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Deinking of Xerographic Wastepaper

Dennis D. Zink
Western Michigan University

DEINKING OF XEROGRAPHIC WASTEPAPER

by

Dennis D. Zink

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ABSTRACT

This study was made to determine a method that would deink xerographic wastepaper effectively. The study was done in two parts, the first being a preliminary feasibility study of the deinking methods found in a literature search. The second part involved a further study of the temperature variable of the most feasible method found in the first part. The results indicated that the flotation method would deink xerographic wastepaper very effectively. Temperatures between 130°F and 190°F were used during the pretreatment stage of the flotation method but no significant change was found in deinkability.

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INTRODUCTION

It has become apparent in the U.S. that recycling of waste paper is needed in order to meet the rising demand of fiber for manufacture of various paper products. To increase the amount of paper recycled some new deinking methods have been developed to produce a reusable pulp which is equivalent in optical and strength properties to that of the original pulp. Waste papers from which these pulps have been produced usually were printed with the more conventional inks. These inks are readily removed or soponified with chemicals at elevated temperatures.

In recent years many new types of inks have been developed, which has made the common methods of deinking increasingly unsatisfactory. These new inks are becoming more and more complex with use of synthetic resins and platicizers in them. Several other deinking problems have also arisen with the use of new sizing and coatings. These problems require that either new methods or revision of old methods be developed to resolve the problems in deinking.

One particular area which has presented a difficulty is in deinking of xerographic wastepaper. The inks used on these papers are called toners and are comprised mostly of a thermoplastic resin. These toners cannot be removed from the fiber with conventional chemical and heat treatment. In fact, these methods can often cause negative effects by further setting and staining of the fibers.

Very little has been published on the deinking of xerographic wastepaper. Thus with the increasing amount of xerographic wastepaper being produced, new deinking methods must be developed so the waste can be reclaimed.

HISTORICAL BACKGROUND

Deinking

The first recorded attempt to reuse printed stock was by George Balthasar Illy in denmark in 1695, although it is thought that the reuse of printed materials was attempted long before this. Mathias Koops was granted the first patent on deinking on April 28, 1800, by the British Patent Office.[18] Koops was granted his patent at about the same time the first fourdrinier machine was started in England. Rapid advancement was made in the use of both fourdrinier and cylinder machines, in fact, by 1850 over four hundred of these machines were in use in the British Ilses. This increase in production of machine made paper created large amounts of waste paper that could be reused. At first there did not seem to be any reason for the reuse of waste paper, since the supply of virgin fiber was so great that there was no economical benefits in recycling.

As time progressed the large growth in the quantity of paper products produced in the late 1800's and early 1900's made it evident that the reuse of waste paper was essential. Although no deinking was done on a large scale until the twentieth century, definite methods of ink removal from waste paper were developed in the late 1800's.

Deinking of waste was first confined to papers made from rag or chemical wood pulps. Only a very limited amount of mechanical pulp(5 to 10%) could be tolerated in the early deinking methods. At first, paper used to make books and magazines was made mostly of chemical pulps, therefore they were the primary source of waste paper that could be deinked.

The original process for deinking is basically the same as that used today. It consisted of two basic steps; 1) defiberization of the stock and dispersion of the ink particles, and 2) seperation of the ink and fiber. Caustic soda and other alkalies were used to saponify the resin base of the inks. Once the inks were dispersed the fillers usually found in the waste paper, helped retard the redeposition of ink particles on the fibers.

Initially drum washers with hollander type beaters were used with open tank vomiting cookers in the first part of the deinking process. Multiple type decker washers gradually replaced the hollanders and then the process became so stream lined that continuous systems were possible. The general continuous systems consisted of a hydropulper, cleaners and screens followed by the final steps of bleaching, washing and final screening.

From 1930 to 1940 significant progress was made in making groundwood pulps with much higher brightness, with the use of sodium peroxide and sodium silicate. Thus these mechanical pulps were used more and more in book and magazine papermaking. Further advances in papermaking technology with the use of labels with adhesives, laminated papers, waxed papers, rubber treated paper, synthetic coatings and new types of printing inks have created a large variety of objectionable material to be found in waste papers recently. This problem has caused a shift in the definition of deinking, which was initially intended to mean just the removal of ink from printed waste paper. With the variety of grades of paper being made, deinking has cometo mean the removal of non-cellulosic material in wastepaper to make useful pulp, The great advances made in papermaking and paper converting has created an increased need for new methods of deinking.

One significant method developed recently is flotation deinking. The flotation process was developed in Europe and is based on the method used in the metallurgical industry for seperating various types of ores. Pierre Hines of Portland Oregon,[8] seems to have been the first to investigate the application of this process to the deinking of wastepaper in the mid-1930's. The first commercial deinking installation was started in 1950 by J.W. Jelkes.[19] The process since has been developed greatly and is a major method of deinking today.

Xerographic Reprography

The use of static electricity for recording images first became widespread in the 1950's, although the first electrostatic recording process was invented some 200 years ago.[3] Xerographic reprography is just one type of electrostatic recording, which was developed by Chester F. Carlson in the 1930's. He was atempting to develop a new high quality method for copying documents and drawings. Carlson continued his work in this area until in 1939, he obtained his first patent for the process.[3] The process obtained its name from the Greek words "xeros" meaning, "dry" and "graphos" meaning, "writing", to emphasize the totally dry nature involved as opposed to wet photographic methods.

The first electrophotographic plate consisted of a photosensitive layer of pure sulfur fused on a small zinc plate and hycopodium was used as a developing powder. Since this first invention the xerographic process has developed phenomanally into two very useful techniques of reprography. They are the Xerographic and Electrofax processes. Both involve the technology of producing images based on the use of a photoconductor and electrostatic charges. Electrofax differs from Xerography in that the image is transfered directly to the photoconductive coating on the surface of the sheet. In Xerography the image is transfered from a photoconductive plate(usually made of an alloy of selenium) to the paper surface. Both systems employ dry toners to develop the image, although recently liquid toners have also been used for this purpose.

THEORETICAL DISCUSSION

Deinking of Printed Wastepaper

The recent past history of the paper industry has been effected greatly by, like many industries, two main factors; the increase in demand of raw materials and pollution control. This increase in demand of raw material not only include basic fiberous materials for papermaking, but also raw materials for energy and chemical production. The new pollution controls placed on today's industry has considerably changed the patterns for designing flow streams, especially in reusing as much water and other materials as possible. And also in correctly disposing of the waste that must be discarded. To meet the demands of both of these factors the paper industry has recognized that it must recycle waste papers, but more importantly it must recycle waste papers using as little energy as possible.

With this great necessity of paper in mind and the fact that "graphic papers" account for about 40% of the total paper production today,[4] it is no wonder that the industry has put a major effort into developing better methods of deinking wastepaper.

Today there are three basic methods of making use of printed wastepaper. Of course all three methods involve initial removal of trash and detrimental materials. Two of the methods deal specifically with further removal of contaminant, mainly ink, while the third method involves dispersion of the contaminants within the fiberous stock system. The two basic methods for removal of ink are washing and flotation. Both methods involve two basic steps; 1) fiberization and dispersion of ink particles and 2) seperation of the ink particles from the fiber system. The major difference in the two methods of deinking lies in the second step. In both cases, pulping is usually done in a suitable fiberizing apparatus such as a hollander beater, jordan or hydropulper. Generally the system is made alkaline in the pulping stage with sodium hydroxide or sodium peroxide. Alkalinity is required to swell the fibers and to saponify and dissolve the ink binders.[13] Dispersing agents are also added at this point to disperse the ink so it will not redeposit on the fiber surface. After the pulping, the stock is passed through a deflaker to obtain complete fiberization and ink dispersion, if desired. The stock then may be screened and cleaned if needed with appropriate equipment.

Once the ink has been dispersed in the stock system, all that is left to do is remove the ink, which can be accomplished in two ways. One method, washing, simply involves subjecting the fiber to alternating dilution and thickening, repeated enough times to produce a clean pulp. Two very popular devices used in the washing method are the Lancaster washer and the Sidehill screen. The Lancaster washer uses cylinder gravity deckers arranged in series, with repulping vats between stages. For minimum loss of good fiber only the water from the first pass of washing generally is wasted to the sewer. The fresh water is added at the last repulper allowing counter-current flow of stock and water. Water requirements are very high, usually ranging from 10,000 to 20,000 gal/ton, depending on the type of waste being deinked.

The Sidehill screen has been accepted as another effective method of washing and its main advantages are low initial cost, low operational cost and low maintenance requirements.[19] The Sidehill screen involves the use of an inclined screen which the stock passes over allowing the free water to drain out. The initial consistency is about .6 to 1%, while the discharge consistency is 3 to 7%. Here again the screens can be used in series and counter-current flow of water is used to save as much fiber as possible. This method also requires large amounts of water to effectively remove the dispersed inks. High wash water requirements has always been one of the biggest drawbacks of the washing method along with several other disadvantages. Washing methods sometime involve as much as 25 to 30% loss in yield,[13] and often a major portion of this loss is fiber fines. This can lead to severe loss of strength in the final sheet. Another problem with washing is that it becomes very difficult to remove ink particles greater than 50 microns in size.[20] This problems has been encountered with the newly developed U.V. cured and thermally catalyzed inks.

To attempt to solve some of the problems with washing, flotation has been developed and has become the second major method of deinking. With the flotation method the ink particles are floated out of the fiber system by air bubbles which the particles collect on. Collecting and frothing chemicals are added to the system so that the air bubbles will specifically collect the ink particles and then be stabilized at the surface as a froth. The froth is skimmed off at the surface, removing the ink particles.

Flotation deinking has become very popular because of the low fiber losses(10 to 15%) that can be obtained. Since the colletors are very specific to the ink particles, very little fiberous material is lost. Three types of flotation units have been developed and are in use today.[17,9] The older type of flotation cell by Voith involves injecting the stock and air into the bottom of the cell, dispersing them with a rotating impeller and scrapping the froth off the surface. In the newer Escher-Wyss Unicell the stock flows into the cell over a weir at one end. Air bubbles are supplied to the cell from several air lines or an air bubble mat located at the bottom of the cell. The froth is removed from the surface by several foam-collecting gutters, while the fibers flow out of the cell over another weir. The Sveen-Pederson cell is actually a type of fiber flotation saveall somewhat like the Escher-Wyss Unicell.

One main advantage the flotation method has over the washing method is that it is possible to remove larger ink particles. Also if the wastepaper contains fillers very little is removed. Thus with flotation deinking the final product obtained can be as good in optical properties as the non-printed areas of the original copy.

Specialty coated papers, laminated board, wet strength materials, waxed or asphalted paper require a more severe pulping method before they can be reused. Also these types of papers cannot always be deinked by washing or flotation economically, therefore instead of removing the ink particles they are dispersed finely in the fiber system. One way of accomplishing this is with the Disperger process.[21] The Disperger process can disperse wastepaper contaminants at consistencies above 20%. The wastepaper is first initially pulped lightly then dewatered before it is screw-fed into the center of the Disperger unit. The fiber then passes over a centrifugal disk and arrives at the working members, which are multi-stage concentric rings with teeth. The teeth to stator distance is preset and cannot be changed and the circumferential speed is about 50meters/sec. Decreases in brightness by this dispersion are small and often the sheet may appear lighter in color due to its higher homogeneity. Damage to the physical properties does not usually occur since the actual treatment is very fast, in fact, the strength properties are often improved so that subsequent refining is not required.

It should be understood that the above discussion of deinking is not complete. Many variations exist depending on the type of fibers being deinked, the type of ink being removed and the use of the end product obtained. Many companies do not disclose there operational methods freely and thus the field of deinking is still one with many new possibilities.

Flotation Mechanics and Variables

The flotation process may be broken down into two main steps, each of which is equally important in obtaining an acceptable final product. The first is a mechanical- chemical step in which the ink particles are seperated from the fibers and dispersed into the fiber system. The fibers are first mechanically broken down in the pulper. Alkali is added before or during repulping, which chemically breaks down the bonding between the ink and fiber. Normal alkali concentrations used in deinking are 4 to 8 percent, much less then that used in soda or kraft pulping.[18,19] Since the waste paper fiber have already been exposed to some degree of pulping, bleaching and/or refining, considerable surface area is exposed for penetration and action of the chemicals. Therefore deinking does cause some loss of fiber due to cellulosic breakdown. For preparation of wood-free pulp, sodium hydroxide is used as alkali. But with woody paper, the use of caustic soda alone would cause yellowing. Therefore, as most of the paper grades contain some groundwood, sodium peroxide is employed. The active O_2 of the peroxide prevents yellowing while slightly bleaching the fibers. Water glass(sodium silicate) has been found to stabilize thes active oxygen,[4] therefore is added also.

The main difficulty in pretreatment is in breaking down the adhesion between the fibers and the ink particles. To assist the chemical action, heating to 40-60°C and mixing is used to help seperate the fiber and ink. Dispersing agents and collector chemicals are also added at this stage of the process. Retention time for the entire mechanical-chemical treatment is usually 1 to 1½ hours, with final seperation and dispersion of ink particles being accomplished with a deflaker, if desired. The stock from the pretreatment is usually at a consistency of about 3 to 6% and must be diluted to .5 to 1% before entering the flotation cell. The frothing agent must now be added so the ink particles can be removed from the fiber system, which is the second main step.

The entire flotation process is dependent on one specific factor, that is the ink particles must be made hydrophobic (water hating). This is accomplished by collector molecules such as oleic or steric acid. These collector molecules attach themselves to the ink particle surface making the particle hydrophobic. Now that the particles have a hydrophobic nature any time the particles has a chance to emerge from the water they will. But since these particles are usually heavier than water they will not float to the surface by themselves. Exceptions to this are found when deinking non-conventional type inks.[5] To accomplish particle flotation then, air bubbles are injected into the ink-fiber system. Once the air bubbles have surfaced with ink particles attached the resulting foam is stabilized by a frothing agent such as pine oil. The frothing agent acts to reduce the surface tension of the water allowing bubble to surface and remain unbroken.

A more or less complete monolayer of collector molecules will be adsorbed onto the ink particles if a sufficient amount is added to the system. Having a complete monolayer would seem to be best at making the particles the most hydrophobic. It has been found though that optimim flotation occurs at only 5 to 15% monolayer of collector.[1] This situation is well understood when collector-frother interaction is taken into consideration. Before the particle is attached to the air bubble the majority of collector is located at the solid-liquid surface, while the majority of the frother is at the liquid-air

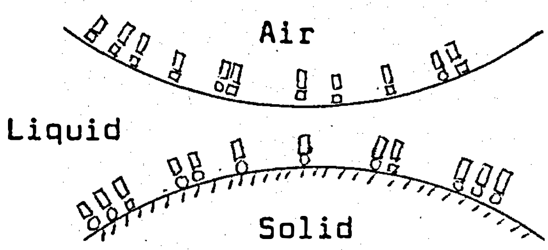


Fig. 1

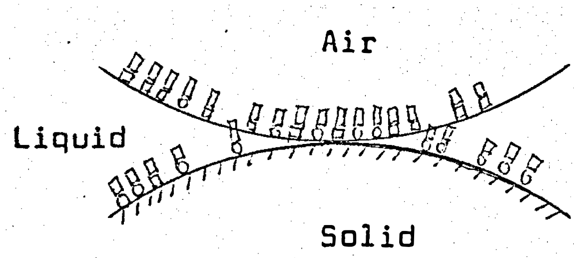


Fig. 2

Collector
Frother

surface as shown in Fig. 1. After merging, Fig. 2, the collector film and frother film are said to be "locked in", creating a very stable system. Thus if the solid had 100% monolayer of collector, this "locking in" could not occur. It has been found that the primary function of the frothing agent is to stabilize the attachment of the particle to the bubble, while its frothing ability is only of secondary importance.[22]

Once the ink particles are floated to the surface they are removed with the froth, while the fiber flows out of the cell below the surface. Usually the flotation process employs primary and secondary cells. The accepted stock is collected from the last of 6 to 10 primary cells connected in series.[4] The froth from each primary cell is diluted and pumped to the secondary cells for reclassification. Any fiber recovered from the secondary cells is returned to the primary cells, while the froth is dumped as waste.

In the pretreatment stage the main variables controlled are consistency, temperature, reaction time and chemical concentrations. Optimizing these variables depends greatly on the type of waste paper that is being deinked. As many as 8 different variables are encountered in the actual flotation stage itself, which can be easily measured and controlled. For both stages of deinking a summary of these variables is given in Table 1 with possible optimum conditions used when deinking a typical mixture of news-magazine wastepaper.[13,15]

TABLE 1. FLOTATION VARIABLES

Pretreatment Stage	Optimum Range
Consistency	5-7%
Temperature	40-50°C
Reaction Time	30 min.
Sodium Peroxide	2%
Sodium Silicate	4-5%
Sodium Hydroxide	
Collector	.3-.8%
Complex Formers	.1-.3%
Final pH	9-10
Storage Chest	1-2 hrs.

Flotation Cells	
%Composition	High% ctd. paper
Retention Time	10-20 min.
Temperature	40-60°C
Water Hardness	380-500ppm
pH	7-10.5
Impeller Speed	2500rpm
Air Bubble Vol.	10-30%
Filler Addition	No advantage

The flotation method has several advantages which are worth mentioning here. First the flotation process gives fiber yield losses as low as 5% with uncoated grades, but can be as high 15-20% with coated grades. The advantage in deinking coated grades is that the fillers tend to help keep the ink particles from redepositing on the fibers. Also since less filler is lost in the flotation process a brighter final product can be obtained. Another advantage of flotation is that a closed water system can be used which reduces fresh water requirements considerably. Finally the flotation process provides a method of recovering high quality pulp efficiently, resulting in a saving with lower virgin fiber requirements.

Deinking of Xerographic Wastepaper

The type of paper required for Xerography and Electrofax is quite different, because of the method involved in applying the developing toner. For Xerography any suitably smooth sheet may be used, but for Electrofax the sheet requires several specific quilities. In the end the Electrofax sheet must be very smooth, have good solvent holdout and have good resistance to toner absorption.[14] Thus the Electrofax sheet will have a considerable amount of coating on the sheet, while Xerographic paper usually requires no coating at all. This difference in the surface of the sheet upon which the resin is deposited may greatly effect the deinkability of the sheet. With the Electrofax sheet the toner will only be in contact with the coating, thus making seperation of fiber and toner much easier. With the Xerographic sheet though, the toner is in direct contact with the fibers and the chemical properties of these toners can make them very hard to remove.

The toner particles consist of a binder and pigment like many other inks, but in this case the binder is usually a thermo-plastic polymer.[11] Some typical binders used are; polystyrenes, polyvinyl acetate, polyvinyl butyral, phenolics, polyolefins, and alkyd resins. Common pigments used are;

carbon black, charcoal, iron oxide and cadium red. The toner particles are fixed onto the sheet by thermal or solvent softening. For both Xerographic and Electrofax, as the toner particles are softened they first tend to flow together, then they flow into the surface of the sheet.[3] Most common thermal fixation is done at about 350-375°F.

Very little literature has been written on the deinking of Xerographic or Electrofax wastepapers. From what has been written though,[1,5,15,20] it is thought that conventional deinking techniques would be very unsatisfactory. One successful new technique has been patented by Green.[5] A major disadvantage to Green's technique is that it is very specific to Xerographic and Electrofax papers only. Therefore if deinking is to be done with his method complete classification of the wastepaper must be made. It would be very advantageous then if a method already in use today could be found to deink these types of wastepapers.

EXPERIMENTAL

Objectives

The objective of this thesis was initially to find, through a literature search, the possible methods available for deinking xerographic wastepaper. Upon completion of the literature search the objective was to test the feasibility of deinking common xerox copy machine wastepaper with the methods found. A further objective was to study one or more of the variables involved in the most feasible method found.

Experimental Design

After completion of the literature search it was found that very little published material was available dealing specifically with the deinking of xerographic wastepaper. Only one article, a U.S. patent by Charles Green was found which offered a new method of deinking xerographic wastepaper.[5] Other articles dealing with specific methods of deinking often did not contain information on the types of wastepaper they would and/or could recycle best. Therefore to initialize my experimental work the study was divided into two stages.

The preliminary stage of study was made to determine which methods found in the literature search might best deink the xerographic wastepaper. Since only one method of deinking xerographic wastepaper was found in the literature search, Green's method was the first chosen to be studied. Appendix I gives a brief description of the steps involved in his method.

Green's entire process depends on the ability of the toner particles to float in an aqueous solution with mild agitation. After repulping, the wastepaper is diluted to .5 to 2% consistency and transferred to a suitable tank for agitation. Along with mildly agitating the slurry, it is heated to between 150 and 205^{o}F and the toner is skimmed from the surface for 15 to 45 minutes. At this point a sufficient amount of immiscible organic solvent is added to form a thin film over the stock suspension and agitation is continued. The solvent acts as a collector for the toner particles. After 15 to 20 minutes of agitation the solvent is skimmed off and the cleaned pulp is reclaimed.

During the preliminary investigation of the method several different solvents, benzene, toluene and cyclohexanone were used to optimize the toner removal. A more exact outline of the procedure used is given in Appendix II.

Due to the thermoplastic, polymeric nature of the toners used in xerography, I felt that the toner particles would remain relatively large after repulping as compared with other common inks using simple varnish binders. It has been shown that flotation deinking is capable of removing large ink particles that other methods cannot such as screens and cleaners. Therefore I chose also to investigate the flotation method in the preliminary stage. A brief decription of a general flotation process is given in Appendix III.

From conversations with people knowledgable in the field of deinking it was thought that xerographic wastepaper could be deinked with a very conventional mechanical-chemical recipe for flotation. Therefore in my preliminary work using a Voith lab flotation cell, a recipe was developed which would optimize the removal of the toner particles.

The major effort made in this stage was to find a suitable collector to use during the flotation step and compatible with a simple chemical pretreatment formula. Also steps were made to obtain a process that would give fiber losses below 15 percent. A detailed description of the final recipe developed is given in Appendix IV.

The secondary stage of my work involved a further study of the best method found in the preliminary stage for deinking xerographic wastepaper. The study would specifically investigate how a certain variable, temperature, might effect deinkability. Due to the thermoplastic nature of the toner particles it was hypothesized that chemical and/or heat treatment of the wastepaper would soften the toner particles. This softening action would then allow the particles to further deposit on the fibers and decrease deinkability. Thus the objective of the secondary stage was to varify this hypotesis.

Procedures

The wastepaper used throughout the experimental study was copies produced on a Xerox 2400 duplicating machine. All Copies were duplicates of a standard original and were made using Xerox 4200 Dual-Purpose White paper and Nashua Type 6 toner. A fiber analysis was made on the rawstock, but no attempt was made to identify the exact chemical nature of the toner.

For all experimental work simple laboratory equipment was used except for the Voith lab flotation cell. The outlines in Appendices III and IV give the steps involved in the two methods studied in the preliminary stage. The procedure outline given for the flotation method was the process found to work most satisfactorily and was also used in the secondary stage of work except that hot tap water was used during the flotation step.

Deinkability during the preliminary stage was determined by visual observations only with Green's method. During the secondary stage of work and the preliminary study of flotation, deinkability was determined by Tappi brightness, color of the final accepts and by the percent fiber loss during deinking. The optical properties were determined using the Technidyne Model S-4 Brightness Tester and Colorimeter. The meter allows calculation of the dominant wavelength and percent purity from the CIE tristimulus values. The procedure for sampling and testing was followed from the found in the instrument instruction manual.[6]

Percent fiber loss was found by making pads of the rejects to determine the total dry weight of refects. Thus the percent fiber loss equals the dry weight of rejects divided by the dry weight of wastepaper times 100.

Ash tests were also made in an effort to determine approximately how much filler was initially in the rawstock and how much was lost during deinking. Ash testing was accomplished following the procedure outlined in Tappi standard T413 ts-66.

Discussion of Results

The final results of the preliminary study indicated that Green's method of deinking would not work well while the flotation method would easily deink the xerographic wastepaper. During the prelinimary study of Green's method two major difficulties arose. First the specific toner used would not readily float to the surface. Even after mild agitation for 45 minutes very little toner material was seperated from the mixture. I felt that possibly using different apparatus and lowering the consistency below 1 percent would increase the floating action. Even if such variations in the procedure would solve the first problem the second major problem would have caused this process to be unfeasible.

The second major problem involved the use of the immiscible organic solvents, all of which were found to be very volatile and known to be somewhat toxic. From these results then I found Green's method would not provide a safe and economical means of deinking.

Observations made during run NB-7(ie, notebook page 7) in the preliminary study of the flotation method indicated that the toner particles could be readily removed. The major problem that occurred was the high percentage of fiber losses. To solve this problem two variations where made; the collector was changed and more heating was used during pretreatment. The observations made in run NB-14 showed that the use of Oleic acid as a collector-frother and heating during pretreatment to above 100°F would lower the fiber losses below 15 percent. It has been found that most industrial flotation processes have optimum percent fiber losses between 10 and 15 percent.[7] From these results therefore I felt that this mechanical-chemical formula of flotation deinking should be studied further in the secondary stage.

The flotation process developed in the preliminary stage was found to be very simple and feasible. The chemicals used were all typical deinking chemicals used in the industry today. A temperature range between 130 and 190^{o}F was chosen to test the hypothesis made about the effect of temperature on deinking. To test the hypothesis rigorously the upper level of 190^{o}F was chosen eventhough this high of a temperature is not often used in industry.

Triplicate runs were made at three different temperatures (130^{o}F,160^{o}F and 190^{o}F)in the secondary stage of study. The deinkability test made on these runs showed very little variations due to the change in temperature. It was found that at all three temperatures the brightness of the deinked waste-paper was as good if not better than that of the rawstock. The brightness increase over the rawstock's was attributed to the difference in formation of the handsheets as compared with the machine made rawstock, since increase of only 2 or 3 points were found. Test for percent fiber loss showed average losses of about 10 percent.

Ash test were made on both rawstock and deinked samples. It was found that between 3.0 and 3.5 percent decrease in ash occurred during deinking. Thus this was found to be the only drawback to this procedure. Possibly without loss of filler an even higher brightness may have been obtained, assuming that a major portion of the ash was pigment. In conclusion to this discussion Tables I and II are presented to give a detailed list of all the results obtained in both the preliminary and secondary stages of this study. Also a graph of the averaged results is given on Graph I.

TABLE I

Preliminary Study Results

Green's Method

Run Number	Immiscible Solvent	Observations
NB-2	Benzene	Little or no toner removed
NB-3A	Cyclohexanone	Little or no toner removed
NB-3B	Toluene	Little or no toner removed

Flotation Method

Run Number	Pretreatment temp	Pretreatment pH	Flotation temp	Flotation pH	Collector	Observations
NB-7	Room temp	11.0	Room temp	10.0	Ivory Snow	Good toner removal, high %fiber loss
NB-11	135°F	9.8	90°F	8.8	Stearic Acid	Poor toner removal, high %fiber loss
NB-14	158°F	10.5	77°F	8.5	Oleic Acid	Good toner removal, low %fiber loss

TABLE II

Secondary Study Results

Individual Results

Run Number	Pretreatment Temperature	Brightness	Dominant WL	Purity	%fiber loss
		Deinkability Data(W/F)			
NB-36 Control	130°F	82.3/84.1	480/490mu	5%	--
NB-17	130°F	82.9/83.4	480/480	"	10.0%
NB-19	130°F	85.6/86.0	490/490	"	9.3
NB-21	130°F	83.6/84.5	480/490	"	6.7
NB-37 Control	160°F	83.0/84.7	480/480	"	--
NB-23	160°F	81.5/82.5	480/490	"	20.4
NB-25	160°F	81.6/83.6	480/490	"	7.1
NB-27	160°F	77.3/80.9	540/480	"	10.1
NB-38 Control	190°F	85.2/85.5	540/540	"	--
NB-29	190°F	81.4/82.7	480/490	"	16.4
NB-31	190°F	82.7/84.0	480/490	"	5.8
NB-33	190°F	85.4/85.9	480/480	"	10.2

Averaged Results

Temperature	130°F	160°F	190°F
Brightness	84.0/84.6	80.1/82.3	83.2/84.2
%fiber Loss	8.9%	12.7%	10.8%

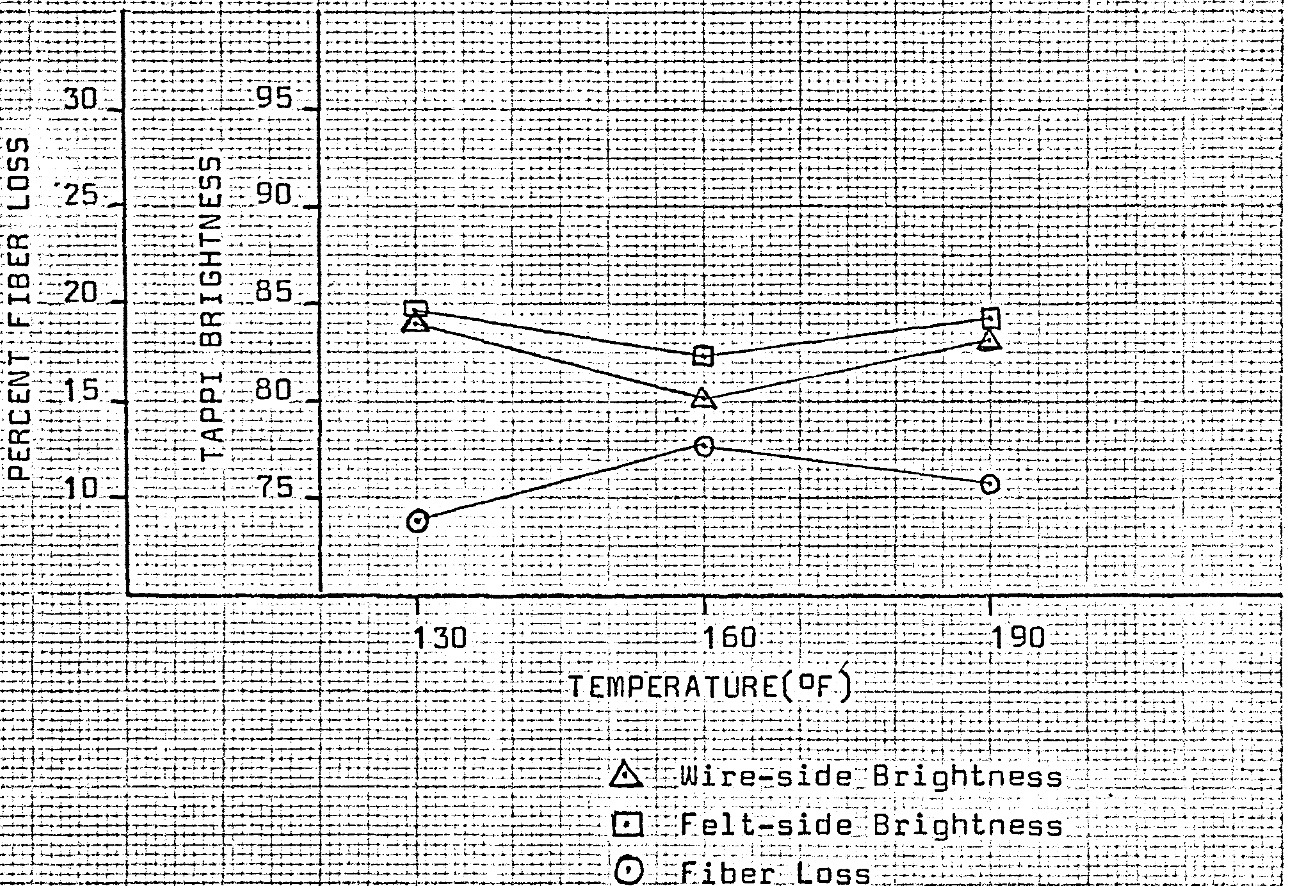
Fiber Analysis Results

79.4% Softwood

20.6% Hardwood

GRAPH I

Secondary Study Averaged Results



CONCLUSIONS

From the results of this study it has been found that deinking of xerographic wastepaper can be easily accomplished using flotation deinking. Furthermore with the use of common deinking chemicals, pulp can be reclaimed with a brightness as high as that of the rawstock's, with only 10 percent fiber loss. It must be understood though, that this study was made on only one type of rawstock-toner combination. With this in mind, I still believe that flotation deinking would prove to be very effective in removing many of the various toners used in xerography today.

The results found in the secondary stage of work have shown that temperature variations between 130°F and 190°F will not decrease deinkability. This proves the hypothesis, that chemical-heat treatment would hindered toner removal, is indeed false. Therefore as far as temperature is concerned this method has proven to be very versatile. From these results I believe that xerographic wastepaper would not cause a major problem if it was deinked along with various other types of office waste.

Samples of the rawstock, pulped printed stock, and deinked pulp are given in Appendix V. As can be seen in the samples of the deinked paper a few toner particles are still in the sheet. I believe with the use of various other types of cleaning or screening equipment common to most deinking processes the last few particles could be removed. Also I believe that after the toner particles are removed, a sheet could be produced with qualities as good as the rawstock's.

RECOMMENDATIONS

Further studies may be made in several areas which have been discussed in this thesis. One such area of study would be to test wether deinkability varies with the use of different types of toners, specifically centering on those with known composition. Also in this same study it might be advantaeous to determine wether using different types of rawstock would cause variations in deinkability.

A further study might also be made on this thesis to determine wether the percent fiber loss could be reduced with the use of secondary flotation of primary refects. Still another expansion of this thesis might involve using scaled up pilot equipment for deinking.

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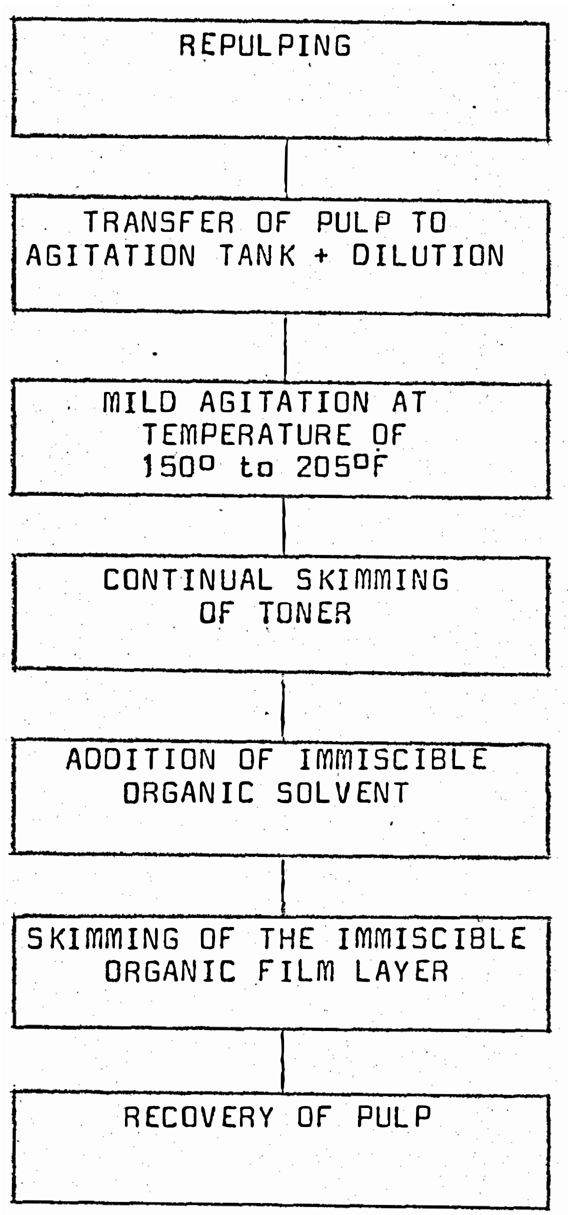
APPENDIX I

Deinking Xerographic Wastepaper by Charles Green



APPENDIX II

Procedure Used With Green's Method of Deinking

1) 40g of wastepaper is repulped in a Waring blender for not more than 60 seconds at 4% consistency.

2) 500ml of slurry is diluted to 1% consistency.

3) The diluted slurry is agitated, skimmed and heated to 150°-205°F for 45 minutes.

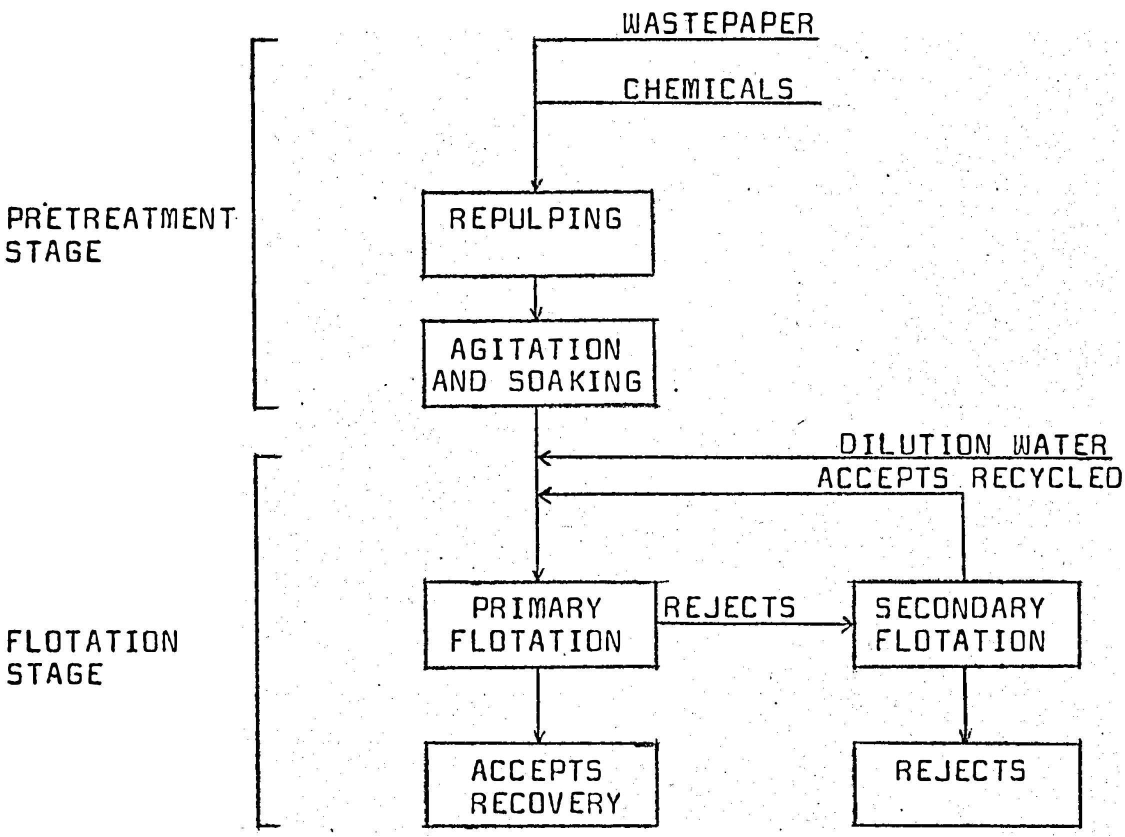
4) The slurry is removed from heat and a layer of immiscible organic solvent is added to the surface.

5) After20 minutes of agitation the solvent is removed with accumulated toner.

6) Observations are made to determine the success of deinking.

APPENDIX III

General Flotation Deinking Process



APPENDIX IV

Flotation Method of Deinking

A) Pretreatment Stage

1) Chemicals,(0.2% Calgon T, 2.0% Sodium Silicate, 1.5% Sodium Peroxide and 0.5% Oleic Acid) are dissolved in hot tap water.(Note: chemical addition based on dry weight of wastepaper)

90g of wastepaper is added to the chemical mixture and water is added to obtained 4% consistency.

3) The wastepaper is soaked for 30 minutes.

4) The wastepaper is repulped in a Waring blender for not more than 60 seconds.

5) The mixture is heated to desired temperature and agitated for 30 minutes.

B) Flotation Stage

1) The repulped slurry is transferred to the flotation cell and diluted to 0.5% consistency with hot tap water.

The flotation cell is turned on and run for 15 minutes.

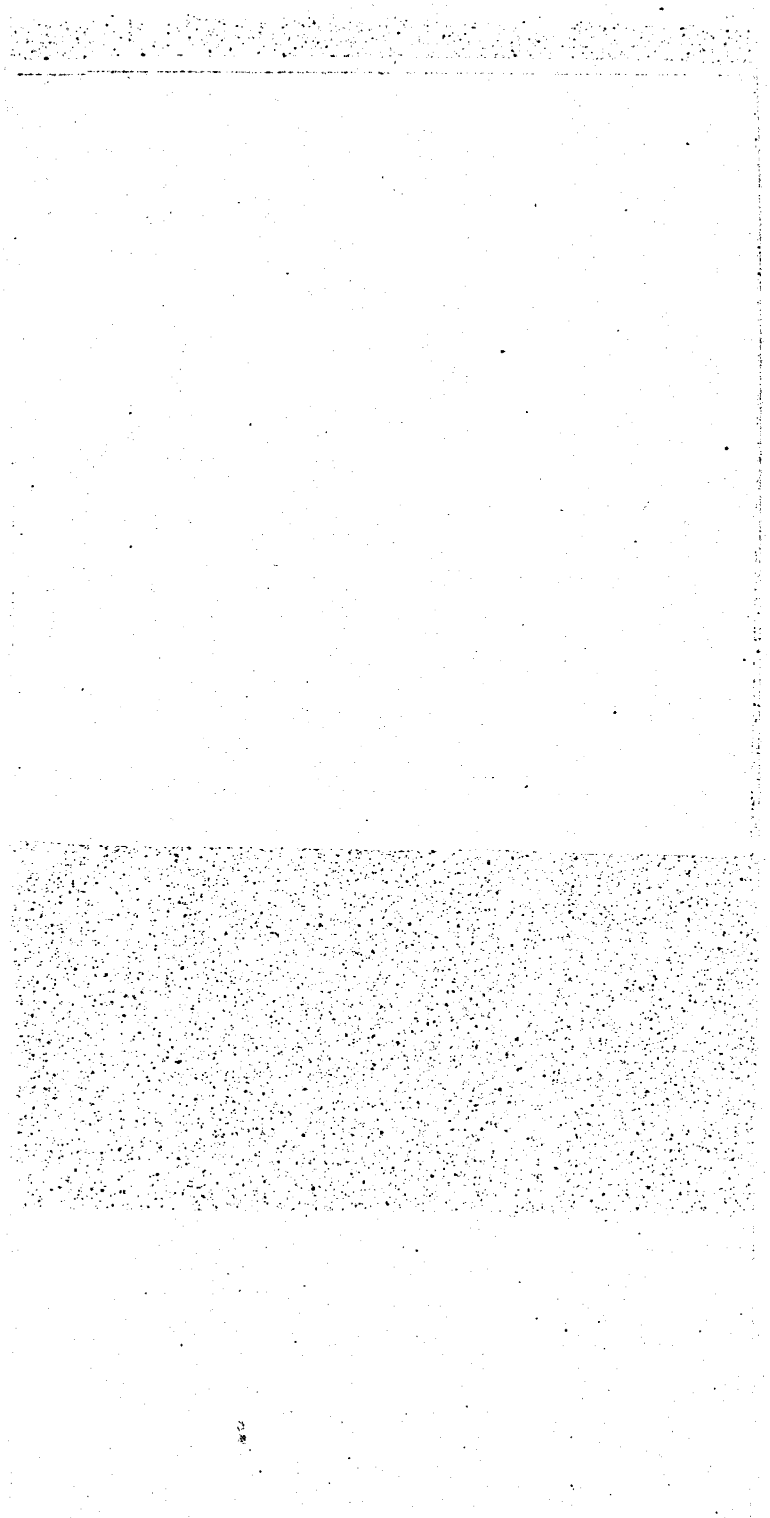
The toner is skimmed off surface along with foam and scum and collected during entire flotation cycle.

4) The flotation cell is turned off and accepts and rejects samples are recovered.

5) Pads are made from rejects to determine fiber losses.

6) Handsheets are made from accepts and optical tests are made to determine deinkability.

APPENDIX V



Rawstock

Pulped Printed Stock

Deinked Pulp Sample