A Review on Waste Paper Processing

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ABSTRACT

A brief description of the Recycled Fibre Process, sequence in removal of contaminants by the Mechanical and Chemical Treatment, problems associated during processing, various bleaching techniques, technology upgradation and process modifications are reviewed and summarised.

INTRODUCTION

Most important factor which will decide the growth rate of paper industry in the coming years is the availability of rawmaterials economically. Pulp and paper industry has historically been very intensive user of natural resources like forest, water, energy etc. Some of these resources are depleting day by day due to population explosion, modernisation, urbanisation and industrialisation. Industrial growth of paper industry depends upon the fiber availability. The raw material for fibre requirement depends upon

1) Forest based wood and bamboo.

2) Agro bases like bagasse, rice/wheat straw, kenaf etc.

3) Secondary fibres.

Due to depletion of forest resources, increase in per capita consumption of paper, The shortfall of fibre estimated in India during 2000- 2001 will be 16.92 lakhs MT and 2010 To 2011 36.4 lakhs MT to meet the supply and demand gap, to conserve and protect natural resources and pressure from enviromental groups, government control over cutting of the forest, toxicity level of conventional process etc. The focus of the industry was shifted to waste paper utilisation.

WASTEPAPER

When it comes to question about waste paper utilization trends, it is difficult to obtain accurate source of information about the quality used in pulp and paper industry. For the last decade the recovered paper has become a global commodity although the industry sources of pulp have not changes in recent years. The percentage of Recycled and Deinked Fibre used in paper making process has grown significently. Countries like Netherland, Singapore and Taiwan have recovered paper utilization rates more than 85%.

The Global Scenario show that (3)

Year	Pulp and Paper Prodn. (Million Tons)	Waste Paper Consumption (Million Tons)	Apperent Utilization Rate %
1986	202	63	31
1990	237	85	36
1992	246	96	39
2000	307	138	45

It is estimated that the apperent utilisation rate will increase from 31% in 1986 to 45% in the year 2000. Present utilisation of waste paper in India is around

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15% of the total paper produced in the country c npared to recycle ratio over 25% in developed countries. The advantages of recycled fibre for

SR. NO.	PARAMETER	PROCESS			
		CP	TMP	CTMP	DIP
01.	YIELD, %	40-45	92-94	88-92	75-85
02.	WATER CONSUMPTION, m^3/MT	60	140-150	50	10-20
03.	ENERGY REQUIREMENT, kWh	500	2000-2200	1500	400
04.	BOD LOAD, kg/ADMT	10	5	27	7
05.	COLOUR Pt. CO. UNITS/ADMT	1000	500	2,00000	< 100

manufacturing of pulp is given as follows:

The positive impact of waste paper pulping is as follows:

1) Less water consumption

2) Less energy input

3) Less expensive for treatment of waste water because less volume. BOD, COD, Colour, Toxicity etc.

4) Maximum waste water can be reused.

5) Less capital investment.

6) Saving of wood means helping the nature (Deforestation).

COLLECTION OF WASTE PAPER

Industrial waste paper is collected mainly from different sources such as publisher, printing house, converters, departmental stores, Super Markets and by mostly dealers of industrial waste. Old news, magazines and other wasterpaper is collected by door to door basis, is another source of collection. Green Earth movement volunteers are also collecting the wastepaper and sell at a minimum price to the dealers and trading concerns. Other channels include local governments to reduce the garbage by keeping seperate blue boxes for waste paper and ask residents to use these boxes for paper related materials.

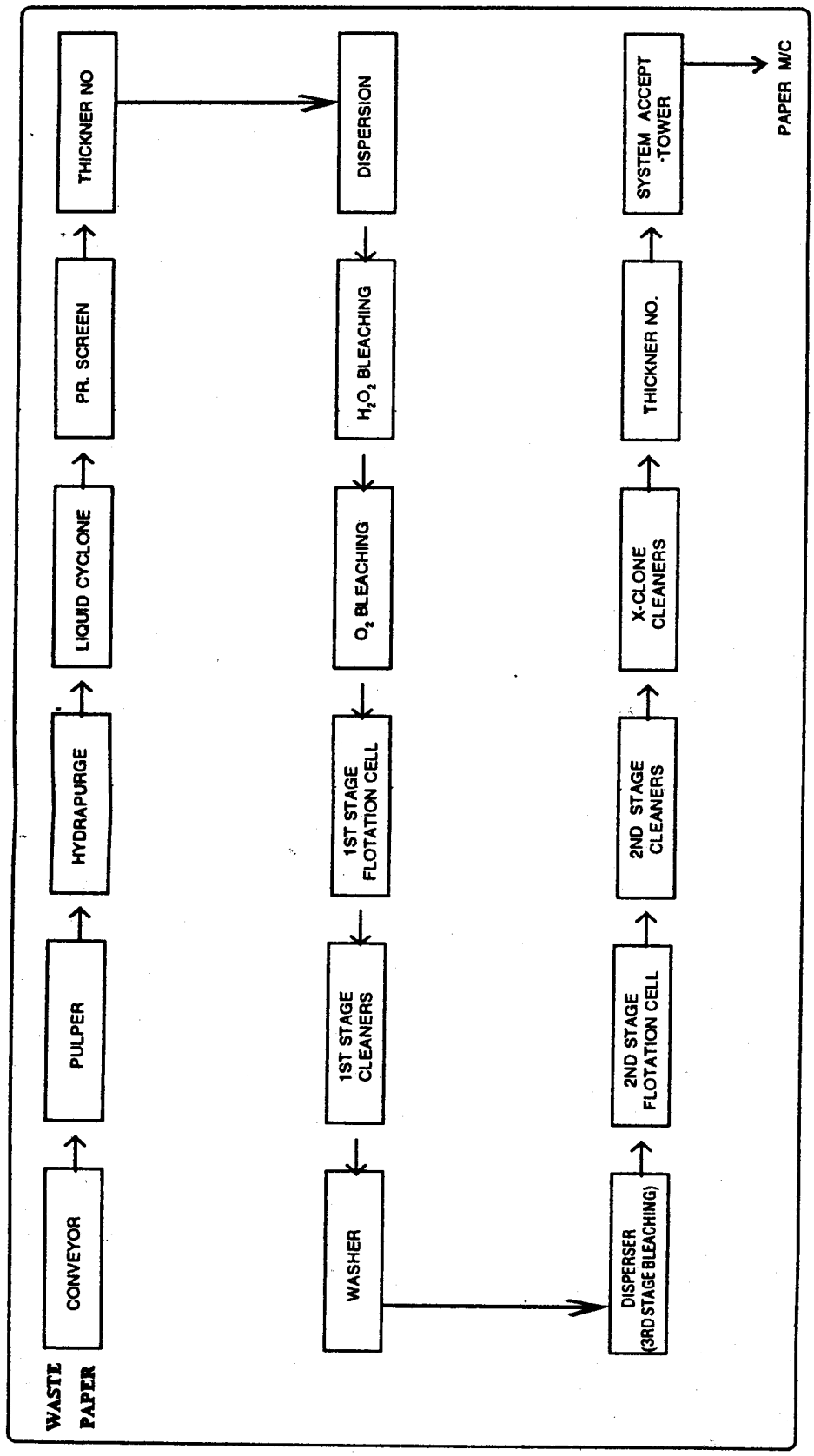
When waste papers are a mixture of many fibre types, depending upon the end use they have been sorted out and graded accordingly. The purpose of waste paper grading system is to provide a frame work for sorting so that grades which are defined with the system represent acceptable levels of non homogenity of fibre types. There are many different waste paper grading systems are in use in various countries. In U.K. The grading system concentrate on the production of homogenous grades. In Germany and Europe the emphasis has been on volume recovery. Price of waste paper depends upon the grades, collection charges, labour, sorting, baling, transportation. etc.

SELECTION OF APPROPRIATE RECYCLING TECHNOLOGY

A great deal of effort is required for designing the waste paper process. The process sequence, equipment, capacity technology and operation and all these are designed according to the raw-material and the final product. Contaminant removal by various mechanical and chemical additive treatment methods are developed. The problem associated during the processing of waste paper is the various types of contaminants like additives, consumer debris, stickies etc.

WASTE PAPER PROCESSING

Crow and Secor (5) list 10 steps for deinking, pulping, pre-washing, heat and chemical loop, screening (coarse and fine) through flow and reverse cleaning, washing flotation, dispersion, bleaching and water recirculation and make up. Not all the steps are used in all recycles fibre plants. Process for waste paper treatment particularly deinking techniques are gaining movementum. Now a days the process generally include pulping, screening, cleaning and deinking by


ANNEXURE-1 PROCESS FLOW DIAGRAM FOR DEINKING SYSTEM
WASTE PAPER
CONVEYOR
PULPER
HYDRAPURGE
LIQUID CYCLONE
PR. SCREEN
THICKNER NO
WASHER
1ST STAGE CLEANERS
1ST STAGE FLOTATION CELL
O2 BLEACHING
H2O2 BLEACHING
DISPERSION
DISPERSER (3RD STAGE BLEACHING)
2ND STAGE FLOTATION CELL
2ND STAGE CLEANERS
X-CLONE CLEANERS
THICKNER NO.
SYSTEM ACCEPT TOWER
PAPER M/C

combination of soaking, flotation and washing depending upon the input raw material and final product. A typical process flow diagram for deinking system was been illustrated in Annexure-I.

(I) PULPING

Pulping is the first unit operation in the recycling and deinking process. The pulping process is to facilitate the separation of the non-fibrous material from the fibres, remove the contaminants in subsequent process. Various options have developed now a days like,

1) High consistancy pulping; batch type and continuous
2) Low consistency pulping;
3) Explosion pulping system
4) Soaking or reaction tower for course pulping (OCC, NCC etc.)

The energy input is required to achieve the defibering goal. The pulping variables are (A) temperature and (B) pH. The increased pulping temperature reduces the pupling time, and also seperation of ink and other contaminants (4) above 70°C aggrevate the stickies problem. Higher pH will increase the yield loss, wetting speed increased there by reduction in pulping time and reduce the specific electrical energy consumption (5).

The pulper additives include alkali for fibre swelling, Deinking chemicals and H_2O_2 with associated chemicals to stablize peroxide. During pulping some of the gross contaminants like wire, plastic, tapes etc. Can be removed by ragger. Large heavy contaminants were screened through the holes of the pulper and seperated by Junk remover. Typically white ledger paper pulped at 15% consistancy, ONP at 5-10% consistancy & OCC at 5% consistancy.

II. SCREENING AND CLEANING

Stock from pulper is sent to screening system for removing non-fibrous contaminants. Seperation depends upon size and shape of the contaminants. Different types of sequences are required for seperation depending upon the size of the contaminants. The predominantly particles whose form is not solid enough to prevent them from being altered in shape or size through acceleration. The size of particles is wide ranging and so are specific weight of these particles can be 0.3 times to 2.2 times as heavy as fibre (6) the debris in waste paper comparison with fibre is as given in the table on page no. 65.

Generally two types of screens are used for cleaning. The course screens are used to remove the debris, rigid particles which are larger than screen perforations normally 12-20 mm. subsequent course screening done by holed pressure screens with the perforation in the range of 1.2 to 2 mm with the consistancy of 1 to 5% followed by a fine screens. The fine screens are slotted screen can be operated at 0.8 -5% consistancy. The slot width varied from 0.125 to 0.4 mm and even now a days fine slots of 0.1 mm are being used for better cleaning. Centrifugal cleaning are useful for removal of high and low density contaminants. High density cleaners useful for removal of high specific gravity (>1) like sand, grit, glass pins etc. and low density cleaners are useful in removing of low specific gravity (< 1) like wax, plastic, adhesives etc. All these systems operate on different density principle. Generally the specific gravity of pulp is 0.88 to 1.08 gm/cm^3 (7).

III. DISPERSION AND KNEADING

The emergence of polymeric inks used in laser printers and copier papers necessiated usage of dispersion and knead equipment, it helps the ink release from fibre and reduction of ink particle size. Temperature upto 150 °C helps to melt the stickies and reduces of biological acitivity and disadvantage is high energy cost. As a function of different particle sizes of undesirable particles like macroparticles can be removed from the suspension by mechanical separation, fine tuning of chemical additives in the entire system, optimisation of water management and seperation of microstickies from the filtrate are the main tools to control stickies.

IV. DEINKING

Generally ink constitute 0.5 to 2% of the mass of the waste paper. Deinking can be done by washing/ flotation depending upon the requirement. The washing deinking is less effective in the removal of large ink specks >20 microns where as flotation deinking is less effective in removal of small ink specks < 20 microns.

A) WASHING DEINKING

Ink removal by washing from fibre using caustic, sodium silicate, dispersant and H_2O_2 in pulper . The water ink emulsion is washed from the pulp and the ink is removed from the wash water by flocculation or flotation using suitable chemicals. The clarified water

SR. NO.	TYPE	SIZE IN PARTICLES (μm)	SPECIFIC WEIGHT IN COMPARISON WITH FIBRE
1.	SAND	40 - 4000	2.0 - 2.2
2.	METAL	> 4000	6 - 9
3.	FILLER	> 40	1.8 - 2.6
4.	WAX	> 40	0.9 - 1.0
5.	POLYETHYLENE	400 - 4000	0.91 - 0.97
6.	POLYSTYRENE	400 - 4000	0.3 - 0.5
7.	LATEX/RUBBER	40 - 4000	0.3 - 1.1
8.	HOT MELTS	40 - 4000	0.35 - 1.1
9.	TAR	40 - 400	1.1 - 1.5
10.	PAINT	LIQUID 400	1.2 - 1.6

may be reused in the system. The washing equipment may take on variety of forms like vacuum washers, double belt washers, DNT washer etc. The counter current washing is common in washing deinking. Washing efficiency is influenced by inlet consistancy, freeness, pH. temp. rpm of washer, wire porosity. The inlet consistancies are in the range of 0.7 to 3% and outlet consistancy of 6-12%.

B. FLOTATION DEINKING

Flotation is a process that seperates materials based on the property of wettability. Ink particles are more hydrophobic than fibres. Chemicals are added to increase the difference. Between fiber and inks hydrophic materials are able to adhere to the air bubbles and rise to the surface and the process is carried out in flotation cells. Large ink particles size 10-50 micron can agglomerete and skimmed out from the slurry. The system efficiency depends upon the various factors like stock consistancy, temp, pH, collector chemicals, water hardness, ink particle size, air bubble dia, air to stock ratio and foam removal system. Flotation deinking is done at lower consistancy than washing deinking system i.e. 1% and temperature about 40-45°C, pH range of 6-9. The collector chemicals like fatty acid salt with 0.4 - 0.8% on OD fibre gives good results. High concentration have negative effect. The minimal air bubble size is estimated at 0.3 to 0.5 mm. Air stock ratio 10:1 to 4:1 and retention time of 5 to 20 minutes are used in the process. Apart from this ther are other deinking techniques like dry deinking, solvent deinking, ultrasonic etc. Which are not successful in commercial scale.

V) WATER RECYCLING AND SLUDGE RECOVERY

In order to reuse the water containing ink, the dissolved air flotation process is used with the aid of polymers. The sludge collected can be used for land fill, fuel in boiler, low grade board making etc.

VI) BLEACHING OF SECONDARY FIBRE

After deinking and cleaning, bleaching of deinked pulp is done similar to the virgin pulp. The bleaching can be done with oxidative or reducing agents. Oxidation attempts to modify the lignin/ink by either making it soluble for removal in the washing stage or by changing its colour to white. Reducing agents modify the chemical structure of dyes present in the pulp causing them to appear colourless. Oxidising agents used for bleaching like chlorine, hypochlorite, Hydrogen peroxide, oxygen and ozone. The reducing agents used in bleaching the recycled fibre are sodium hydrosulphite and formamidine sulfinic acid (FAS). Colour is an integral part of sec. fibre furnishes due to lignin presence, apart from other sources like pigments & dyes. Dyes are largely unaffected by oxidative bleaching but can be decolorised by reductive bleaching. Usage of chlorine and its compounds are restricted due to various reasons like AOX formation, low yields and colour reversion. Traditionally H_2O_2 and sodium hydrosulphite or its combination was used for high bright ess gains. Chlorination of pine and birch wood pulp effluents can increase the toxicity and elemental chlorine used for bleaching pulp typically discharge 5-10 kg of AOX/MT of pulp.

HYDROGEN PEROXIDE

H_2O_2 is a very effective lignin preservative bleaching agent. It can be used in pulper as well as in bleach tower. When added in pulper it reduces the yellowness of pulp caused by caustic and a brightness gain of 3 to 8 points and in tower bleach response of 10- 15 points were reported (8). H_2O_2 marginally effective in colour stripping dyes and is often used in conjunction with a reductive bleaching.

OXYGEN AND OZONE

These strong oxidative bleaching agents can be used only when very little mechanical pulp is present in the waste paper. During oxygen bleaching lignin oxidation takes place and brightnes gain of 9-13 points are reported for various grades of secondary fibre. Oxygen bleaching bleaches in alkaline conditions (pH 9-12) and high temperature of 110 to 130°C. If intermediate reactions are not properly controlled severe degradation of cellulose occurs. Oxygen delignification at medium consistancy can increase pulp yield and reduce chemical costs and also reduces effluent loads. Oxygen delignification coupled with 100% chlorine dioxide substitution have reported reduction of 93% in AOX level being 0.2 kg/MT or less. Ozone is a powerful oxidizer, generally produced at site by electrolysis through oxygen. Ozone gas reacts to destroy the dyes and oxidise contaminants as well as acting on chromophores present in the pulp. Brightness gain of 5-12 points with wood free deinked pulp with single ozone stage, when combined with H_2O_2 15 points gain have been observed (9). It is most effective when pulp is acidified to pH 2-4 and high consistency with a reaction time of 1 to 5 minutes.

SODIUM HYDROSULPHITE

It is the most common reductive bleaching agent for waste paper. Hydrosulphite is an excellent bleaching agent for color stripping and there is no loss of yield (10) in the bleaching stage. The conditions (11) required is 3-5% consistency, Temp. 60°C. Retention time 1-2 hrs. At 6 pH and in tower application it offers 10-15 points brightness gain. Secondary fibre containing ground wood is subject to alkali darkening at high alkalinity and high consistancy pulps have not shown good brightness response to hydrosulphite bleaching.

FAS: FAS is generally called as thiourea. It is an effective reductive bleaching agent. It has been found to be a better color striping than hydrosulphite. It is most effective at medium consistency with high temperatures consistancy range of 3-35% have been used effectively with temperature range of 50-80°C. If alkalinity is not carefully controlled caustic yellowing of ground wood countaining fibre may occur.

New bleaching and color removing chemicals are gaining movementum with new technologies

They are 1) peroxy acid salts

2) Potassium peroxy monosulphate (PPMS)

3) Caros Acid (H_2SO_6).

4) Enzyme bleaching

5) Direct borol injection

In order to improve the optical cleanliness of secondary fibre, Herald Selder (12) has suggested the effective process modules for removing disturbing components shown on page no. 67.

TECHNOLOGY UPGRADATION AND PROCESS MODIFICATION

There are several bottlenects while processing the recycles fibre. Strategies for mill to overcome wax containing, OCC entering the mill should be minimised by establishing routine furnish checks and seggregation. The pulping (13) temperature should be maintained around 50-55°C so as to keep wax particle large enough to be screened out. The concentration stream in the mill should be purged to reduce the build up of wax and other contaminant in the white water systems. Equipment like turbo pulper can operate continously without compromising the throughput and contaminant removal. It has also having advantage like increased deflaking of the fibre. With a continuous feed until the tank is filled with 50-60% of pure rejects as all the good brokenup fibres have passed through the screen plate. A motor load sensor will indicate when the body is full of reject as claimed by the suppliers (Kraft Paper machinery U.K.) to produce high quality liner board with OCC involves the use of coarse and fine screening together with forward and through flow cleaners or rotating body cleaners. Many of the debris are extremely flexible and may change their form through its flow geometry and mainly due to turbulance on the screen basket surface and significantly reduce the chances of seperation by pressure screen. The "gentle screening" process i.e. low acceleration by the feed of the pressure screen and the rotor, can prevent

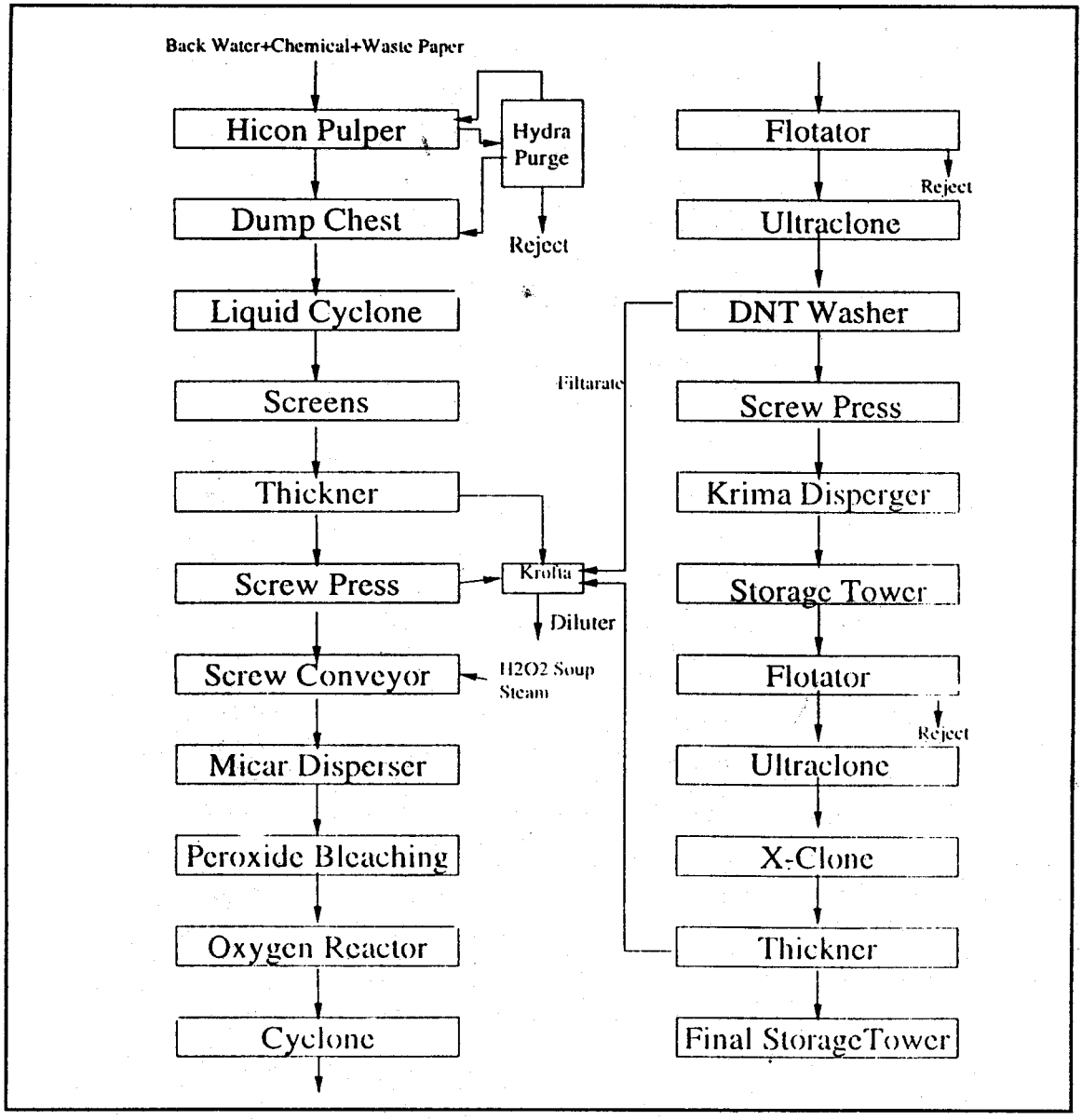
DISTURBING COMPONENTS	SCREEN ING	FLOTATION	WASHING	PROCESS MODULE				
				CENTRICLEANING		DISPER- SION	BLEACHING	
				HEAVY WEIGHT	LIGHT WEIGHT		OXID- ATIVE	REDU- CTIVE
Conventional Printing Inks	—	●	◑	○	○	●	○	○
Non Impact Inks	○	●	—	○	○	●	—	—
Lacquers	○	●	—	◑	—	●	—	—
Flexo Inks	—	○	●	—	○	—	—	—
Fibres with Undetached inks	—	—	—	—	—	●	◑	○
Unbleached fibres	—	—	—	—	—	—	●	—
Coloured fibres	—	—	—	—	—	—	—	●

● HIGH ◑ MEDIUM ○ LOW — NO EFFECT

such type of passing. Ceramic material of one piece with smooth surface and wear resistance have an excellent choice of material for cleaner manufacturing. Dispersion and further processing can be added depending on the quality requirement.

Conventional deinking of ONP, OMG mixture is carried out under alkaline conditions to enhance ink detachment due to fibre swelling. Peroxide and silicate are added to guard against fibre yellowing. Using standard fatty acid soaps as an ink removal of 93% and ash removal of 12-15% with fibre loss of 4-6% is reported. Regarding deinking of flexographic newspring the alkaline condition and addition of calcium ions and fatty acids improves the flotation efficiency. Flotation stage II after dispersion can make an important contribution to reduce the stickies. Dispersion can reduce the size but also helps in better flotation. The washing efficiency can be improved by lowering the feed consistancy. some of the studies revealed that laser printed paper 50% computer print out under neutral condition using properietary inorganic deinking agent higher brightness is obtained after flotation. Some studies indicate predispersion flotation is effective in removing ink particles in 75-300 micron range. Forward cleaning is more effective in removing ink greater than 300 micron size. To achieve target brightness of 85% ISO from office recovered papers the bleaching sequence should be (EOP) ZY, (EOP) ZP and (EOP) ZF process. The chemical cost is lowest for (EOP) ZY process. To remove stickies, non-ionic polymer surfactant is more effective than alkyl phonol ethoxylate in flotation system. The correct use of cationic and anionic wet end additives can contribute to improve paper machine operation. In water clarification and reuse of dual polymer system gives beter results. The overall environmental impact of deinked recovered paper, the solid waste disposal should be judged against burning or incintration of the residue. Heating values of residue taken from deinking plant ranges from 2800 to 3900 kCal/kg. Ash consists of mainly silica, aluminium, calcium and small amounts of other metals. Due to deinking process, no change in crystalinity index or degree of polymerisation. Fibre length is uneffected by pulping and by washing. It is noticed that the fibrillation factor of pulp decreased with increasing number of recyles. The deinking systems followed in Rama Newsparts and paper Ltd. for processing waste paper is shown in annexure II/III.

Flotation Deinking Plant Annexure-II



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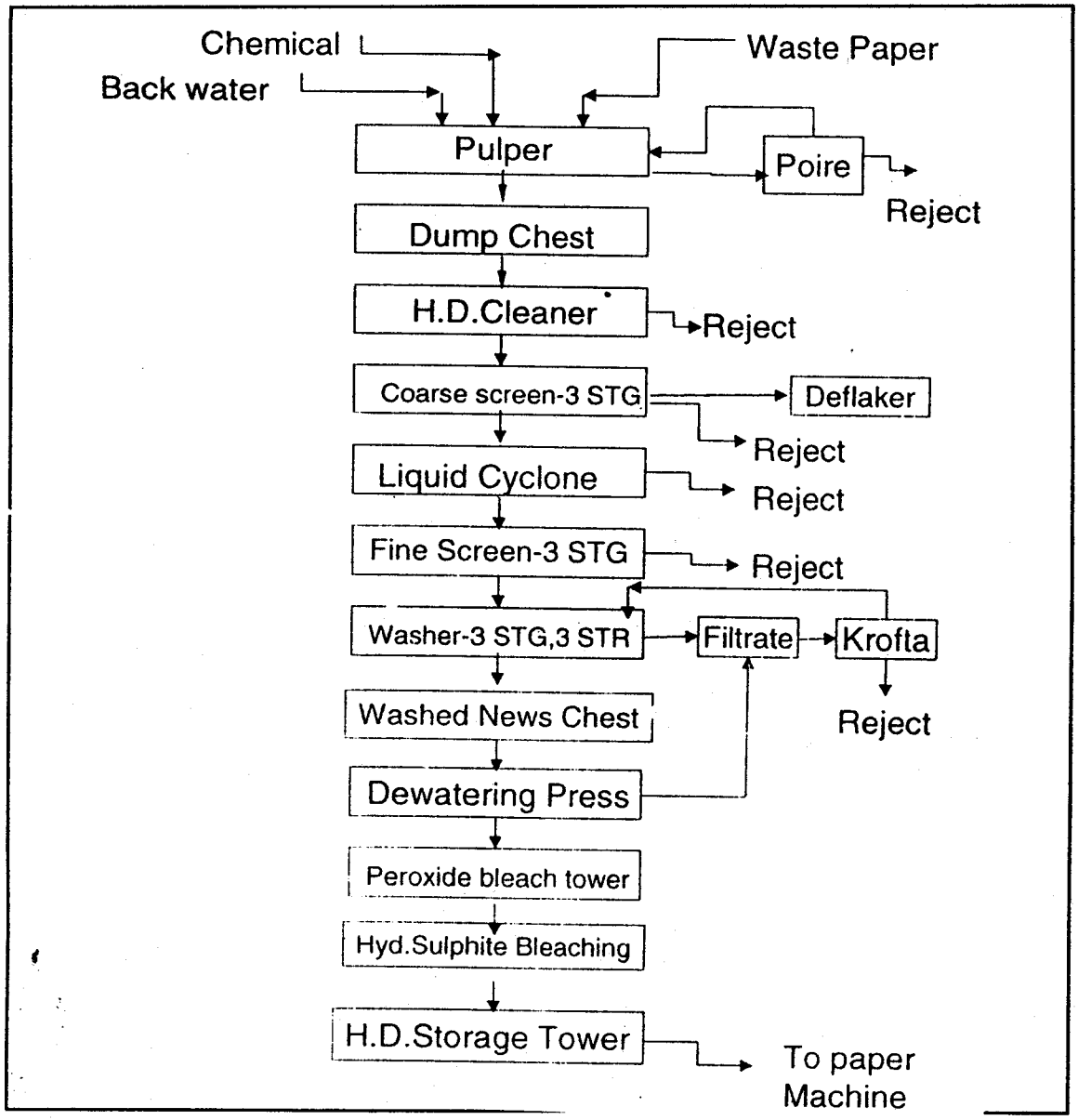
Washing Deinking Plant Annexure III



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