscriminate collection are sure to make the task difficult if not impossible. The source could be expected to separate bleached, unbleached and heavy coloured papers, mechanical pulp paper (Newsprint) and adhesive bonded papers etc. One very important type of waste paper which need attention of separate collection is the hand written writing papers used by educational establishments, institutions and students at various levels.

Additional research and development is needed to identify key fibre properties which might serve the basis for sorting in dry or wet form.

(i) Contaminant removal

As said under (h) best way to reduce multiple contaminant entry is efficient sorting at the source, sorting at individual house and office and further proper collection through hawkers, municipal and state authorities using wagons, street bins etc. may help through proper public awareness of the purpose.

New approaches are needed in the area of separating contaminants from waste paper. The existing equipments are based on the two principles viz, screening and centrifugal cleaning. The former relates size difference while the latter on density difference between contaminants and cellulose fibres. A serious problem exists when waste paper contains contaminants having similar size and density e.g., Stickies, hot melts etc. The need is to understand and apply basic principles to specific separation of such tricky contaminants. The removal of the printing ink from the papers that are too old and printed with inks which are difficult to disperse by existing techniques, needs a special attention. In fact, fundamental aspects of process separation for both contaminant and ink removal need to be better understood. There is some understanding that role of solid liquid interfacial tension and zeeta potential phenomenas for both processes are important. Another area of potential research is to use extra cellular microbial enzymes e.g., lipases, cellulases, xylanases to facilitate contaminant and ink removal. Enzymes act on only surfaces which may affect solid liquid interfacial properties of a fibre suspension and may lead to increased release efficiencies and separation of contaminants and ink removal (2).

(j) Bleaching affects

Since molecular or morphological structure of the recycled fibre is not the same as that of virgin fibre the bleaching methods utilised conventionally may be injurious to the former. Therefore, attention should be paid to identification of various chromophores responsible for colour development in waste papers. The bleaching methods selected should be such that only chromophores are attacked leaving the cellulose fibres unharmed. Moreover, these bleaching methods should be environmentally friendly.

WORLD WIDE TRENDS TO DEINK DIFFICULT TO DISPERSE PRINTING INK CONTAINING PAPERS

With the development of more and more resistant printing and incorporation of non-impact-inks (NIP) into printing art, it has become difficult to deink all types of printed waste papers by conventional deinking technologies. With age, the ink hardens and becomes difficult to disperse. The dispersion is also difficult in case of electrostatically printed and laser printed papers.

Several methods and new techniques have been suggested to deink difficult-to-disperse inks by a

number of workers. Approaches undertaken during past few years to tackle such inks are (a) ink binder removal from the fibre with the combination of mechanical dispersion and removal (b) ink binder agglomeration followed by removal (3). Effective dispersion of Xerox inks, ultraviolet and other cross-linked inks along with stickies and hot melts is reported to have achieved at low consistencies by using Micar processor (4). Thermal dispersion at 120F using thermo mechanical refiner is tried by Quick for deinking Xerox papers (5). Chemical densification i.e., chemically modifying the toner particle surface is reported to have successful laser print deinking (6). Ultrasonic wave dispersion treatment for removal of ink has also been tried and some success is reported (7,8). A novel deinking formulation added to the pulper dislodges the toner particles from the cellulose fibres and agglomerates them into larger particles that could be removed using a slotted screen and forward cleaner (9). Dry defibering of the waste paper has been tried for removal of inks from papers having printing on heavily coated papers and Xerox papers but with limited success (10,11). One interesting new technology developed for deinking by Recoupe in U.S. is steam explosion vessel, heating under pressure for several minutes and discharging through a small blow valve. This treatment is claimed to be very effective at repulping the waste paper and also dispersing even laser printer inks and wax coated boards.

One of the most recent developments in the field of deinking worth mentioning is "Enzymic Deinking". This technique is some sort of pre-treatment to waste paper with cellulases and hemi-cellulases, reportedly dislodge ink particles from fibre surface and is further removed by flotation technique (12, 13). Since the cellulases and hemicellulases have hydrolysing nature, it might additionally reduce the strength of the cellulose fibre.

Under the unmatured status of deinking technology, it is proper to quote Randey Alex of Alberta Research Council, Oil Sands Department, who commented about such existing technologies as "Even though processes exist in the paper industry to remove ink and contaminants, a lot of it has been trial and error at the mill technical bench" (14).

All that, what has been seen above, calls for a revolutionary idea something different than what paper Industry is presently having or striving for to develop upon through agencies like equipment suppliers, ink manufacturers, research institutes and the like. This is so because to meet the quality demands of the market and provide the returns needed to keep the recycled printing and writing paper business attractive, industry must have to learn how to economically manufacture large volumes of high quality printing and writing papers that contain substantial quantities of mixed office waste such as photostats/ xerox copier and other non-impact printed materials.

DEINKING USING ORGANIC SOLVENTS

A group of chemicals namely organic solvents, is not so commonly used but tried for deinking of waste paper. However, some of the solvents like acetone, toluene, perchloroethylene, isopropanol, chlorinated hydrocarbon and other aliphatic hydrocarbons were recommended for the pre-treatment before deinking by conventional deinking technology (15). Further development of the idea of using organic solvent is reasoned by Woodward (16). According to him cost of the majority of these solvents prohibits their use in most of deinking programmes. Proper insolubility of these solvents in water unabling to make the desired solvent-water emulsion has been put as the second reason for leaving the solvent alone as regards their suitability for deinking. However, Woodward advised the use of a surfactant with good oil in water emulsifying properties while trying with a solvent to ensure good emulsification of the solvent in the pulper. It may be of interest to mention here that Riverside Paper corporation has developed and utilised hot chlorinated solvents to remove wax and polythene from cup stock and bleached board and found the whole thing profitable.

NOVEL IDEA

The novel idea on which the investigation is based, is to combine the aqueous deinking chemistry with the solvent extraction capability of various constituents. Since, it is observed that under certain modified surface behaviour of ink and cellulose fibres, the former is attracted by hydrophobic solvent phase while the latter remains in the aqueous phase.

The technique is framed from the following two already known facts in the current art of deinking:

(a) The pulping operation of the waste paper along with deinking chemicals is basically a laundering operation; and question arise when the clothes are not torn why should paper be. This way attempt is made to dislodge ink without defibering the paper in the initial stage.

(b) The nature of any printing ink is different than cellulose fibres; former mainly hydrophobic while the latter hydrophilic.

PHASE SEPARATION TECHNIQUE

Based on the above idea a phase separation technique for deinking is developed whose various aspects are given here under:

PRINCIPLE

(a) Unlike the conventional deinking techniques the waste papers in this study, the paper to be deinked, is not disintegrated into discrete fibres. This helps to maintain the brightness of the pulp obtained from such papers due to less of ink particles embedment into the fibrils (pores) of cellulose fibres.

(b) This study is also based on the fundamental difference in the properties of printing ink particles and cellulose fibres. The former being hydrophobic while the latter hydrophilic. Therefore, after the ink/vehicle is dislodged from the paper surface by suitable dispersing environment, the ink particles are separated by phase separation. The phase other than aqueous is selected such that minimum of its content remains with aqueous phase on one hand and maximum ink/vehicle is driven out into the non aqeous phase on the other.

PROCESS

Without divulging the details of the process being patented by C.S.I.R.; the dispersing environment can be acidic or alkaline solution of surface active agents of anionic and/ or cationic nature. The paper in the undefibred condition is soaked in the dispersing solution for a specific time at a specific temperature. The next step is the incorporation of water immissible solvent which synergestically dislodges the ink. The ink and its vehicle along with other solvent receptive material viz. stickies etc. go into solvent phase, while deinked cellulosic material remains in the aqueous phase. The two phases are easily separated.

The deinked paper after defiberation in the conventional manner can be given any treatment like post flotation, washing, dispersing, screening, centrifugal cleaning, inverse cleaning or may be even light bleaching, which treatment/treatments depend on the type of waste paper taken for deinking, condition of paper after deinking step of phase seperation and last but not the least on the intended grade of paper for which the pulp is to be used. Finally the deinked pulp can be used for making papers, stored or dried as per the choice.

SALIENT FEATURES

(a) It is a novel approach which attempts to deink most of the waste paper grades, newsprint and photostatic printed paper in particular.

(b) The process avoids using conventional chemicals which are deteriorative for strength and brightness of the resultant deinked pulp.

(c) The said process is expected to be less cost provocative due to simpler approach than conventional technique.

(d) The process is tested at bench scale and can be scaled up to pilot plant or commercial plant level.

ADVANTAGES

1. The process aims at achieving maximum brightness at the pre-bleaching stage as a result of special method of chemical treatment adopted during the pre-pulping stage.

2. The process also tries to minimise if not e'iminate the injurious chemicals used in the here to fore deinking technologies, because of which the quality of pulp with respect to strength, flexibility and other surface properties is greatly improved.

3. One of the advantages of improved process, with little addition/alternations here and there, is that it provides a very simple and efficient approach to deink the most complicated printed waste paper such as Electrostatic, Photostate, Xerox, and other older variety of old newsprint, etc. which grade in the existing deinking technologies as non dispersable inks and are considered to be problimatic.

4. With the involvement of suitable deinking chemicals and conditions where from the process aims at reducing/eliminating a very tedious problem i.e. "Stickies", faced during the deinking technology currently used.

5. Minimising the quantum of water used and due to other technical reasons as per the improved process, an advantage to get an environmentally friendly process is envisaged.

6. A very important advantage of the improved process of deinking disclosed is that the good quality fibre loss is expected to be much less compared with that takes place in current technologies of deinking.

7. The costly chemicals used in the improved process which can be recovered to the level of 95% + making the whole thing economical.

8. The improved process of deinking can be tailored cut to any desirable size depending on the need. The size may range from a small cottage industry to a full fledged small, medium or large scale waste paper recycling unit.

CONCLUSION

Waste paper recycling after deinking has always been important mainly due to shortage of forest based raw materials for making more and more paper. But, because of non-availability of a matured technology utilisation figure has yet to cross 40% mark world over, while in India this figure is much low. The development of harder inks, non impact inks entering waste paper stream have made the removal of printing inks all the more difficult by conventional deinking technologies. Efforts are on worldwide to successfully deink the waste papers containing diffcult to disperse inks. Therefore, in view of future raw material shortage and environmental legislations to maintain ecological balance, there is an immediate need to develop a deinking technology which could ensure uninterrupted supply of deinked waste paper pulp suitable for making all type of light coloured paper grades including writing printing papers. To have a begining, a process based on aquasol technology is developed by C.S.I.R., The industry should come forward and sponser the project of scaling up the bench scale process through a pilot plant to a full fledged commercial size technology which is the need of the hour.

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