Deinking chemistry: part 2

Loreen D. Ferguson

Discusses the chemicals used in deinking operations and the role of chemistry in the pulping, flotation, washing, deposit control, and water clarification processes.

This paper concludes the article, "Deinking chemistry: part 1," which appeared in the July 1992 issue, p. 75.

Deinking chemicals

Dispersants

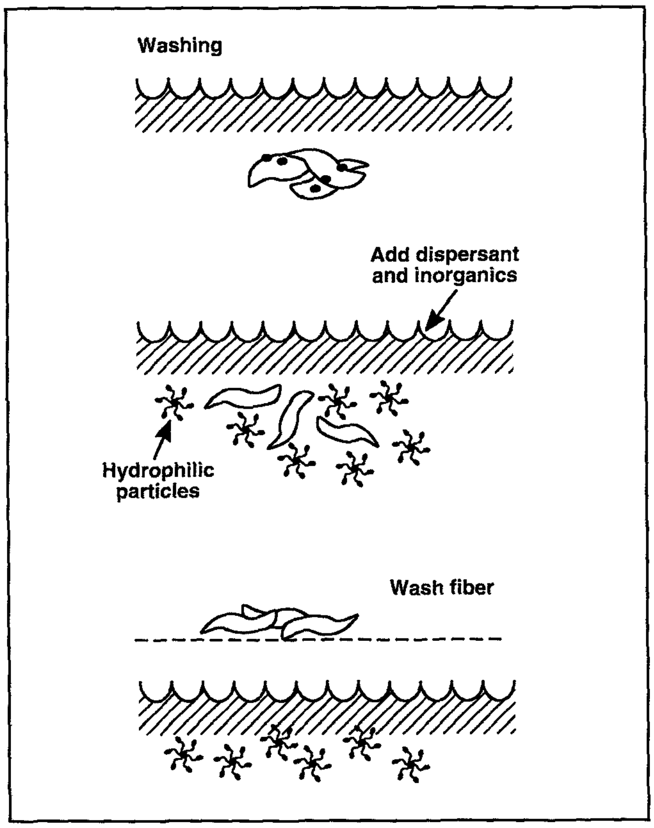
Dispersants are chemicals whose function is to take the ink and dirt particles that have been freed during the pulping operation and keep them in suspension so that they can be removed during a washing or thickening stage. The name of these products well defines their action. Dispersants are primarily found in wash deinking mills and for the newer "short sequence" deinking processes.

Wash deinking: The most commonly used wash deinking dispersants are surfactants such as nonylphenol ethoxylate and linear ethoxylated alcohols. Dispersants for short sequence deinking are often blends of Eo/Po copolymers and glycols and fatty alcohol alkoxylates. Pitch dispersants, on the other hand, can be from such naturally ocurring (or by-product) materials as lignosulfonates and alum; or anionic polymers like naphthalene sulfonate, and cationic polymers like aminomethylated polyacrylamide. Deposit and pitch control agents will be discussed in a later section.

The objective in wash deinking, as outlined in **Fig. 20**, is to keep the particles small enough to be removed through the sidehill and washer screen wire and hydrophilic enough that they will drain easily. The ideal dispersant, therefore, combines wetting, emulsification, and dispersant features. As **Fig. 21** outlines, wash deinking removes particles that have a size approximately below 10 μm —ideally below 5 μm. The actual size range removal will be dependent on the mesh size of the removal screen and the thickness of the mat on the washers, for example, drum washers and deckers. If the mesh size is large on the screen or washer, then more ink will be removed but the fiber losses begin to be unacceptable. Wash deinking with dispersants helps to keep the mesh size small enough to keep fiber losses under control. The structure for a wash deinking surfactant is shown in **Fig. 22**.

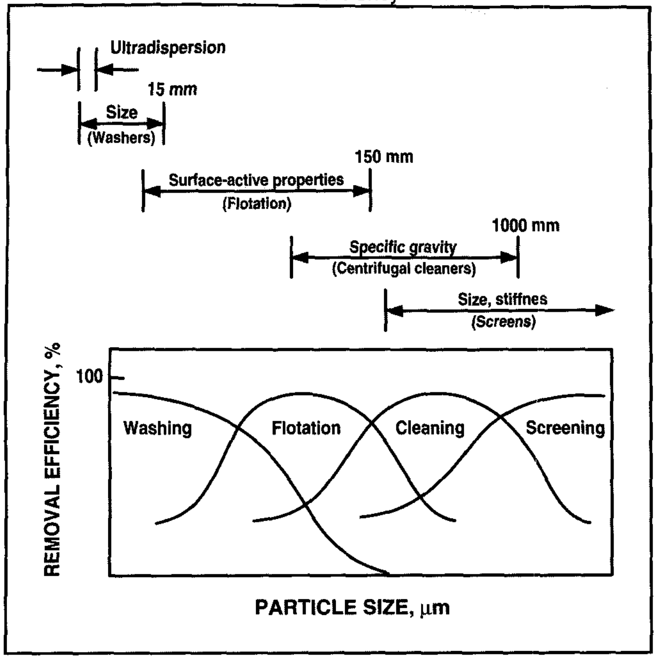
Short sequence deinking: SSD or pulper deinking is a relatively new form of deinking for newsprint and for some office wastes. An outline of short sequence deinking has been given by Woodward *(35, 36)* and Ferguson *(4)*. The application for this type of deinking has been in use for boxboard and linerboard manufacture for quite awhile. For newsprint deinking, the idea is to use only existing equipment and ambient conditions. For example, a process may be to introduce 100% ONP into a broke repulper, which has white water as dilution water, add a surfactant, pulp until defibered, and then sent off to a storage chest. The pH would be 4.5 to 5.5 and the temperature 40–50°C. No intermediary screening or cleaning stages are used, unless they are available. The danger from this type of a system is very clear: it would be sensitive to stickies and other contrary materials, and ink would build up on the paper machine clothing, shear points, and white water loops. However, this approach has been used commercially, usually to give 5–25%

20. Wash deinking *(30)*

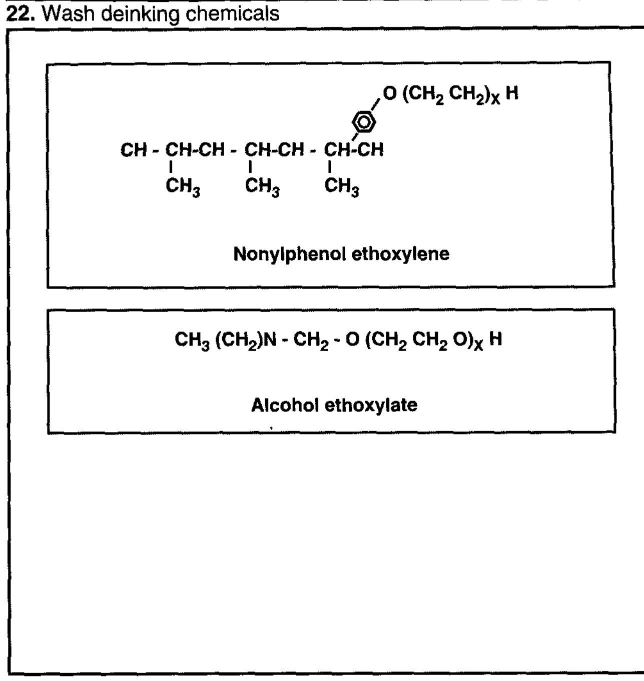


Ferguson is research chemist, Boise Cascade Corp., 4435 North Channel Ave., Portland, OR 97217.

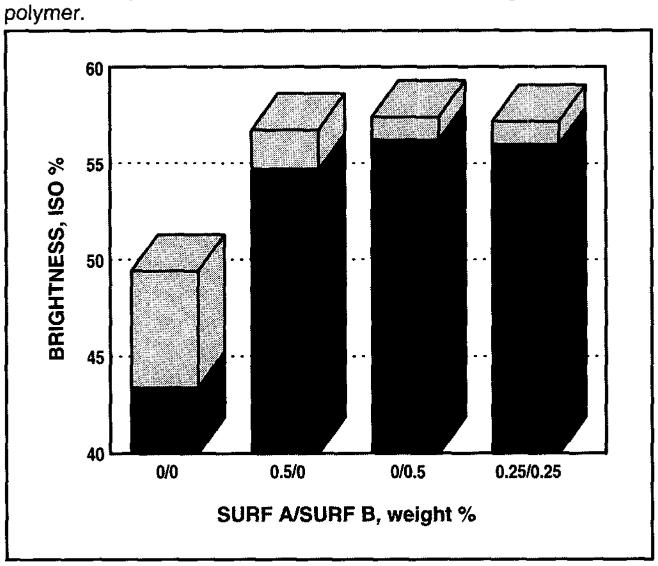
21. Particle size versus removal efficiency



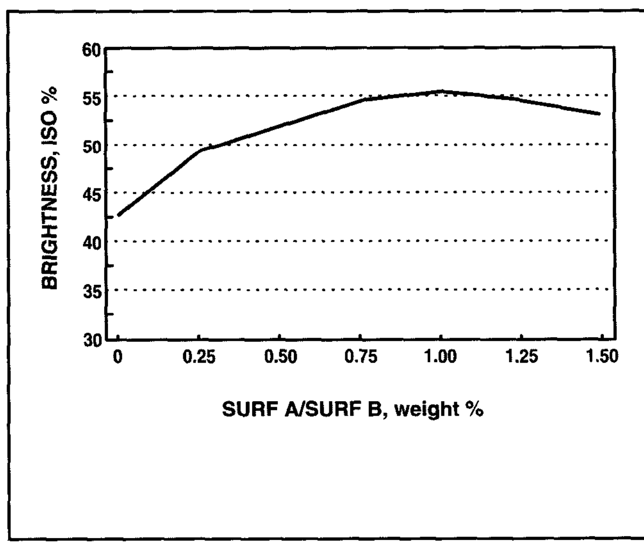
22. Wash deinking chemicals



23. Pulper brightness from short sequence deinking: effect of surfactant type *(4)*. Conditions: pH 5.5, temp. 25°C, pulping time 60 min, consistency 3%; 100% offset news, surfactant A is wetting agent fatty alcohol alkoxylate, surfactant B is anti-redeposition agent Eo/Po copolymer.



24. Pulper brightness from short sequence deinking: effect of surfactant dose *(4)*. Conditions: pH 5.5, temp. 25°C, pulping time 60 min, consistency 3%; 100% letterpress news, single-wash stage, surfactant is fatty alcohol alkoxylate.



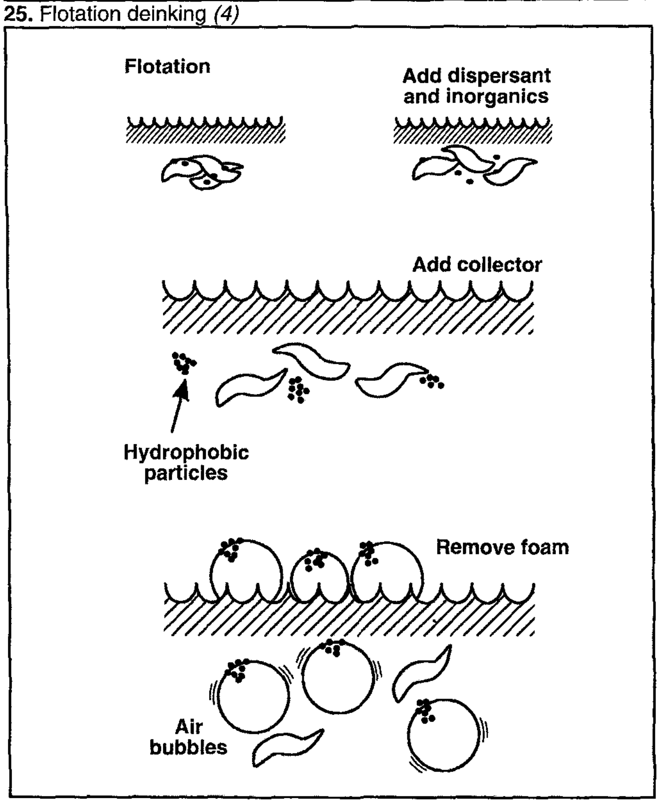
recycle content into a news sheet. The more stages of cleaning, screening and wash, or thickening that can be introduced, the better the chance of success. **Figure 23** shows the results of short sequence deinking on 100% ONP with and without a wash stage. For applications like this, the choice of the surfactant is crucial.

Figure 24 shows the effect of increasing surfactant dose on brightness for short sequence deinking. This figure helps to illustrate one of the basic performance parameters for most surfactants—that too much of a good thing is not necessarily the best. **Figure 25** shows the brightness beginning to drop as the dose exceeds the range 0.75% to 1.0%. In this case, it is thought that the excess surfactant is beginning to form a surfactant "double-layer," in that the hydrophiles are associating together causing the ink–hydrophobe–hydrophile–water–hydrophile–hydrophobe complex to be redeposited onto a fiber or formed into large agglomerates of ink and surfactant. Again, this figure illustrates the care that must be taken with the correct dose of surfactant to be added for any deinking application.

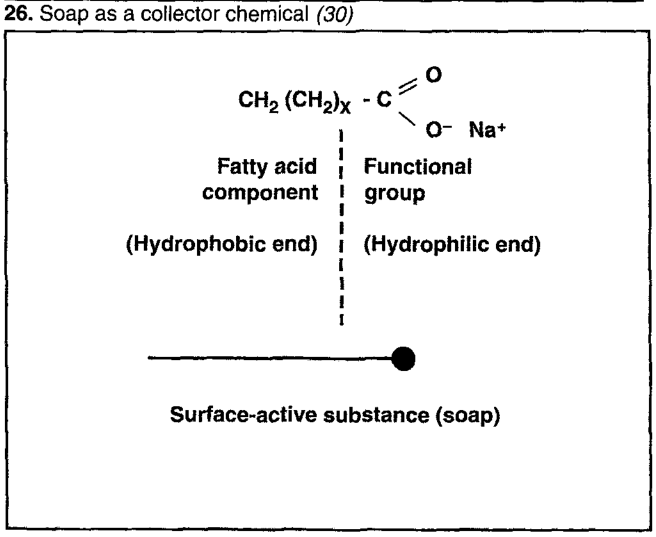
Collector chemicals

The role of the flotation cell is to remove the ink that has been released from the fiber during the pulping stage. Collector

25. Flotation deinking *(4)*



26. Soap as a collector chemical *(30)*



chemicals are used in flotation deinking and can be added either at the pulper or just before the flotation cells. The addition point depends greatly on the chemical in use. Collectors can be made from naturally occuring materials, such as fatty acid soaps; synthetics such as Eo/Po (ethylene oxide/propylene oxide copolymers); and blends such as ethoxylated fatty acids. Fatty acid soaps are more commonly used in Europe than in North America, although several Canadian and U.S. mills are using soaps successfully.

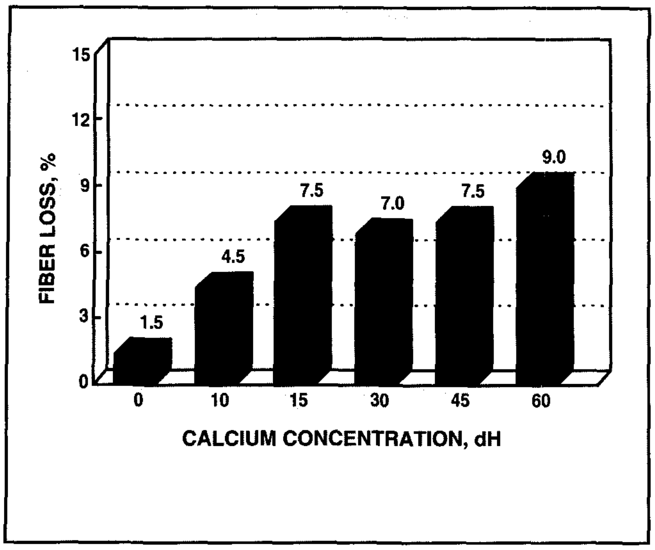
As the name implies, collector chemicals are designed to bring together the ink particles that have been freed by the pulping action, such that they can be removed by the air bubbles. As is shown in Fig. 21, the ideal particle size for flotation deinking is in the range of 10–100 µm. For ink removal to occur, the ink particles must come into contact with the collector chemicals which, in turn, must come into contact with the air bubbles so that the ink agglomerates can be removed, as shown in Fig. 25. This is where the manufacturer of the flotation cell carefully designs the injectors and mixing section to maximize turbulence and the random collisions of all three components: ink, collector, air bubble. It is crucial that the bubble have sufficient surface tension strength to carry the ink through the flotation cell to the surface, and yet still break once the bubble reaches the weir. The formulation of the collector chemical helps to adjust the surface tension of the air bubble to achieve this. One of the early downfalls of surfactants used for collector chemicals is that too high a portion was carried over and began to build up into the backwater causing either too great or insufficient foam stability. This problem is detectable from a gradual decrease in brightness over a 36- to 72-h period.

Fatty acid soaps are a type of surfactant, as shown in **Fig. 26.** They are primarily blends of 16- to 18-carbon atom chains, such as stearic, oleic, palmitic, and linoleic acids as well as the more saturated linolenic and palmitoleic acids. Read *(13)* and Marchildon and co-workers *(37)* have found that the absence of double bonds in the carbon chain, for example, in stearic acid, helps in ink removal from the fiber; whereas the presence of double bonds, for example, in linoleic acid, helps with flotation. It has been established that a formulation with a high percentage of stearic acid gives the best flotation deinking results *(13)*.

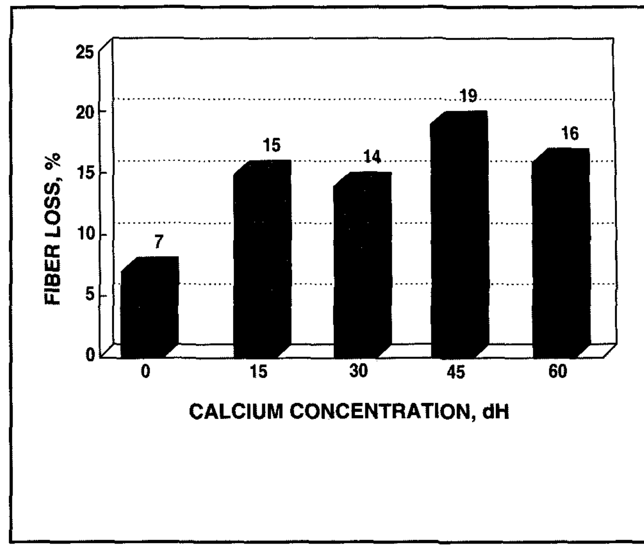
There are three primary means of delivering fatty acid soaps to the deinking plant: solid soap pellets, liquid soap, and the fatty acid itself which must be converted to the soap on-site. The earliest form of soap use was to add the stearic acid directly to the pulper with the wastepaper, with an excess concentration of sodium hydroxide. These conditions were maintained during pulping, and the acid was saponified into the sodium soap. The high alkalinity has the drawback of causing undesirable yellowing for mechanical-pulp-containing furnishes. The soap manufacturers produce the presaponified solid sodium-soap pellets, which can then be liquefied at the deinking plant. A few concerns about handling the solid soap pellets, such as dusting and safety hazards from soap solutions spilled onto the floor, have led some manufacturers into supplying the soap in a liquid form. It is reported that while the liquid soaps form a good amount of foam, the chain length of these soaps is too short to effectively remove the ink, and the cost of shipping water may not make economic sense for mills located far from the soap manufacturing plant *(13)*.

Regardless of how the sodium soap is introduced into the deinking system, liquid or pellet, it must be converted to the calcium soap before it can function as a collector. In order to form the calcium salt of the fatty acid, a source of calcium ions must be introduced into the system. The calcium ions can be sourced from the furnish itself in the form of calcium carbonate from the coatings or fillers, or from calcium chloride (or other calcium source) added specifically to the flotation cells. The water hardness must be at least 12 degrees German hardness (dH), which is approximately 200 ppm calcium. The sodium soap is soluble in water, and the calcium soap is not. In the dilute environment of the flotation cells, the calcium soaps form microprecipitates. The microprecipitates of ink and soap associate with the air bubble and are carried to the top of the flotation cell where they are then removed.

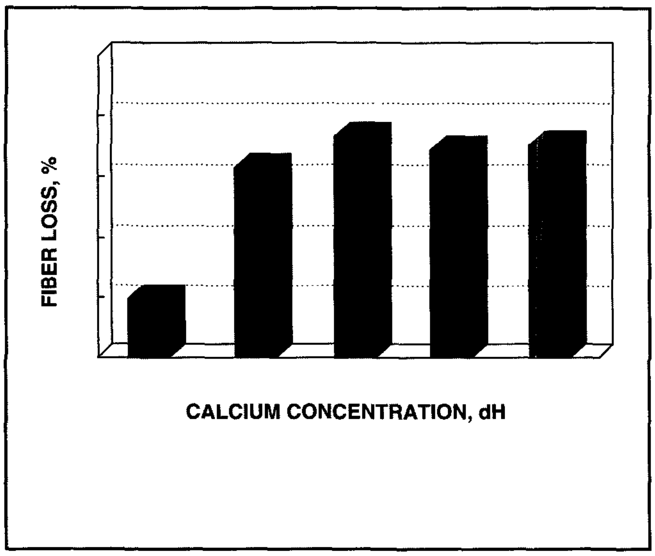
27. Fiber loss at different calcium concentrations without addition of deinking chemicals *(39)*: pulp density 0.2%



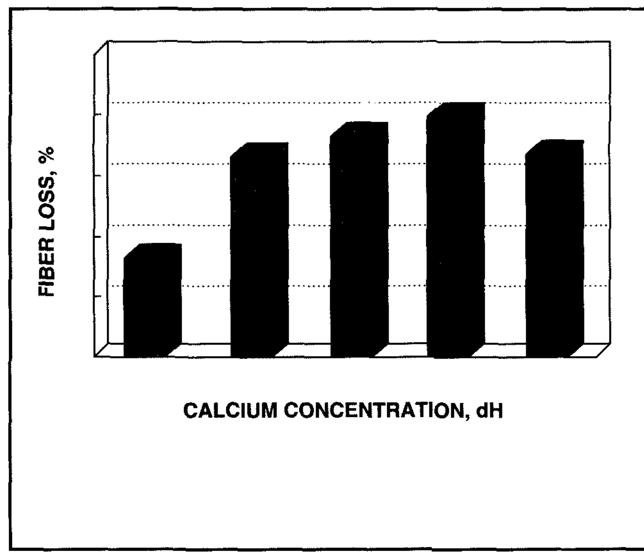
28. Fiber loss at different calcium concentration with addition of sodium oleat *(39)*: *consistency* = exp–6 g/L



29. Fiber loss at different calcium concentrations with addition of nonionic surfactant *(39)*: *consistency* = exp–6 g/L



30. Fiber loss at different calcium concentrations with addition of nonionic surfactant *(39)*: *consistency* = 2·exp–7 g/L



V. Surfactant ionicity

Anionic (negative)	*Cationic (positive)*	*Amphoteric (both neg & pos)*	*Nonionic (no charge)*
Sulfonates Sulfates Carboxylates Phosphates	Ammonium- Pyridinium- Imidazolinium- Piperidinium- Sulfoxonium- compounds etc.	Aminocarbon acids, etc.	Akyl- Alkylaryl- Acyl- Acylamid- Acylamin- Polyglycol ethers Polyolester Alkanolamid Ethyleneoxide Propyleneoxide

Role of calcium. One of the most frequently cited reasons for not using fatty acid soaps is that calcium ions must be added. The concerns are not only that another tank and metering system must be added, and that calcium ions are believed to cause scaling and other deposits on the paper machine and within the deink plant, but that high calcium ion levels contribute to stock loss.

The recent work by Turvey *(38)* has shown that a major cause of stock loss is the presence of calcium ions. He concludes that the calcium ions are attaching themselves to the surface of the fibers causing the fibers to become hydrophobic and thereby float. The mechanism for this is still not clear. Turvey was able to draw the following conclusions: (a) Unprinted mechanical or chemical fibers do not float, even when calcium ions are present; fines behave like fibers. (b) Print, or components of it, cause fibers to float; fibers float to a much greater extent when calcium or magnesium ions are present. (c) Carbon black is the prime component of print that causes fibers to float; when tied up in polymerized print networks it has no effect; when covered with oil it has no effect; when covered with oxygenated species or groups capable of interacting with calcium ions, it causes fibers to float. (d) Most chemicals added to a deinking system, such as chelating agents, common anions, hydrogen peroxide, certain surfactants, talc, etc., play an insignificant role in causing fibers to float.

Schwinger *(39)* has also reported that closing the water circuit in a deinking plant will cause the calcium ion level to increase and the stock loss to increase, whether the calcium ion is introduced deliberately or through the coating and filler component. The effect of calcium ion concentration and deinking chemical used on stock loss is shown in **Figs. 27–30.** Figure 27 shows the stock loss increasing as the calcium ion concentration increases to a level of 9% at 60°dH hardness; however, when the sodium soap is added, the stock loss jumps to 16% at 60°dH (Fig. 28), and 36% with a nonionic surfactant (Fig. 29), but decreased back to 10% when the level of the nonionic surfactant was doubled (Fig. 30). The conclusions Schwinger makes from his work are as follows: (a) The presence of resin-like lignin residues causes flotation of the fibers; (b) calcium ions adsorb on the fiber surface; (c) the adsorption of calcium led to a considerable reduction in the negative charge of the fiber, but not to a charge reversal; (d) the reduction in charge enhances the flotation of the fiber if only a few hydrophobic groups are present on the fiber; and (e) the addition of sodium soap increased fiber loss by a few percent; however, the addition of a nonionic surfactant greatly increased the fiber loss.

Some European mills have found that their natural water hardness level is sufficiently high when combined with calcium carbonate coated magazines that no additional calcium source is needed.

Surfactants. Most of the details for surfactants is given above in an earlier section. Those used in flotation deinking can be cationic (positive charge), anionic (negative charge), or nonionic (no charge). A useful list for determining the charge on the surfactant, if the mill chemist is not nearby, has been assembled by Putz and co-workers *(40)* and is given in **Table V**.

The most frequently used surfactants are nonionic, as they function independently of the water hardness. The actual formulation of these products is usually strictly held proprietary information by the chemical suppliers.

Displectors are products defined by their mechanism of action, i.e. that is surfactants that are a combination of *dispe*rsants and col*lectors*. A contradiction in terms may be the first thing that comes into the reader's mind upon first hearing of this type of products. They were brought forward by several chemical suppliers as a means of assisting the new generation of deinking plants that have both flotation and one or more washing/thickening stages. Displectors are synthetic liquids, and the formulations are often blends of many components. The brightness gained across flotation is lower with displectors than with conventional fatty acid soaps or surfactants, and the brightness across washing is less than with dispersants; however, when the two are combined in the same plant, then the brightness is claimed to be equal to, or better than, conventional chemistry *(41)*. The benefit from using these products, aside from flotation/washing brightness gains, is reported to be the fact that they are insensitive to water hardness, will not cause scaling on equipment, have a low chemical carryover, and have reduced fiber loss *(42)*.

Displectors first found favor with tissue manufacturers where the ink load to be removed is somewhat lower than for ONP. In fine paper recycling to manufacture tissue, the difference is that all components of the incoming waste furnish should be removed except for the fiber. The displectors seemed to have a good effect in helping to remove the range of materials, from ink to fillers. The first introduction to news deinking systems saw some problems with chemical carryover in the backwater, disrupting the flotation cell efficiencies. This has been remedied by the manufacturers, and displectors are gaining acceptance for news and fine paper deinking. In North America, the use of synthetic collectors (surfactant base) and displectors is higher than the use of fatty acid soaps. In Europe, the trend is for fatty acid soaps, mainly for two reasons: (a) the soap makedown systems are in place and there is no incentive to remove or replace them (and they do work very well indeed), and (b) the water hardness is higher in most European countries either naturally or from the calcium carbonate coated and filled papers.

Inks and varnishes: difficult to deink grades

Flexographic inks are water-based and have gained popularity with printers for reasons of safety and ease of press washups. Flexo is a looming menace in the flotation deinking field. The two primary reasons why flexo is so difficult to handle in a flotation cell are: (a) the particle size is small after repulping, at 0.2– 1.0 µm and (b) the ink is water-based (hydrophilic) and likes to remain with the water. Flexo inks are too small (see Fig. 21), and due to their hydrophilic nature they will not be agglomerated by traditional collector chemicals to be removed by flotation. The very small inks get carried around in the water loops causing significant brightness drops above the 6–10% level. Other water-based inks are also being developed for similar health and safety aspects. Water-based gravure inks are starting to be used, and magazines may begin to contribute an increasing share of these types of inks.

Flexo (and most all water-based inks) can be removed by wash deinking. Washing systems use a great deal of water and put a resultant load on the clarification system. For many

European mills, especially in Germany, strict water use requirements have meant that wash deinking is not a viable alternative. For this reason, there has been a moratorium on the use of flexo in Germany. Flexography is currently being run in Italy and in one major press in the United Kingdom. Water use is less of an issue in North America, and two or three wash stages are being designed for the new deinking plants expressly to handle flexo. The introduction of flexographic presses in North America has seen a sharp rise since 1987 and the trend, driven primarily by ecological and safety reasons, is expected to continue.

There are two primary approaches to handling flexo inks. One is to find a collector chemical that will help form particles large enough to be removed in the flotation cell, but the chemical must also remove the traditional offset and letterpress inks. The second approach has been to add washing stages and use the clarification step and special polymers to remove the flexo. There has been an explosion of work on both fronts, with some of the pioneering work on flotation removal being performed by the Eka Nobel Co. and Henkel Chemicals.

An interesting new approach to the problem was presented by Galland and Vernac *(44)* at the recent Recycling Forum in Toronto. Their premise was to add an acid (or non-alkaline) pretreatment stage before the conventional alkaline deinking system. The reasoning behind their approach is that water-based inks are formulated using acidic resins, mainly acrylic-based resins, which become water soluble when neutralized with bases such as amines. The printer uses the reduction in pH from alkaline inks onto acid paper to help "set" the flexo inks. When the paper is repulped under alkaline conditions in the deink plant, the inks are resolubilized. Several researchers had noticed that repulping under acid conditions significantly improved the brightness. Galland and Vernac, working at the Centre Technique du Papier in Grenoble, designed a process to take advantage of this, as is shown in **Fig. 31.** The process is described in their paper as follows: "Mixed wastepapers are pulped in acidic or neutral conditions, a first flotation deinking stage is performed in order to remove the inks which have been detached by mechanical action or surfactants, the lack of alkaline reagents avoids solubilization of binders of flexo inks and a large part of them is removed during this first flotation stage. After thickening, an alkaline treatment (on the flowsheet of peroxide bleaching) and a mechanical treatment are performed in order to detach conventional inks, and a second flotation stage is performed in the same conditions as in a conventional deinking plant. The mechanical treatment can be deflaking if screening and cleaning are implemented in the first non alkaline loop." **Figure 32** shows the results from this type of a system.

Ultraviolet (UV)-cure inks and varnishes: The interest in UV-cure inks is based on several advantages: there is no solvent effluent; the ink film is instantly sealed by the ultraviolet radiation, improving print quality at higher printing speeds; and immediate drying eliminates wet trapping between printing stages *(44)*. A free radical photopolymerization and/or a photoelectric crosslink reaction occurs in most of the UV-cure inks. These polymers prove difficult to break up in the pulper, and remain in the 50- to 100-μm size range.

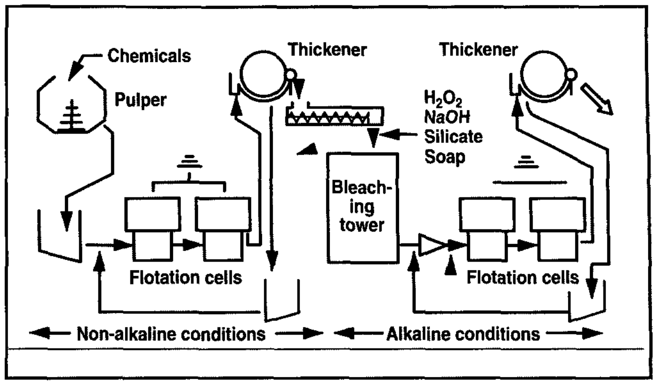
Varnishes are applied to give a glossy finish or as a protective barrier. They can be applied to just the printed area or to the entire sheet. Varnishes (other than UV-cure) are formulated primarily on phenolic-formaldehydic resins, modified alkyd resins, nitrocellulose, and polyurethane *(45)*.

The problem with coatings like this is that they are cured (UV) or cross-linked and form an impermeable layer that normal deinking operations cannot handle. The alkaline environment in the pulper is not sufficiently stringent to make much of an effect on these materials. In some instances, they will be removed as an entire sheet or large strip which can be easily removed by the cleaners and screens. However, these products usually create large specks in the sheet that are very difficult to remove, as shown in **Fig. 33.**

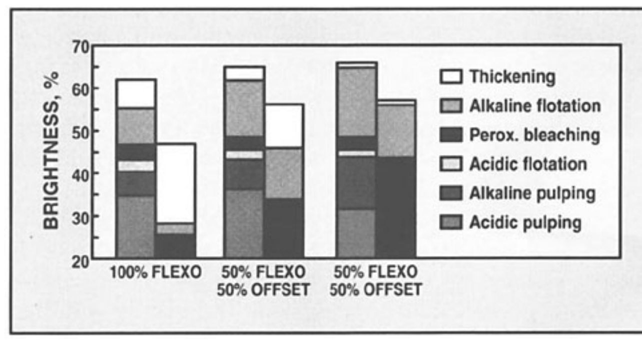
With large specks, it is hoped that the cleaners and screens will take them out. After pulping, the specks have a density of about 1.25 to 1.35 g/cm³ making for difficulties in removal by centrifugal cleaning *(45)*. Another complication is the ease with which these specks will deform without breaking, as the specks have a thin, film-like shape they can force their way through screen and cleaner holes and slots, thereby reducing the removal efficiency. The tough, cross-linked surface makes the particles resistant to attachment by collector chemicals, or most any other conventional chemicals.

A few approaches have been taken to remove these problem materials, most all of them mechanical: changes in flotation cells, use of dispergers, improved cleaner and screen design, etc.

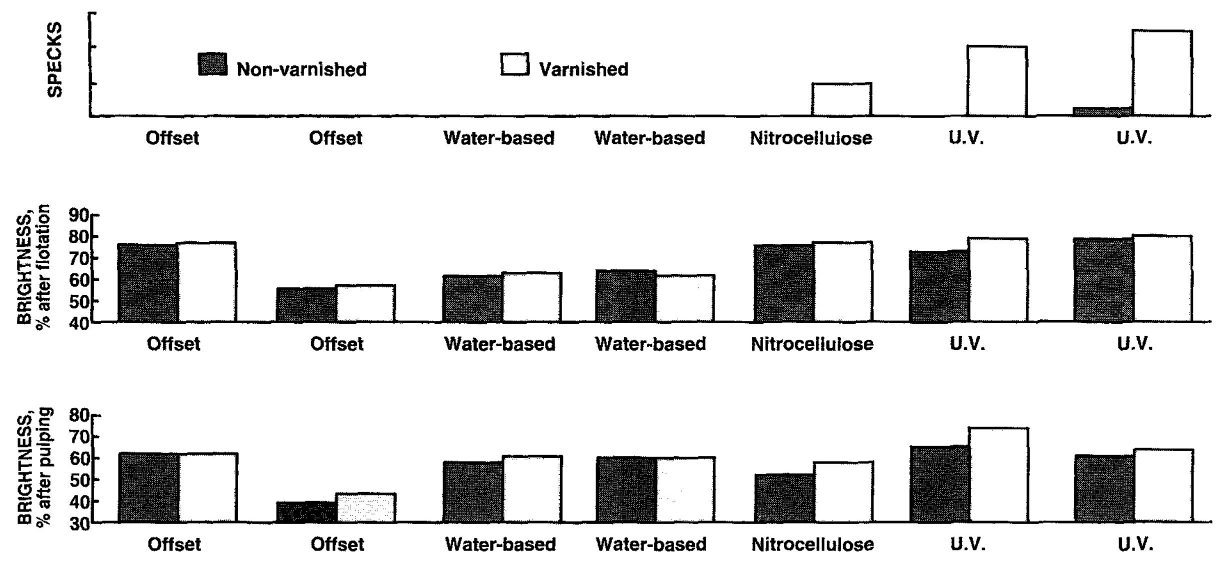
31. Flow diagram for two-stage removal of flexographic inks *(44)*



32. Results from two-stage flexo ink removal system *(44)*: comparison of results between conventional deinking and the proposed two-stage deinking process for French offset and Italian flexo newspapers.



33. Influence of different various applications on speck and brightness of deinked pulp *(45)*



Clarification chemistry

Clarification chemistry is, perhaps, one of the most underrated and overlooked areas of an entire deinking system. But the clarifiers have one of the major roles to play in the successful operation of a deink plant. The objective of the clarifier is to take as much of the ink, dirt, filler, fines, fibers, etc., that have been sent to the water loop out of the system so that clean water can be sent back to wherever water is required, for example, the pulper, shower bars, and dilution points.

Most deinking mills have one or two stages of clarification within the deink plant, which is separate from the main mill primary clarifier. Deink mills usually use dissolved air flotation (DAF). The term "Krofta" is frequently used to mean the dissolved air clarifier. Krofta is a manufacturing company that makes dissolved air flotation cells (amongst other equipment). The use of Krofta, to mean the DAFs, has crept into common useage, much the same way "Kleenex" has become synonymous with tissue. The use of the word Krofta is not intended to imply this manufacturer is better than another, but frequent use of the term has meant it has become part of the deinking vocabulary. There are several excellent companies manufacturing dissolved air flotation cells, e.g., Purgomat, Hydrocal, Poseidon, Permutit as well as Krofta.

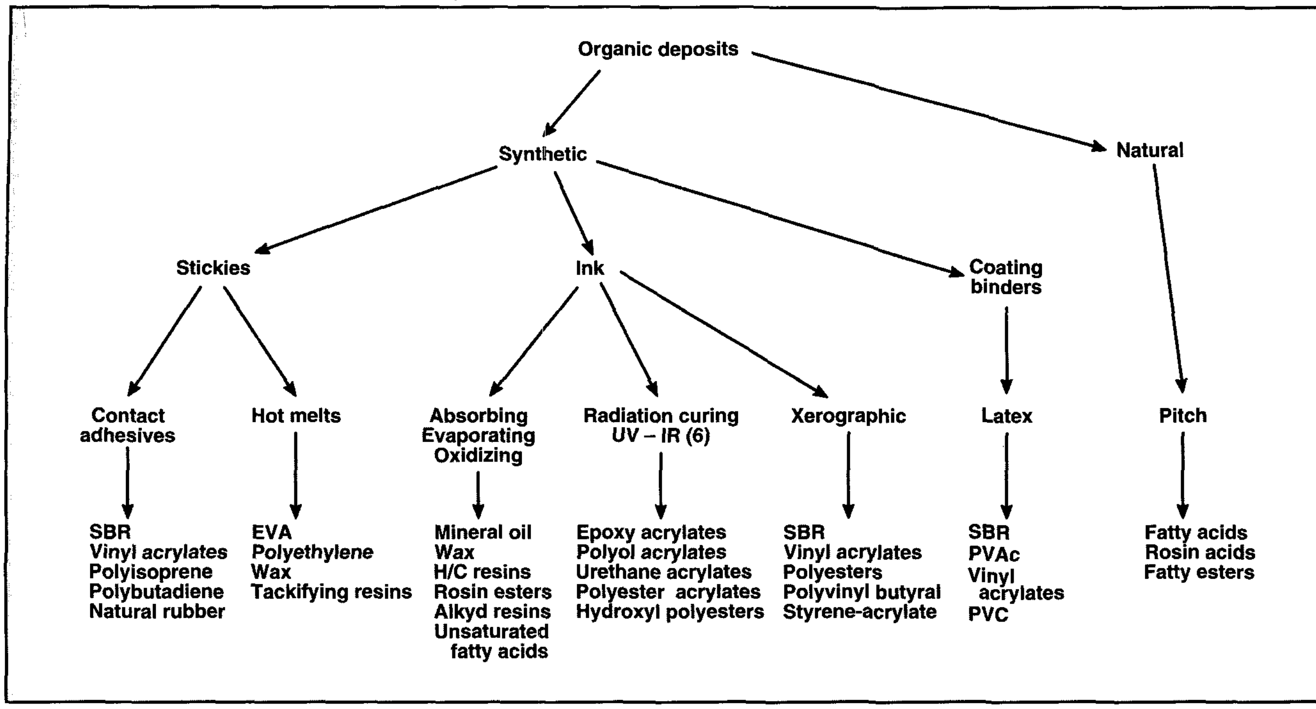
Once the DAF is in place, it is up to the chemist to make the unit work to the best advantage. The typical chemistry is a two-component system: a coagulant to neutralize the anionic charges and form small flocs, followed by a flocculant which forms a bridge between the small flocs creating a larger loose structure that will trap air, thereby causing the larger flocs to float. The mat these polymers form on the surface of the clarifier is removed, thickened, and disposed of while the clarified water returns to the deink mill. The coagulant is usually a high-charge, low-molecular-weight cationic polymer. The flocculant is often a low-to-high charge, high-molecular-weight anionic polymer. The coagulant dose is in the range of 10–40 ppm and the flocculant ranges from 3 ppm to 5 ppm. In the case of a dual water loop deink plant (acid and alkaline) with two DAFs, the polymer dose would be divided between them, with the majority of the polymers being used in the alkaline loop, which is the most heavily ink/dirt laden water stream.

If it is not critical that the effluent from the DAF be of high water clarity, it is possible that a single-component flocculant be used. These may be nonionic (no formal charge) in nature with high molecular weights, and are mainly used for colloidal ink removal, such as flexographic inks. Cationic flocculants are also used for charge neutralization and floc formation; these have medium to high molecular weight and low to high charges.

Bentonite has been investigated as a potential cost savings approach in a dual polymer system, replacing the cationic coagulant. The bentonite is a specially modified clay that has an enormous surface area that will absorb anionic material (ink, fillers, fines, etc.) and provide a starting point for floc formation. The bentonites are teamed with a high-molecular-weight anionic or nonionic flocculant. It has been reported that bentonite will help to reduce the BOD/COD in the effluent.

The correct dosage of the polymers, whether dual- or single-

34. Contaminant profile and source in secondary fiber furnish *(46)*



component, is crucial for both performance and cost purposes. Each polymer has its own operational range. Most DAFs have turbidity monitors for the influent and effluent with feedback loops to automatically control the correct polymer dose. Excessive use of the polymers can create tight, heavy mats that will not float, or if they do float are too dense for the removal system.

Contaminant control

Contaminant Control: "Contaminant" is a useful term that covers the range of materials that are unwanted presences in the water or adhere by one form or another to various bits and pieces of the deink plant, paper machine, and clarifier, as well as all the pipes, fittings, and couplings in these locations. Typical deposit locations for the worst offenders, appropriately named "stickies," are the wires, felts, Uhle boxes, foils, granite rolls, press rolls, and dryer cans.

For the purposes of this chemistry section, deposits will be confined to stickies. **Figure 34** is a line diagram of contaminants tracing the source of various stickies that are frequently found in wastepaper *(46)*. Stickies can be affected by process parameters such as temperature, pH, shear, retention, ionic charges, and other additives. The best method for dealing with stickies is not to allow them in the wastepaper in the first place. Rigorous inspection of the incoming materials and rejection of contaminated batches will significantly reduce the problem. However, it is not practical (and it is dangerous) to assume that no stickes will creep into the deink plant. Stickies are ubiquitous and have a habit of cropping up at unexpected moments. It is wise to be prepared to handle them.

There are two principal methods of removing stickies: mechanical and chemical. There has been considerable progress in recent years on both the mechanical and chemical removal systems. On the mechanical front, pressure screens with fine slots (0.25 mm) have shown promise for dealing with pressure-sensitive adhesives, styrofoam, waxes, etc. *(47)*. Disperger units have been shown to handle hot melts and other stickies *(48)*. Before embarking on any removal strategy, it is prudent to identify the nature of the contaminant. This may help direct the attack. Many papers have been written on the approach to take for identification of stickies *(49-53)*.

Stickies often have the same density as water and are therefore difficult to remove by flotation or centrifugal cleaners. Some of the stickies can deform their shape and fit through screen holes and slots. For these reasons, and to remove the stickiness from stickies, chemical means are taken. The approach that is taken with chemicals is a multiphased approach, including dispersion, detackification, passivation, and agglomeration. The chemical means for dealing with stickies have focused in three main areas: inorganics (talc and zirconium compounds), dispersants/ passification, and synthetic fibers. Some excellent review articles have been written on these topics *(54-58)*.

Inorganics: Talc is a soft, plate-like mineral consisting of a layered structure in which a magnesium sheet is sandwiched between two silica sheets, with the plates being held together by Van der Waals forces *(59)*. The unique property of talc is the hydrophobic face and hydrophilic edge of the plates. This property allows dispersion in water and permits small stickies to adhere to the face of the talc; or the talc to coat the surface of large stickies. Talc dose varies on the nature and severity of the contaminants, but 0.6–1.9% on o.d. fiber is often used. Talc will not work on stickies that are not tacky at headbox temperatures but become tacky at dryer temperatures *(58)*. Talc has an additional useful benefit in that it acts as a white filler in the sheet, improving brightness and printability.

Zirconium compounds have been tested for their ability to passivate, or coat, the surface of stickies. Goldberg noticed that zirconium compounds tend to change the appearance of the sticky from black and tacky to grey and flaky *(60)*. Goldberg continued with the following summary for the effectiveness of zirconium products: "Zirconium chemicals control all of the stickies some of the time, some of the stickies all of the time, but not all of the stickies all of the time."

Dispersants/passification: Dispersants are usually anionic (negative charge) or nonionic (no charge). The anionic dispersants work by placing a negative charge on the stickies which keeps them dispersed in the water. Nonionic dispersants work by attaching the hydrophobic end to the sticky leaving the hydrophilic end hanging about in the water. This approach helps to prevent stickies from agglomerating together and becoming one LARGE sticky and one large sticky mess. Cationic dispersants have been developed that react with the anionic groups of the fibers and provide a bridge between the sticky and the fiber. The stickies will attach to the fibers and be removed with the sheet. The drawback to cationics has been the price. Passification or detackification chemicals work by modifying the contact adhesion of stickies, and are usually organic molecules *(61-63)*. These approaches tend to work best on smaller size stickies.

Another approach to the passification is to treat the paper machine wire with a cationic polymer such that the stickies will no longer adhere to the wire. When carefully applied, the wire spray will prevent accumulation of pitch and stickies on the wire and is reported to have a detackifying mechanism on the stickies which prevents agglomeration and subsequent formation of larger particles. The cationic coated particles are attracted to the anionic fibers and leave with the sheet *(64)*. Typical treatment levels are 10 mL/min/m, which is approximately 1.0–1.25 lb/ton of finished paper.

Alum, the "papermaker's friend" can cause considerable problems with stickies and ink agglomeration if it works its way back into the deink mill. Products are available on the market that are reported to sequester the aluminum ions and reduce the agglomeration of colloidal contaminants *(65)*. Typically, alum use in the paper mill is shut off entirely if there is a chance that the water may be recirculated into the deink plant.

Synthetic Fibers: Modified polypropylene fibrils have a high affinity for tacky, sticky particles. The fibrils have a highly branched structure with a very large surface area, typically 8–10 times the surface area of a hardwood kraft fiber *(66, 67)*. The high surface area of the fibrils "wraps" around the sticky particle and reduces the tendency to adhere to wires and felts. The non-tacky particle remains with the paper. The synthetic fibrils do not stick to pulp fibers. McKinney and Currie *(68)* have shown that removal of stickies during flotation is unaffected by the presence of the fibrils.

Residual chemical effects

It is wise to end this section with a brief comment on what is the fate of these chemicals. A great deal is not known about the fate of the various chemicals, and a great deal of speculation, accusation, and supposition goes on, with very little hard proof. Some chemicals are carried forward with the paper; this is the ideal situation for the deink mill but it may not be good news for the paper mill. Some are carried out with the effluent to the mill clarifier or with the sludge to the landfill. But there is the unknown percentage that remains and gets carried around in the water loop. These residual chemicals may build up in concentration and have potential for a significant impact on the deinking operation. Much remains to be done on this topic by the chemical suppliers and the deinking mill. ☐

Literature cited

1. Woodward, T. W., "Deinking Chemistry"; 1991 TAPPI Chemical Processing Aids Short Course; pp. 85–102.
2. Schriver, K. E., Pulp & Paper 64(3): 76(1990).
3. Horacek, R. G. and Jarrehult, B., Pulp & Paper 63(3): 97(1989).
4. Ferguson, L. D., TAPPI 1991 Pulping Conference, TAPPI PRESS, Atlanta, p. 793.
5. Zabala, J. M. and McCool, M. A., Tappi J. 71(8): 62(1988).
6. Woodward, T. W., Pulp & Paper 60(11): 59(1986).
7. Hornfeck, K., Conservation & Recycling 10(2/3): 125(1987).
8. Suwala, D. W. and Feigenbaum, H. N., TAPPI 1983 Pulping Conference, TAPPI PRESS, Atlanta, p. 533.
9. Read, B. R., Stephenson Process Chemicals, Technical Report, Bradford, England.
10. Wood, D. L., TAPPI 1982 Pulping Conference, TAPPI PRESS, Atlanta, p. 435.
11. Mattingley, J. T., TAPPI 1983 Pulping Conference, p. 515.
12. Jossinet, J., Custom Deinking of Newsprint, 1991 CPPA Technical Section Meeting, p. A369.
13. Read, B. R., TAPPI 1991 Pulping Conference, TAPPI PRESS, Atlanta, p. 851.
14. Aspler, J.; "Printing Inks and Processes"; CPPA Tech Course: 1991 Recycling and Deinking of Newsprint and Fine Papers Course.
15. Andrews, D. H. and Singh, R. P., The Bleaching of Pulp, TAPPI PRESS, Atlanta, 1979, p. 211.
16. du Manoir, J. R., "Hydrogen Peroxide Bleaching of Mechanical Pulps"; 1990 CPPA Tech Section Mechanical Pulping Course.
17. Colodette, J. L., Rothenberg, S., and Dence, C. W.; J. Pulp and Paper Sci. 14(6): J126(1988).
18. Lachenal, D., de Choudens, C., and Monzie, P., Tappi J. 63(4): 119(1980).
19. Kutney, G. W. and Evans, T. D., Svensk Papperstid. 88(9): R84(1985).
20. Burton, J. T. and Campbell, L. L., 1989 International Symposium of Wood and Pulping Chemistry, TAPPI PRESS, Atlanta, p. 255.
21. Mathur, I., CPPA 1991 Recycling Forum.
22. Colodette, J. L., Rothenberg, S. and Dence, C. W., J. Pulp and Paper Sci. 15(2): J45(1989).
23. Burton, J. T., J. Pulp and Paper Sci. 12(4): 95(1986).
24. Ferguson, L. D., Kanters, C. J., and Parent, C. M., TAPPI 1991 Pulping Conference, TAPPI PRESS, Atlanta, p. 953.
25. Ali, T., Evans, T. D., Fairbank, M. G., *et al.*, J. Pulp and Paper Sci. 16(6): J169(1990).
26. Fairbank, M. G., Colodette, J. L., Ali, T., *et al.*, J. Pulp and Paper Sci. 15(4): J132(1989).
27. Ali, T., McLellan, F., Adiwinata, J., *et al.*, "Functional and Performance Characteristics of Soluble Silicates in Deinking. Part I: Alkaline Deinking of Newsprint/Magazine"; CPPA 1991 Recycling Forum.
28. Colodette, J. L., Rothenberg, S., and Dence, C. W., J. Pulp and Paper Sci. 15(1): 3(1989).
29. Michalowski, R. J. and Christiansen, S. H., Pulp & Paper 12(6): 76(1988).
30. Shrinath, A., Szewczak, J. T., and Bowen, I. J., Tappi J. 74(7): 85(1991).
31. Quick, T. H. and Hodgson, K. T., Tappi J. 69(3): 102(1986).
32. Darlington, W. B, Tappi J. 72(1): 35(1989).
33. Turai, L. L. and Williams, L. D., Tappi J. 60(11): 167(1977).
34. Wood, D. L., TAPPI 1992 Pulping Conference, TAPPI PRESS, Atlanta, p. 435.
35. Woodward, T. W., TAPPI 1986 Pulping Conference, TAPPI PRESS, Atlanta, GA, p. 425.
36. Woodward, T. W., Pulp & Paper 63(3): 138(1989).
37. Marchildon, L., LaPointe, M., and Bonnelly, B., CPPA 77th Annual Meeting, 1991, p. A89.
38. Turvey, R. W., "Why Do Fibers Float?", CPPA 1991 Recycling Forum, p. 123.
39. Schwinger, K. and Dobias, B., "The Influence of Calcium Ions on the Loss of Fiber in the Flotation Deinking Process," CPPA 1991 Recycling Forum.

40. Putz, H-J, Schaffrath, H-J, and Gottsching, L.; "Deinking of Oil- and Water-Borne Printing Inks—A New Flotation Deinking Model," CPPA 1991 Recycling Forum, p. 183.
41. Horacek, R. G. and Jarrehult, B., Pulp & Paper 63(3): 97(1989).
42. Jarrehult, B., Horacek, R. G., and Lindquist, M-L., TAPPI 1989 Pulping Conference, p. 391.
43. Forester, W. K., Tappi J. 70(5): 127(1987).
44. Galland, G. and Vernac, Y., "Deinking of Wastepaper Containing Waterbased Flexoprinted Newsprint," CPPA 1991 Recycling Forum.
45. Galland, G., Vernac, Y., Saint Amand, F. J., *et al.*, Presented at the 1990 Papiertechnische Stiftung Deinking Symposium.
46. Moreland, R. D., TAPPI 1986 Pulping Conference, TAPPI PRESS, Atlanta, p. 193.
47. Vitori, C. M., "Stock Velocity and Stickies Removal Efficiency in Slotted Pressure Screens," CPPA 1991 Recycling Forum.
48. Matzke, W., and Selder, H., TAPPI 1986 Pulping Conference, TAPPI PRESS, Atlanta, p. 597.
49. Chang, Y. C., TAPPI 1985 Papermakers Conference, TAPPI PRESS, Atlanta, p. 113.
50. Sjostrom, J., Holmbom, B., and Wiklund, L., Nordic Pulp and Paper Res. J. 2(4): 123(1987).
51. Dunlop-Jones, N., and Allen, L. H., Tappi J. 71(2): 109(1988).
52. Cathie, K., Haydock, R., and Dias, I., "Understanding the Fundamental Factors Influencing Stickies Formation and Deposition," CPPA 1991 Recycling Forum.
53. Scott, W. E., TAPPI 1989 Contaminants Problems and Strategies in Wastepaper Recycling Seminar Notes, TAPPI PRESS, Atlanta, p. 69.
54. Hoekstra, P. M,. and May, O.W., TAPPI 1987 Pulping Conference, TAPPI PRESS, Atlanta, p. 573.
55. McKinney, R. W. J., TAPPI 1989 Pulping Conference, TAPPI PRESS, Atlanta, p. 177.
56. Smith, S. E., Progress in Paper Recycling 1(1): 69 (1991).
57. Doshi, M. R., Progress in Paper Recycling 1(1): 54 (1991).
58. Doshi, M. R., TAPPI 1989 Contaminant Problems and Strategies in Wastepaper Recycling Seminar Notes, TAPPI PRESS, Atlanta, p. 81.
59. Williams, G. R., TAPPI 1987 Pulping Conference, TAPPI PRESS, Atlanta, p. 563.
60. Goldberg, J. Q., TAPPI 1987 Pulping Conference, TAPPI PRESS, Atlanta, p. 585.
61. Miller, P. C., TAPPI 1988 Pulping Conference, TAPPI PRESS, Atlanta, p. 345.
62. Ling, TAPPI 1991 Pulping Conference, TAPPI PRESS, Atlanta, p. 1039.
63. Dykstra, G. M., and May, O. W., TAPPI 1989 Contaminants Problems and Strategies in Wastepaper Recycling Seminar Notes, TAPPI PRESS, Atlanta, p. 97.
64. Duffy, R. J. and Aston, D. A., CPPA 1988 Annual Meeting, p. B81.
65. Ormerod, D. L. and Hipolit, K. J., TAPPI 1987 Pulping Conference, TAPPI PRESS, Atlanta, p. 597.
66. Wade, D. E., TAPPI 1987 Pulping Conference, TAPPI PRESS, Atlanta, p. 579.
67. Wade, D. E., Pulp & Paper Canada 90(1): 154(1989).
68. McKinney, R.W.J. and Currie, P.G.C., TAPPI 1986 Papermakers Conference, TAPPI PRESS, Atlanta, p. 161.

The author would like to sincerely thank Boise Cascade for permission to prepare and teach this TAPPI course. Thanks are also extended to my long-suffering colleagues.

Received for review May 4, 1992.

Accepted May 6, 1992.

Presented at the TAPPI 1992 Deinking Seminar.

Keywords: Chemicals, contaminants, deinking, deposits, dispersants, fine papers, flotation, inks, newsprint, surfactants, washing, water clarification.