Recent Advances in Deinking Techonology

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ABSTRACT: The 10 important stages in deinking process of various waste papers namely pulping, prewash, screening, reverse cleaning, forward cleaning, washing, floatation, dispersion, bleaching and water recirculation have been described. Recent advances and improvements in deinking technology specially by use of different chemicals have been reviewed. The performance in floatation stage has been elaborated supplementing with process improvement possibilities.

INTRODUCTION:

The global galloping trend in price rise of fibrous raw materials and waste disposal problem are inducting paper producers for increasing use of secondary fibre for paper products. The dramatic development in paper quality and printing technology, brought in the last decade, has complicated the process of deinking (1). Separation of speciality chemicals used for printing, with varying properties without deteriorating the strength and optical properties of the cellulosic papers, calls for highly advanced and non-conventional deinking processes, such as floatation, adsorption on polysterene foam pills (2) and others. Application of image analyser (3-4) considered vital now for effective separation of microscopic ink particles and formation of ink particles agglomerates. Deinking technology necessitates thorough understanding of the ink particle-fibre interaction and interface science. Deinking technique to be followed, depends on the waste paper; for example, newspapers, can be deinked without floatation step unlike with magazines (offset printed). For laser or xerography printed (5) papers, the process of conventional washing and floatation alone do not work (5-8). Based on desired brightness level and strength, requirement of chemical addition as well as bleaching, washing, floatation and other steps are to be decided (8).

The waste paper consumption rate in different countries are given in Table-1. The world wide consumption amounts to 37% (110 million tons) in 1995 and likely to increase to 55.3% by the year 2000 (9-11).

TABLE-1

Consumption of waste paper in different countries- (9-11)

Country/Continent	Year	Amount in Million tons
World wide	1995	110.0
Total Europe	1995	25.0
Germany	1995	7.8
England	1995	3.0
Sweden	1992	1.2
U.S.A.	1994	3.2
Australia	1994	0.97
Africa	1991	0.55
South Africa	1991	0.21
Japan	1992	14.8
Korea	1992	3.8
Taiwan	1992	3.2
Malaysia	1992	1.24
Indonesia	1992	1.19
Thailand	1992	0.86
Singapore	1992	1.01
Philippines	1992	0.32
India	1995	2.06

Waste paper:

In order to make the deinking process effective, the waste paper collection, storage and classification according to ink or paper qualities are very important. The source of waste paper can be divided into 3 groups:

a) Household, b) General industry including shops, hotels, food products etc. and c). New paper converters from printing houses and others.

The waste paper grades range from high

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quality wood free white non printed covering trim, offsets and boxmakers clippings to low quality mixed grades containing significant quantities of mechnical pulp and a diverse range of contaminants. Different grades of waste paper in U.K. (1) has been listed in Table-2. In U.S.A. the waste papers have been divided into 49 different grades. In India (12) different grades of waste paper can be classified as given in Table-3.

TABLE-2
Waste Paper Classification (UK) (1)

Group	Composition
1.	Pulp substitutes, best white and cream shavings, fine shavings.
2.	White and coloured shavings, mechanical wood pulp cuttings, best one cuts.
3.	Buff envelop cuttings, buff tab cards, light browns.
4.	Ledger, heavy letter, continuous stationary carbonless copy, computer print out (CPO).
5.	Overissue and one read news, periodicals and magazines (PAMS).
6.	Coloured manilla, brown and coloured kraft, wet strength kraft sack.
7.	New kraft lined corrugated waste.
8.	Container waste.
9.	Mixed waste paper and coloured cards.

TABLE-3
Waste Paper Classification (India) (12)

Group	Composition
A.	Pure white cuttings, trimmings, unprinted (with and without ruling) and ledger paper.
B.	Mixture of printed and written waste of white and coloured paper.
C.	Old Newspaper without contamination.
D.	Printed books and sheets.
E.	B.B. gray, coloured and unbleached printed paper and board.
F.	Kraft corrugated cartoon pieces (bitumen free) and
G.	All sorts of paper and board, printed-coloured unbleached papers.

The raw material for deinking plant is taken from a broad base of waste paper grades dependent on the required deinked pulp quality and final paper product. Table-4 shows some waste paper grades and their end use. Recently, the use of deinked newsprint as a part of furnish for production of copy paper has been reported (13).

TABLE-4
Products from waste paper (17,18)

Waste	Product
Old Newspapers (ONP), Periodicals and magazines (PAMS)	News print
Ledger, Mixed office paper, computer print out xerographic. ONP and PAMS	Tissue
Light printed, pulp substitutes and white and light shavings	Printing and Writing
Mixed waste, ONP box board cuttings, wrappers and corrugated containers	Paper board, Liner board and insulation

Deinking principles:

The equipment and chemicals required for selection of deinking processes are determined by the type of ink in the waste paper. The size of ink particles to be removed, becomes the primary criteria. *Fig.1* depicts the different deinking processes to be adopted based on the particle size of the ink (14,15). From the graph it can be seen that the washing is most effective for removing small particles (<10 μm) and floatation for the middle (10-100 μm) range. Screening and centrifugal cleaners are meant for removal of large ink particles (> 100 μm). The Mechanism of ink removal during floatation and washing (15-17) has been shown in fig.2. The deinking process to be followed depends also on the ink used for different papers and furnishes are listed in *Table-5* (5-16). The common deinking chemicals with their functions (5-15) are listed in *Table-7*.

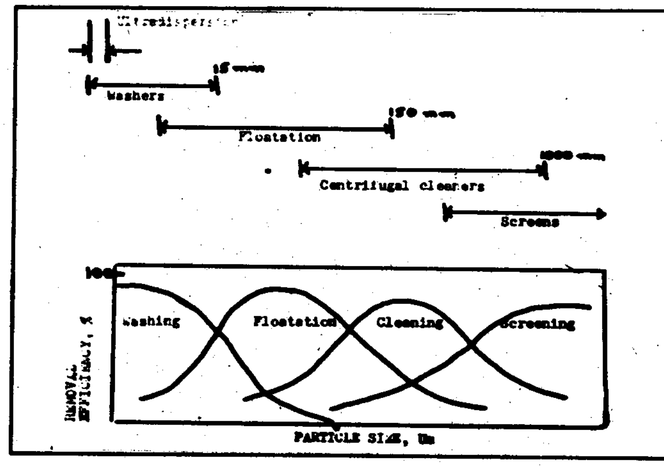

Fig.1 Perticle size versus removal efficiency

TABLE-5

Deinking processes to be adopted based on paper/furnish (5,16)

Paper/Furnish		Deinking process
Traditional news print	-	Washing
News print + Magazines	-	Washing + Floatation
Letterpress inks in news print	-	Addition of surfactant (1-2%) as dispersant
Offset lithographic news print ink	-	Addition of silicates + surfactant in cold dispersion
Flexographic printing inks in News papers	-	Use of displectors in Floatation (pH of 7-8 instead of 9-10 during pulping) + 2-stage washing (with nonionic surfactant)
UV ink particles	-	Use of floatation aids such as fatty oil and alkylene oxide derivative (FOAD)
Xerographic inks	-	Cold dispersion followed by washing and floatation/ floatation-dispersion-floatation
Laser printed inks	-	Slotted pressure screening + centrifugal cleaning.

Deinking processes:

The processes well known for deinking are: Winestock, Snyder-Mc Laren. Oxford, Aterling, Silco, Becker-Partington, Zundal, Chemwood, Celluplast, Butler, Degussa, Garden state, Fibre claim, Humasote, River side (18). Floatation and few other processes are of recent origin, Efficiency of deinked plant (18, 19) is determined by the properties of pulp produced namely: Brightness, Variable efficiency of bleaching process, Variation in waste paper furnish, yield of deinking, Variable loss of high or low brightness filler, Yellowing of mechanical fibre at alkaline pH, Degree of dispersion and particle size of remaining ink. In order to produce high quality papers from deinked pulp, efficient cleaning, deinking and upgrading (bleaching) for high brightness treatments are required. The deinking processes are restricted because of:

- Fluctuations in waste paper quality, mechanical pulp and ash contents,

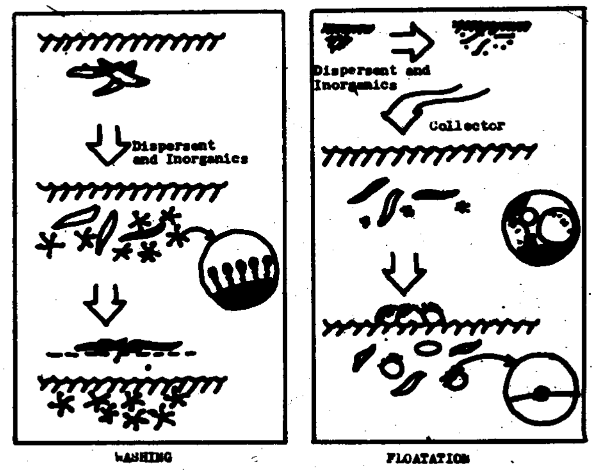

Fig.2 Ink removal mechanism during washing and floatation

- physical modifications of fibres during paper making: beating, drying and calendering,
- Chemical additives used in paper making and coating,
- Residual ink,
- Water system contamination of the mill by organic and inorganic compounds,
- Biological contamination of pulp.

There are 10 important stages for deinking (20-22), which are described below:

1. pulping

The various pulpers available commercially are Kneader pulper, Hydrapulper, Dynopulpers, Pulp Master, Beatapulper, Hilo pulper and Solvo pulper.

Pulping for deinking can be either a batch or a continuous process. Batch pulper is most common. The conditions for pulping of waste paper and chemicals (15,19) are shown in Table-7. The first objective of deinking is physical removal of ink particles from the fibre so that they may be washed or floated away (41).

H_2O_2 is activated by temperature and alkalinity. For every 10°C rise with alkaline activated H_2O_2,alkalinity is to be reduced by 0.1%. Higher

TABLE-6

Common deinking chemicals and their functions (5, 15)

Deinking Chemical	Structure/Formula	Function	Furnish Type	Dosage, Percent of dry fibre weight
Sodium hydroxide	NaOH	Fibre swelling-ink breakup, saponification, ink dispersion	Wood-free grades	3.5-5.0
Sodium silicates	Na_2SiO_3 (hydrated)	Wetting, peptization, ink dispersion, alkalinity, and buffering, peroxide stabilization	Groundwood grades	2.0-6.0
Sodium carbonate	Na_2CO_3	Alkalinity, buffering water softening	Groundwood grades lightly inked ledger	2.0-5.0
Sodium or potassium phosphates	$(Na_3PO_4)n$, n=15 hexametaphosphate $Na_5P_3O_{10}$ tripolyphosphate tetrasodium pyrophosphate	Metal ion sequestrant ink dispersion, alkalinity, buffering, detergency, peptization	All grades	0.2-1.0
Nonionic Surfactants	CH_3 $(CH_2)n$ CH_2-O $(CH_2CH_2O)x$ H ethoxylated liner alcohol, ethoxylated alkyl phenols	Ink removal, ink dispersion, wetting, emulsification, solubilizing	All grades	0.2-2.0
Solvents	C_1-C_{14} aliphatic saturated hydrocarbons	Ink softening, solvation	Wood-free grades	0.5-2.0
Hydrophilic polymers	CH_2CHC= OOH (Na)n polyacrylate	Ink dispersion, antiredeposition	All grades	0.1-0.5
Fatty acid	CH_3 $(CH_2)_{16}$ COOH stearic acid	Ink flotation aid	All grades	0.5-3.0
Hydrogen peroxide	H_2O_2	Ink degradation, anti yellow, bleaching	All grades	0.5-2.0
Fatty acid soap		Former, ink collector	All grades wight	0.5-1.0

TABLE-7

Pulping conditions and chemicals for waste paper deinking (15, 19)

Particulars		***Range***
Conditions		
1. Temperature	°C	20-100
2. pH		9-11
3. Consistency,	%	5-20
4. Duration	min	4-60
Chemicals		
1. Sodium hydroxide	%	0.8-5.0
2. Hydrogen peroxide	%	0.5-2.0
3. Sodium silicate	%	0.25-6
4. Magnesium sulphate	%	0.05
5. Surfectant	%	0.25-1.5
6. Chelant	%	0.15-0.5
7. Sodium Carbonate	%	2-8
8. Kerosene	%	0.1

brightness was possible with 15% consistency than at 10%. Increasing consistency from 5 to 15% brightness increase by 4 points and 2 pts when 15 to 30% consistency (15).

2. Pre wash

It consists of dewatering screw which takes the dump chest stock from 4-5% upto 14-15% consistency; the effluent is recirculated for pulper make up. The fibres, clay and fines can be separated by adding a screen, floatation cell, clarifier or a settling tank in the dewatering line (20). Although there are many advantages of using a pre-wash system, it is not absolutely required (20).

3- Screening

The secondary fibre contains (17):

a) heavier contaminants such as staples, paper clips, stones etc. which may damage the screen.

b) plastics, stickies, wax and other light materials.

In order to separate the first contaminant, a medium density cleaner and for the second one, pressure screens (slots of 0.25-0.35 mm) are used. The low efficiency of screening for larger particles (150 µm slot size) is due to the plate-like shape of particles (14,15).

4. Reverse Cleaning

Centrufugal cleaning separates based on difference in specific gravity and particle shapes. In order to remove completely the light contaminants, a through flow cleaner or reverse cleaner has been suggested. Presently throw flow cleaner with low pressure drop (10-15 psi) and low hydraulic reject rates (5-15%) have been developed which serve effectively and produce very concentrated rejects with minimum water loss. Reverse flow cleaners remove particles lighter than water (20).

5. Forward cleaning

A 3rd stage of cleaning is required to remove the fines which are light also. A 3-stage fine cleaning system is used where the cleaners operate at low consistancies, i.e. 0.6% for maximum efficiency. Forward cleaners remove particles heavier than water (23).

6. Washing

Use of a high speed single wire washing device has been found quite successful. The effluent consistency remains 0.1-0.25% and stock consistencies of 10-12%. Like any other washing system, the efficiency depends upon quality of clarified water, the chemistry of make-up water and a counter-current water system (24,25).

Washing becomes sometime ineffective because of particle size. For 10% consistency, the particle size may range from 40 to 400 µm and successful washing requires (14-15) particles <25 µm.

7. Floatation

Floatation combined with good washing systems make the deinking system very effective and allow more flexibility in using various grades of secondary fibres (22). The role of floatation is to remove the ink that has been released during earlier operations.

The primary requirement for effective floatation is that:

a) The particles should be water-repellent or hy drophobic so that they can easily be separated from aqueous phase (15).

b) Particle size (14/15) should be 10-100 µm.

Particles in the size range of visible limit show the highest floatation rate constant, while smaller particles and large spakes are more difficult to remove (26). The number of particles extracted by each bubble is proportional to the number of particles in the suspension. Smaller bubbles has been found more efficient than large bubbles because of their high specific surface, but also leads to higher fiber losses for a given air ratio (26).

All Floatation cells have 3 zones (27) namely a) Aeration, b) Mixing, and c) Separation Zones. In the aeration zone, air can be added in correct amount. The mixing zone is to maximize collisions between ink particles and bubbles. The separation zone is designed such that the ink bubble complex can be brought to surface as quickly as possible, and the inky foam can be removed from the surface of the stock with minimum fibre loss.

Other factors which effects the flotation deinking process are:

a) Water hardness- Maximum flotation is achieved when all hardness agents are floculated and a slight excess of free active soap present at the surface. For effective ink removal, the calcium ion level should be 150 ppm (as $CaCo_3$) and can go up to 225 ppm (as $CaCO_3$).

b) pH- To get adequate foam stability (28) the pH should be maintained above 8.5.

c) Consistency- The floatation cell consistency should be kept below 1.2% because yield suffers when consistency increases.

d) Particle size- Though floatation is less sensitive to particle size than washing system (23) still it plays a vital role in deinking. For the particles below 5 µm, Brownian movement counter acts the adhesion of particles to the air bubbles (28).

e) Bubble size- Smaller bubbles are more effective for ink removal but too small bubbles leads to fiber loss and do not breakdown the froth where dirt accumulates (3). Below pH 5 large bubbles are found and above pH 11 thick dense froth are formed with small bubbles (28).

f) Dwel time- The dwell time of 8-10 minutes is usually sufficient for floatation deinking depending upon the floatation cell design.

g) Temperature- Temperature around 40-45°C is recommended to get a brighter pulp.

TABLE-8

Comparison between floatation and washing (27)

Parameter	Floatation deinking	Wash deinking
Fibre yield	High Yield (85-95%)	Lower yield as fines removed, (~80%)
Ink wash	Removed in concentrated form	Removed in very dilute form
Water consumption	Low, generally only to replace water carried forward	High, giving large amount of water requiring cleaning
Ash	Ash removal is low	Up to 95% of ash may be removed
Control	Less sensitive to ink particle size	Ink particle size must be removed as far as practical

A comparison between washing and floatation process (27) is given in *Table-8*. In the process where single floatation step is not sufficient a combination of wash float and float-float systems seem to work efficiently. For deinking of xerographic, laser and cpo papers floatation- dispersion-floatation step has been found quite successful. The intermediate floatation step breaks down large ink particles, so that they can be removed in the final floatation step.

Floatation cell:

The floatation cells are the heart of deinking system where actual separation of the ink takes place (1). The cells classified as agitator cells, compressed air cells, sub-aeration units and vaccum floatation cells. Agitator cells were the premier class floatation cells used to deink secondary fibers. Voith floatation cell is an example of the above class. New Voith multiinjector cell has claimed benefits like, space saving 75%, energy 58% and investment cost of 80% compared to the earlier one.

Swemac floatation cell is a cylindrical type in which air being introduced in an air mixing and dispersing unit outside the floatation cell. The ink is discharged through concentric central pipe, with froth discharge being assisted by a blower (18)

Other types of floatation cells used are Escherwyss CF type, Aikawa, Lamort and Outokumpu OY, basically working on the same principle of floatation deinking. The Beloit Lineacell Floatation unit has been used in Spain. It minimizes fiber losses and maximizes ink removal because of the vacuum system used here (28). Only 4-stages of primary floatation are used instead of 6-9 primary and 2-3 secondary stages in other industries. Improvement in chemical consumption, temperature losses and brightness has been claimed by using this process (28).

Recently it has been claimed that floatation with CO_2 showed improvement in pulp optical properties such as greater brightness and less yellowing compared to air, O_2 or N_2 as carrier gases. Use of CO_2 as carrier gas dissolves in water and brings down the pH of the solution as per following equation:

$$CO_2 + H_2O \longleftrightarrow H_3O^+ + HCO_3^- \quad (1)$$

$$HCO_3^- \longleftrightarrow H_3O^+ + CO_3^- \quad (2)$$

By floatation with CO_2 as a carrier gas pulp suffers a loss in mechanical properties, but can be recovered by passing the pulp through an alkaline washing stage (29).

8. Dispersion

Dispersion is intended to reduce ink speck size, Free ink from fibers, disperse stickies and other contaminants. It also homogenises the stock, so that there will not be optically disturbing and will not interfere with the papermaking operation or degrade the quality of waste paper (30).

Dispersion is required for inks such as ultraviolet, Xerographic and computer based inks (jet print type inks). This dispersion has been achieved at medium (10-14%) as well as (25-35%) high consistencies at temperatures of 120-190°F. Again hot dispersion is harmful to brightness (17).

Residual ink is one of the main causes for low brightness of recycled pulps. The greater the dispersion of ink particles, greater is the loss of brightness (80% reduction in size of specks can induce brightness loss of 12 points). A cold (non-pressurised) dispersion step ahead of floatation and washing has been found successful for removing UV cured inks in Japan (5).

9. Bleaching

Bleaching is practised (a) in the pulper, (b) after the heat and chemical dewatering screw in a bleach tower and (c) before the deink washers using conventional two tower bleaching systems. The first one eliminates the capital investment like in second and third because of low consistency, chemical requirement will be high. The second one takes advantage of high consistency of 12-14%.

Some conventional bleaching sequences include HH,CH, CEHED, CEop P, PP, OP and OH (30). For better brightness gain the sequences such as formaldehyde sulfonic acid (FAS), Hydrosulfite (S), peroxide-hydrosulfite (PY), ozone-peroxide (Zp), so dium borohydride and sodium dithionite (F) are gradually becoming popular (31).

Different levels of brightness achieved with different grades of pulp are given in *Table-9* (31). maximum brightness achieved with newsprint is 63% ISO while with writing and printing grade is 84% ISO. Bleaching of deinked pulp from ONP and OMG is possible using either sodium hydrosulfite, formaldehyde sulfonic acid and hydrogen peroxide. In these cases calcium hypochloride did not increase the brightness (31). For badly deinked pulp, secondary Flotation stage or washing after bleaching is required. Washing With NaOH and Na_2Sio_3 gives good dispersion and the reduced particle sizes allow than to be removed more easily. Washing has been done with inclined screw washers and increase of 3 point brightness has been reported (27).

10. Water recirculation and make up

Water requirement for deinking can be minimized to 2000 gallons/ton though some mills use ten times more. The problems for recirculation are because of: a) pH adjustment, b) Al^{3+} ions and c) Hardness in water. The deinking is carried out at high pH while for paper machine area, low pH is required. On the other hand, the paper machine back water which is easily available for deinking, contains alum and it is not desirable in deinking process. If raw water is to be used as make up water, the hardness has again to be kept minimum. For using the water of the deinking plant; the ink, fines and fillers etc. are separated in a clarifier first before adding the make up water (20,32).

Chemicals used in the deinking system:

The chemicals for the deinking can be added either at pulper or just before the flotation cell. The addition point depends greatly on the chemical in use. The various chemicals in use with their functions are as follows:

a) Alkali - The caustic increases the swelling of cellulosic fibers with increase in the alkali concentration, thus the deinking effectiveness also increases. The absorption of hydroxide ion is thought to increase the electrostatic repulsion between the fibers and ink particles, thus resulting greater ink detachment (33). The increase of alkali concentration increases the pH of the system. Higher pH value causes yellowing of wood containing pulps.

The pigment in ink is released by breaking down the oil based vechicle carrying the pigment. NaOH reacts with oil based vehicles (15) giving out soap and alcohol through saponification reaction as follows:

$$R-\overset{O}{\overset{||}{C}}-O-R + NaOH \longrightarrow R-\overset{O}{\overset{||}{C}}-O-Na^{+} + R-OH \quad (3)$$

Ester (vegetable oil) Na-salt of ester (soap)

However, inks based on synthetic resins and special inks such as high gloss and metallic inks can not be removed by alkali. Milder alkalis like $Na_2 Co_3$, $Ca(OH)_2$ or Na_2SO_3 may partially replace NaOH. The alkali level is to be decided based on experimentation, pH of normally 10-12 is preferred (31).

b) Stabilizers- Sodium silicate often added as a stabilizer effects positively for separation of inks from fibers. It has also been reported that silicates prevent redeposition of inks on the fiber surface. Sodium silicate increases the pH of the floatation cell as per reaction below:

$$Na_2Sio_3 + H_2O \text{----}> 2Na^+ + OH^- + HSiO_3$$

It acts as a buffering agent (29) operating around pH of 11.3. At low concentrations silicates are good emulsifiers. It also helps fiber wetting and dispersion. Na_2SiO_3 is an effective stabilizer against metal decomposition of hydrogen peroxide and prevents yellowing of ground wood pulp. Sodium silicate can be added with chelating agents like Na_2 DTPA (Diethylene triamine-penta acetic acid) for better performance (33).

c) Hydrogen Peroxide- Hydrogen peroxide is widely used for bleaching mechanical pulp. In combination with Na_2SiO_3 a 20 point gain in brightness has been reported (34). Peroxide not only just brightens the pulp, but also helps in ink removal by penetrating into the fiber and subsequent decomposition. By oxidising the varnishes or oily substances in the ink, it helps saponification. A pH of 10.5-11.0 is preferred for peroxide application. Peroxide can be added at a number of points in deinking process such as pulper, bleaching stage before or after floatation. The reaction between the peroxide and caustic soda is shown in equation below:

$$H_2O_2 + NaOH \text{ <----> } HOO^- + Na^+ + H_2O \text{----- (4)}$$

The perhydroxyl anion (HOO^-) is the active bleaching agent. Heavy metal ions such as Mn^{2+}, Fe^{2+}, Cu^{2+}, Al^{3+} and some enzymes such as catalase increase peroxide consumption as per reaction below and decrease in brightness has been reported (34,35).

$$\text{Metal ion} + H_2O_2 \text{ ----> } 1/2\ O_2 + H_2O \text{ ----- (5)}$$

High pH and temperature also activate the above reaction. The decomposition can be reduced by addition of chelants and sodium silicate. The furnish must be clean and free from enzymes which reacts with H_2O_2 (15).

d) Surfactants- The surfactants react on the surface of the fiber to release the ink particles and also help to disperse ink particles in water, so that they are not redeposited on the fibers. In general, surfactants are applied with NaOH, Na_2SiO_3 and H_2O_2. Surfactants have a characteristic molecular structure called "amphipatic", means when water is solvent, it contains both hydrophilic and hydrophobic parts. The hydrophobic part consists of a chain of

TABLE-9

Brightness (% ISO) achieved with floatation and bleaching of the deinked pulp (31)

Composition of deinked pulp		Initial brightness	Brightness increase after floatation (1% NaOH)	After bleaching P	Y	F
News print	- 100%	43	+15	+5	+3	+5
News print +	- 50%	44	+17	+4	+4	+6
Magazine	- 50%					
Magazine	- 100%	47	+17	+5	+3	+6
Waste paper						
Mechanical pulp + Wood free pulp	- 25% - 75%	60	+10	+4	+4	+6
Chemical pulp (Coated or printed)	- 100%	67	+13	+3	+2	+4

hydrated carbon, whereas hydrophilic part based on ionic or polar groups (35). Structural formula of some surfactants are as given below:

$$CH_3\text{-}\underset{CH_3}{\underset{|}{CH}}\text{-}CH_2\text{-}\underset{CH_3}{\underset{|}{CH}}\text{-}CH_2\text{-}\underset{CH_3}{\underset{|}{CH}}\text{-}C_6H_4\text{-}O(CH_2CH_2O)_x\,H \quad \text{-(1)}$$

(Nonyl phenol ethoxene)

$$CH_3\,(CH_2)_n\,CH_2 - O\,(CH_2CH_2O)_x\,H \text{ ---- (2)}$$

(Alcohol ethoxylate)

$$CH_3\,(CH_2)_n\,C_6H_4\,(OCH_2CH_2)_x\,OH \text{ ---- (3)}$$

(Alkyl phenol ethoxylate)

$$CH_3(CH_2)_n - C(O) - (OCH_2CH_2)_x\,OH \text{ ---- (4)}$$

(Fatty acid ethoxylate)

Surface active agents excluding the soaps and fatty acids are used for detachment of ink particles from the fibers. These materials also disperse the colours and form the foam needed for floatation. The hydrophilic-lipophilic balance (HLB) factor of surfactants should be in the range of 12-14 for floatation deinking (15). Nonionic surfactants have been found more effective in the floatation deinking process. Biodegradation of surfactants as well as other chemicals is becoming more of an issue as environment is concerned. The HLB Factor, chain length and cloud point are also important factors for characterising a surfactant.

e) Dispersing agents- Dispersing agents prevent reagglomeration and redeposition of the pigments on the fibers. Common dispersing agents such as sodium polyphosphates and hydrophilic polymers are used in the deinking processes.

f) Collecting chemicals- Various soaps and fatty acids are used as collectors to promote attachment of particles to be floated to the passing air bubble (5,15). Fatty acids are primarily blends of 16-18 carbon atom chains, such as stearic, oleic, linolenic and palmitoleic acids as well as the more saturated linolenic and palmitoleic acids. The increase of double bonds in the carbon chain promotes ink detachment. The typical structure of a collector chemical is given below (35):

$$(CH_2 \text{ ----- } (CH_2)_x \text{ ----- } C(=O)\,O^-Na^+)$$

Fatty acid component : Functional group

(Hydrophobic) (Hydrophilic)

The fatty acid soaps are usually applied as solid soap, liquid soap of fatty acid itself converted into soap on site. Out of the above forms, liquid soaps form a good amount of foam in flotation deinking process and short chain length effectively removes the ink. Regardless of how the soap is introduced into the system, it must be converted to the calcium soap before it acts as a collector (17).

For inks difficult to saponify and disperse such as UV cured inks the Japanese mills use (34) soaking tower before floatation and washing to extend the time for the deinking chemicals to act on the ink and fibers. For removing offset inks new floatation aid called FOAD (Fatty oil/alkylene oxide derivatives) has been reported for better penetration and good flocculating and foaming properties.

g) Enzymatic treatment- Enzymatic treatment is a recent process, which gives better performance to reach a desired deink pulp properties. At low pH different enzyme preparation containing cellulases and hemicellulases have been used. The process does not require conventional chemicals used for flotation deink process. The enzymatic treatment of laser and xerographic office waste (36) at 3% consistency. pH 9.0, temperature 40°C and retention 30 min, the brightness improvement of 4 ISO, reduction in fines content, improvement in freeness and strength properties have been reported. For deinking of coloured offset newsprint (37), in addition to above properties a significant reduction in chemical use have been claimed. For enzyme enhanced deinking of mixed office waste (38), better removal of toner particles, preservation of fibre integrity have been reported in addition to increased pulp brightness and drainage properties.

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