5wRP 1107
P-01940
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CONTROLLING CONTAMINANTS IN THE PRODUCTION AND USE OF DEINKED PULP

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ABSTRACT

Recycled fiber use introduces fines, fillers, microbiological contaminants and stickies contaminants to the papermaking system. Deinking processes are designed to remove or control these contaminants. Important considerations in selecting a deinking processes are the type of wastepaper to be deinked and the desired quality of the deinked pulp. These will determine the extent to which contaminants must be removed and controlled. An understanding of the behavior of contaminants across each unit operation and the role of surface chemistry is improving removal efficiency is essential for effective control.

INTRODUCTION

"Recycled fiber is not inferior to virgin fiber — it's just different."[1] This comment serves as an appropriate prelude to the context of this paper. Whether you are a "new" recycled fiber user producing fine paper or a traditional operation shifting to lower recycled fiber grades, a learning curve will exist. The key to beneficial, cost effective use of recycled fiber is to utilize the right tools to fix the problems.

Deinking involves three basic steps: removing ink from paper fibers, separating the ink from the pulp, and removing the ink from the system. These three steps require three types of energy: physical, chemical, and thermal. Some deinking processes use mainly chemical energy. Other methods, such as steam explosion, use large amounts of thermal energy. Still others rely primarily on mechanical energy.

How does one choose the right method? A number of factors, including economic and environmental factors, will influence the choice. However, system chemistries and equipment are based on the feed stock (the recycled fiber to be processed) and the type and desired quality of the final product. The key component is the raw material.

Once the wastepaper type has been selected, the next step is to identify the types of contaminants. An understanding of the behavior of these contaminants in your system will allow effective control decisions to be made. Problems run the gamut — from new sources of microbiological contamination, increased fines and lots of ink — to serious stickies contamination arising from hot melt glues, contact adhesives, and waxes. The problems associated with recycled fiber contaminants can be roughly broken into two broad categories: sheet quality problems and deposition-induced operational problems.

Product quality problems may manifest themselves as sheet spots or holes and reduced sheet strength, which often adversely affect printing and converting operations. Product quality problems include: high dirt counts, sheet appearance, underliner show-through in board grades, stick-downs and pickies in converting, and coating or printing problems.

Operational problems often manifest themselves as sheet breaks, which result from forming fabric deposition, deposits in the press section, or deposits in the dryer section. These often result in lower machine speeds or excessive downtime for cleaning and washups.

Contaminant Behavior

Two factors that greatly influence contaminant behavior are surface chemistry and particle size. Good surface chemistry:

- helps provide the proper distribution of particle sizes
- stabilizes the particles to keep the proper size distribution
- increases the efficiency of each unit operation

Why is particle size so important? Figure 1 shows particle removal efficiencies as a function of particle size for various unit operations in a deinking/recycling plant. The curve on the left illustrates removal efficiencies for washing systems. Washing efficiency rises as particle sizes reach five microns and above and then drops off quite rapidly as particle size reaches 20-25 microns. At that range, the efficiency of flotation cells starts to increase. It reaches maximum efficiency at 80-120 microns and drops off as particle size approaches 150 microns.

The curve on the far right of Figure 1 shows the particle removal efficiencies for screening, which becomes effective at 300 or 350 microns.

An analysis of Figure 1 reveals why laser inks are so difficult to deink. Many untreated laser ink particles are 150-300 microns and neither washing, flotation, nor screening efficiently remove these size particles. Furthermore, there is no dispersion chemistry currently available that enables the pulper to break down all laser inks to a removable particle size. Because office wastepaper contains 40-70% laser print, this is a serious problem.

MECHANICAL TECHNOLOGY

Stock Screening

Historically, screening was based on a "feedback loop" philosophy where the secondary and tertiary screen accepts would be directed to the primary and secondary screen feeds (respectively). Contaminant cycle-up within the screening loops often occurs. Poor tailings management is also a major contributor to overall stock prep system stickies particle cycle-up. This occurs when systems limit their rejects in an attempt to limit excessive fiber loss.

The following are typical examples of how systems adversely promote the cycle-up of stickies contamination:

- rejects of screens/cleaners are fed back to repulpers/storage chests or to clarifiers
- since contaminant removal equipment has limited capacity, partial flow is diverted back to repulpers/storage chests
- flotation saveall/clarifier sludge is diverted back into the process

Today many changes are being implemented to reduce contaminant cycle-up concerns. Recommended screening schemes utilize forward feed (of accepts) during secondary as well as the primary stage[2]. This is accomplished by using the same screen design and size in both stages. The forward feed approach eliminates cycle-up between primary and secondary stages.

Slotted fine screens (0.15-0.25 mm or 0.006-0.010 in.) are widely used. Slotted screens are more efficient for recycle-related contaminants than traditional hole screens. This allows standard equipment to handle more capacity[3,4,5,6]. Mechanical dispersion equipment is now used to disperse stickies and ink after screening is complete to further reduce stickies particle size.

There are limitations to the level of contaminants a given mechanical system can handle. It is most important to understand the capabilities of the stock preparation system and utilize the proper recycled furnish grades so final product specifications can be met[7].

Ink Removal

Deinking can be subdivided into five processes:

- *repulping*: defibering and removing the ink from the fiber
- *cleaning and screening*: removing large, dense, and light contaminants
- *washing/flotation*
- *dispersion*: reducing contaminant particle size
- *clarification*: separating ink from the system

Centrifugal cleaners separate particles from pulp fibers based primarily on differences in density and shape, but not size. Screening removes larger particles (300 microns and larger) based primarily on size and to a certain extent on shape. All deinking operations use washing or flotation systems or a combination of the two (see Figure 2). Washing systems use large amounts of water in a series of dilutions and thickenings that flush out ink particles. In flotation systems, air is injected to create a froth; the ink particles attach to the bubbles and are skimmed off the surface. In clarification (usually the last process), solids are removed from the process water through flotation and/or sedimentation.

How does one choose the right system for the mill? The end use of the paper plays an important role. If, for example, the end use requires low ash, as tissue does, washing should be considered because the ash washes out with the ink. If the mill is water-restricted, flotation is a better choice because washing systems use a large amount of water.

Most new deinking systems use a combination of washing and flotation to maximize the advantages of both systems. Flotation systems remove ink particles ranging from 20 to 150 microns best. Since specs are caused by particles which fall within this range (≥60 microns), flotation removes particles that cause specs. Washing will remove the very small particles, which most negatively impact brightness.

Clarification

One of the most important unit operations in the control of contaminants (especially in mills with high water reuse) is clarification of process water. Properly clarified water can be reused in the process, in many cases in place of fresh water. The rejects from clarification contain sufficient solids (~5%) for thickening in a belt or screw press. Over 90% of the suspended solids can be removed.

Dissolved air flotation (DAF) clarifiers have become the most common because of their efficiency in solids removal. In dissolved air flotation, suspended particles agglomerate into a floc and readily float to the water surface via their attachment to air bubbles. Proper chemistry is critical to achieving maximum efficiency. The polymer type for optimum solids removal should be determined by testing actual mill clarifier influent. Variables such as flow, total suspended solids, and particle surface charge will influence removal efficiencies.

Coagulation and flocculation are the two chemical mechanisms associated with clarification. Coagulation typically utilizes a low molecular weight cationic polymer or alum to neutralize anionic charge and form a weak or "pin" floc. Higher molecular weight cationic or anionic flocculant will then agglomerate these into larger flocs. Depending upon the level of anionic material in the system, a coagulant may not be required and suitable water clarity can be achieved with a single high molecular weight, high charge, cationic polymer.

It is becoming common to control polymer dosage by using DAF effluent turbidity as the control variable. There are indications that chemical feed rates may better correlate with particle surface charge. Monitoring instruments, such as on-line streaming current detectors and automatic charge titrators, are being studied to further optimize water clarification.

CHEMICAL TECHNOLOGY FOR STICKIES CONTROL

There are four complementary stickies control treatment technologies successfully used to solve stickies related problems. These four treatment technologies are:

- dispersion
- detackification
- cationic polymer
- passivation

Dispersion Technology

The basis of dispersion technology is chemical enhancement of the thermal and mechanical characteristics of the recycled fiber repulping process[8]. These repulping characteristics work together to break down large stickies to small, discrete particles. Dispersion chemistry also acts to stabilize small stickies to prevent reagglomeration. Chemical mechanisms involve wetting, emulsification, solubilization, and stabilization.

Pulper addition dispersion chemistry is designed to solve:

- sheet quality/appearance problems
- dry end stickies deposition
- converting bottlenecks related to stickies

Reducing the size of the stickies contaminant improves quality by reducing unsightly large stickies in the sheet. The smaller, discrete stickies blend in with the fiber mat, thereby solving sheet appearance problems.

Dry end stickies deposition and converting bottlenecks, such as pickouts and breaks, are related to large size stickies. Reducing the individual stickies surface area via dispersion technology also reduces the stickies/dryer fabric bond strength. Although high dryer temperatures still cause the stickies to become tacky, the small nature of the stickies and the discrete manner in which retention occurs results in less deposition.

Detackification Technology

Detackification is the elimination of the contact adhesion properties often associated with tacky stickies surfaces. Detackification technology also stabilizes stickies type contaminants, preventing agglomeration[9]. Detackification chemistry will stabilize and detackify stickies particles but will not reduce their physical size. Nonionic polymer, zirconium, and talc are three detackification treatments.

Nonionic Polymer

Nonionic, high molecular weight detackification polymer encapsulates stickies particles and develops a multi-layer shield that effectively covers the stickie surface, rendering the stickie non-tacky[10, 11, 12]. Hydrophobic segments of the nonionic polymer are attracted and subsequently attached to the hydrophobic stickies. The hydrophilic segments of the nonionic polymer extend into the water phase.

Eliminating the stickies surface contact adhesion properties:

- stabilizes stickies particles
- reduces stickies hydrophobic characteristics
- dramatically reduces paper machine deposition

Detackification treatment of the recycled portion of the furnish has been very successful at solving wet end and press section stickies deposition. Dryer section stickies deposition can be positively impacted under ideal conditions. Mechanical dispersion or pulper dispersion treatment is recommended.

Zirconium

Zirconium chemicals are marketed as stickies control agents that will coat stickies with either a hydrophobic or hydrophilic layer to reduce its tackiness[13]. The organic salt of zirconium, ammonium zirconium carbonate, has been used with limited commercial success over the last ten years.

The mechanism of control is associated with the hydrolyzed zirconium species interacting with functional groups, such as the carboxyl groups on the stickies surface[14]. A covalent bond forms shielding the tacky surface inhibiting on-machine deposition.

Talc

Talc is a soft mineral consisting of a layered structure in which a magnesium sheet is sandwiched between two silica sheets. Talc platelets have large hydrophobic surfaces and hydrophilic edges[15]. In stickies applications, talc platelets align to shield the stickies tacky surface based on their hydrophobic interaction with stickies.

One point that often limits the use of talc is its poor resiliency to shear. Due to the nature of talc and the large stickies particle size (as compared to natural wood pitch), talc-stickies interaction is very shear sensitive. Shear points, such as pumps, refiners, and on-machine shear effects, often result in platelet removal. This in turn may cause stickies agglomeration and machine deposition.

Cationic Polymer Technology

Stock addition of low molecular weight, high charge density cationic polymers is widely marketed for charge neutralization and stickies control. This technology is based on the ability of a low molecular weight, high cationic charge density polymer to "fix" an anionic stickies particle to an anionic fiber.

Cationic polymer technology is typically added at the machine chest in systems utilizing various percentages of recycled fiber. Recycled fiber systems have a high percentage of fines, fillers, and anionic trash in the systems[16]. When fed close to the machine, cationic polymer added to treat "stickies" actually acts as a retention aid. High cationic polymers are effective in retaining fines, fillers, and anionic trash on the fibers. The improvement in retention acts to "clean up" the white water system[17]. As with all papermaking systems, if the white water fines and ash is low, the process will run more effectively.

Concerns regarding the treatment and retention of large stickies (50-100 microns), selectivity of cationic polymer to stickies (rather than fines/fillers), and how recommended feed rates may adversely affect formation are being addressed as more information develops.

Passivation Technology
Passivation products create a soluble barrier, which keeps the treated area free of stickies. Forming fabric and roll neutralization occurs when passivation products stabilize contact surfaces. Numerous products are available that use cationic, low molecular weight, high charge density polymers to inhibit stickies deposition on forming fabrics. Wire return roll, lump breaker, and press roll passivation technology involve both the cationic polymer and surfactant/dispersant treatment approach.

Proper application of passivation chemistry is critical to avoid detrimental effects, such as forming fabric streaking or filling. A properly engineered passivation program will not cause any adverse effects.

Passivation technology inhibits stickies deposition but will not remove existing stickies deposits. This type of localized stickies inhibition treatment is very effective, but is not a substitute for a comprehensive stickies control program.

DEINKING CHEMISTRY

Washing and flotation deinking systems require different kinds of equipment and different chemistries. With washing, the basic procedure is solids separation by thickening dilute slurries of ink and fiber. The ink particles should stay dispersed in the water phase and leave the fiber behind. To do this, the ink particles must be chemically altered so they "like" to stay in water, which means making them hydrophilic[18].

Flotation deinking is also a solids separation procedure. However, in flotation the goal is for the ink to selectively absorb onto air bubbles. Air bubbles are hydrophobic (water-hating), and hydrophobic material attracts other hydrophobic material. Although most ink particles are naturally hydrophobic, the performance of flotation can be greatly improved by enhancing this hydrophobic nature[19].

Washing and flotation chemistries have opposite objectives. So, how do you accommodate both if you have a system that combines washing and flotation? The primary way to modify ink particles in both washing and flotation systems is through surfactant treatment. Each system uses different types of surfactants.

The washing deinking process removes small particles suspended in water. In washing systems, the surfactants turn hydrophobic ink particles that don't "like" water into hydrophilic particles that remain dispersed in the water phase. In flotation systems, surfactants are used to enhance the attraction of ink particles to air bubbles.

These opposing natures of washing and flotation chemistries can cause problems in combination systems. Strong washing chemicals can inhibit flotation and vice versa. Therefore, innovative chemical processes are being developed to solve this problem. For example, "displector" technology is now being used in some systems. Displectors are a combination of dispersants for the washing stages and collector chemicals for the flotation stage. The ratio of dispersant to collector in a formulation is important and should complement the specific deinking system.

Removal of Toner Inks

The polymerized nature of fused toner inks makes it difficult to control ink particle size. A significant portion of toner ink particles will be larger than 150 microns and will not be effectively removed by washing and flotation systems. Because these particles are flat and plate-like with densities slightly less than water, centrifugal cleaning is not very effective either. Only the largest toner particles will be effectively screened.

A mechanical approach to this problem is to heat the stock to a temperature of 190-200 °F and apply high mechanical energy. This breaks down these large toner ink particles to a size that will allow them to be removed by subsequent washing and flotation. However, this approach is very capital intensive.

In another approach, the toner ink is chemically modified to allow its removal in standard forward cleaners (see Figure 4)[20]. The process changes the shape of the particles from plate-like to spherical and the density of the spherical particles is increased to >1.0 g/mL. These two changes allow for removal by conventional forward centrifugal cleaning. Two primary cleaning stages are necessary for the production of fine paper quality pulp using this approach.

Summary

Although there are no easy answers to recycling related problems, an organized approach to identifying and solving these problems will be rewarded. The appropriate technology or combination of technologies must be incorporated into a comprehensive contaminant control treatment program specifically designed to solve each individual mill's recycled fiber stickies problems.

Ink and stickies, along with other problems inherent in the use of recycled fiber, can be managed. Contaminant control is the key to making recycled fiber pay off.

REFERENCES

1. Woodward, T. W., *PIMA Magazine* "Recycled Paper Chemistry: A PIMA Magazine Roundtable," 73(2):20(1991).

2. Mallet, P. F., 1990 TAPPI Tissue Seminar Notes "Chemical and Mechanical Treatment of Stickies," TAPPI Press, Vol. 1, p53.

3. McKinney, R. W. J., 1989 TAPPI Pulping Conference Proceedings "A Review of Stickie Control Methods, Including the Role of Surface Phenomena in Control," TAPPI Press, Vol. 1, p. 177.

4. Gooding, R. W. and Craig, D. F., *Tappi Journal* "The Effect of Slot Spacing on Pulp Screen Capacity," 75 (2): 71 (1992).

5. Philippe, I. J., 1990 TAPPI Pulping Conference Proceedings "Operating Characteristics of Non-Conventional Slotted Screen Cylinders," TAPPI Press, Vol. 2, p. 735.

6. Keegan, P. B., 1989 TAPPI Pulping Conference Proceedings "A Mill's Guide to Pulp Mill Screening," TAPPI Press, Vol. 1 p. 67.

7. Smith, S. E., *Progress in Paper Recycling* "Stickies Properties and the Relationship to Their Removal," 1(1):69(1991).

8. Doshi, R., *Progress in Paper Recycling* "Properties and Control of Stickies Progress in Paper Recycling," 1(1):54(1991).

9. Wilharm, M., *PIMA Magazine* "The Chemistry of Recycling," (73)8:54(1991).

10. Ling, T. F., 1991 CPPA First Research Forum on Recycling, "Modifying Surface Properties of Stickies Materials through Polymer/Surfactant Adsorption," Montreal, Canada Vol. 1, p. 105.

11. Moreland, R. D., 1986 TAPPI Pulping Conference Proceedings "Stickie Control by Detackification," TAPPI Press Vol. 1, p. 193 (1986).

12. Miller, P. C., 1988 TAPPI Pulping Conference Proceedings "Chemical Treatment Programs for Stickies Control," TAPPI Press Vol. 2, p. 345.

13. Goldberg, J. Q., 1987 TAPPI Pulping Conference Proceedings "Use of Zirconium Chemical in Stickie Contaminants Control," TAPPI Press, Vol. 3, p 585.

14. McAlpine, Dr. I., *Paper* "Zirconium Chemicals for Stickies Control," 202(3) (1984).

15. Williams, G. R., 1987 TAPPI Pulping Conference Proceedings "Physical Chemistry of the Absorption of Talc, Clay and Other Additives on the Surface of Sticky Contaminants," TAPPI Press, Vol. 3, p. 563.

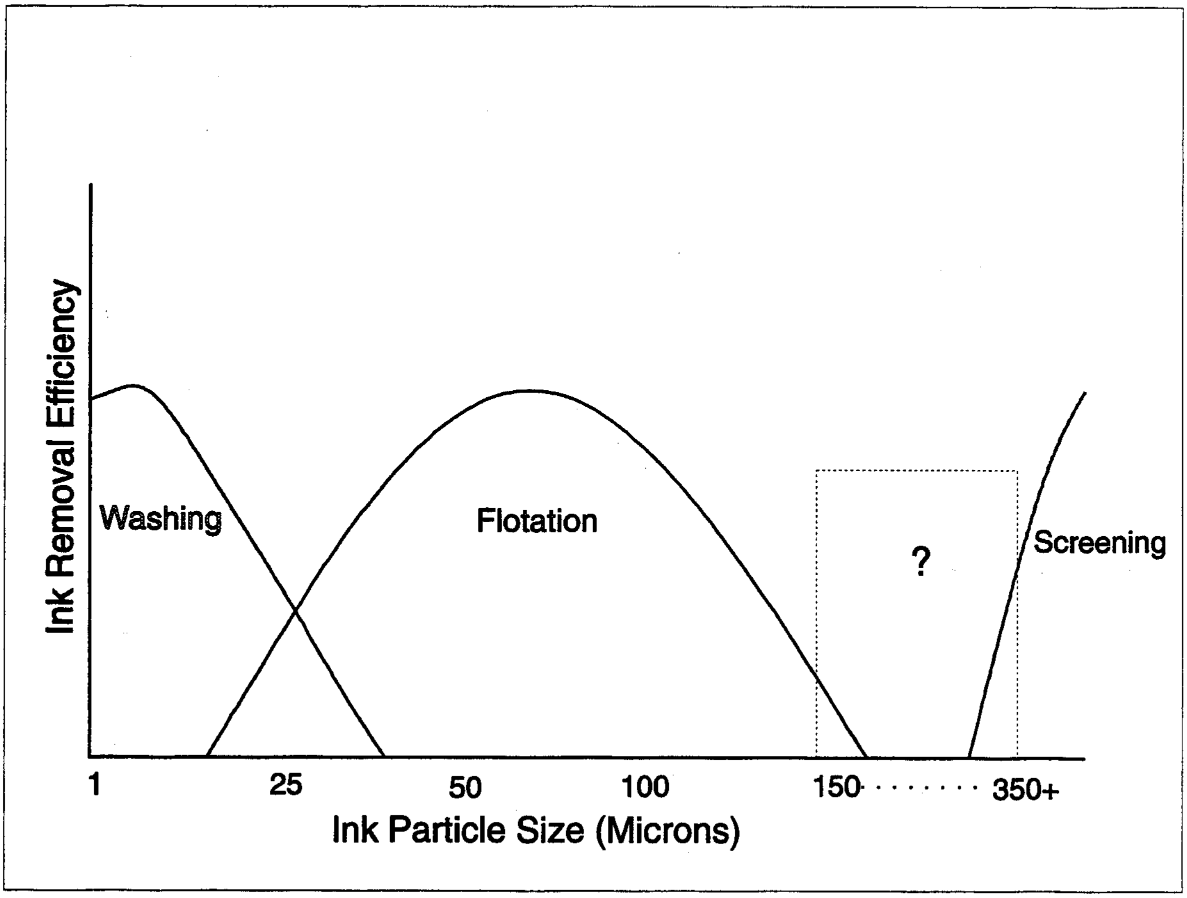
16. Dykstra, G. M.; May, O. W., 1989 Contaminant Problems and Strategies in Wastepaper Recycling TAPPI Seminar Notes "Controlling Stickies with White Water Soluble Polymers," TAPPI Press, Vol 1, p. 97.

17. Dixit, M. K.; Maleike, T. A.; Jackowski, C. W., *Tappi Journal,* "Retention Strategies for Alkaline Fine Papermaking With Secondary Fiber: A Case History," 74(4):107(1991).

18. Woodward, T. W., TAPPI 1991 Chemical Processing Aids Short Course Proceedings, "Deinking Chemistry," TAPPI Press, Atlanta, P. 85.

19. Olson, C. R. and Letscher, M. K., *Appita,* "Increasing the Use of Secondary Fiber: An Overview of Deinking Chemistry and Stickies Control," 45(2):125(1992).

20. Olson, C. R., Hall, J. D., and Philippe, I. J., *Progress In Paper Recycling,* "Laser Print Deinking Using Chemically-Enhanced Densification and Forward Cleaning," 2(2):24 (1993).


Ink Removal Efficiency
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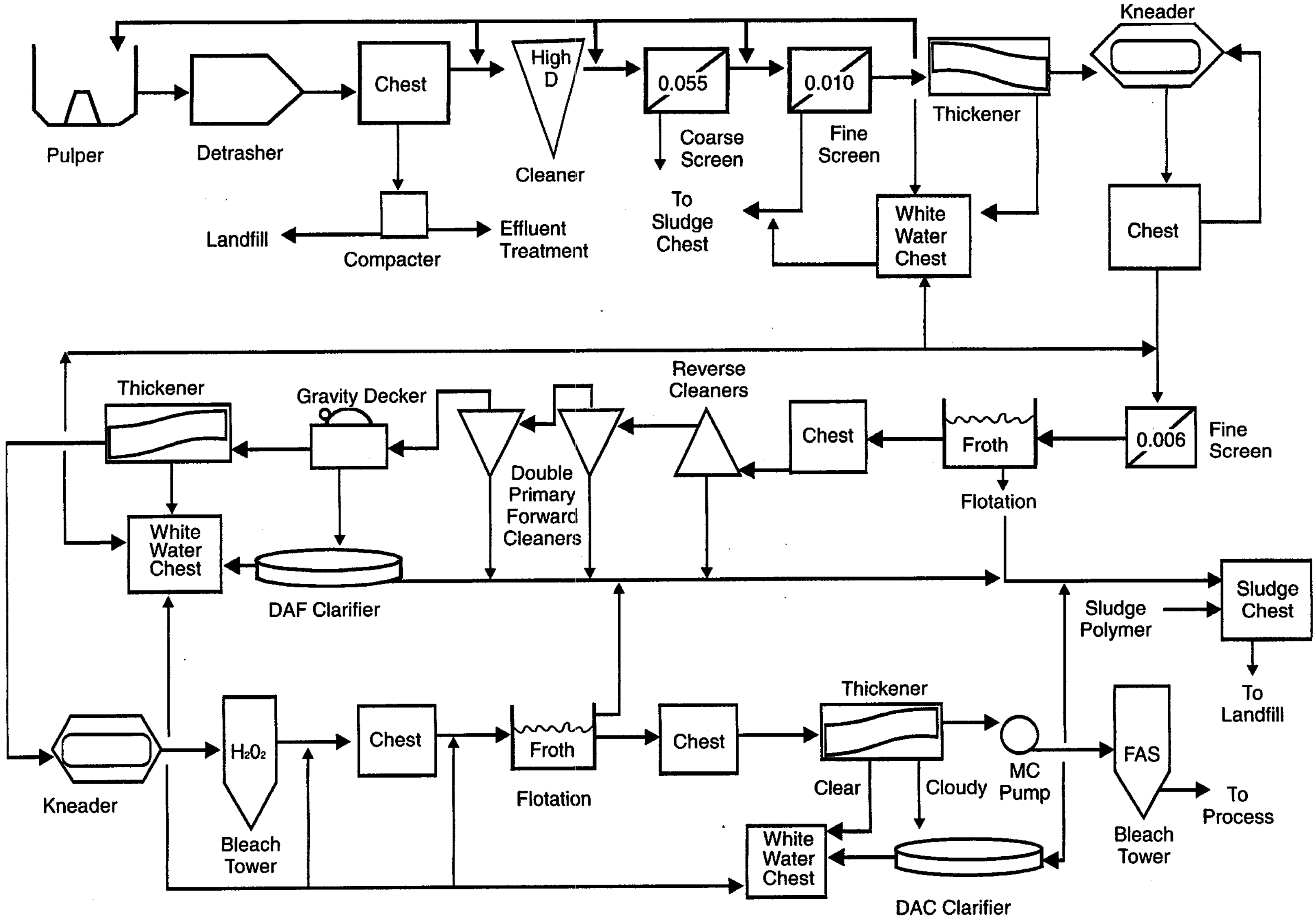

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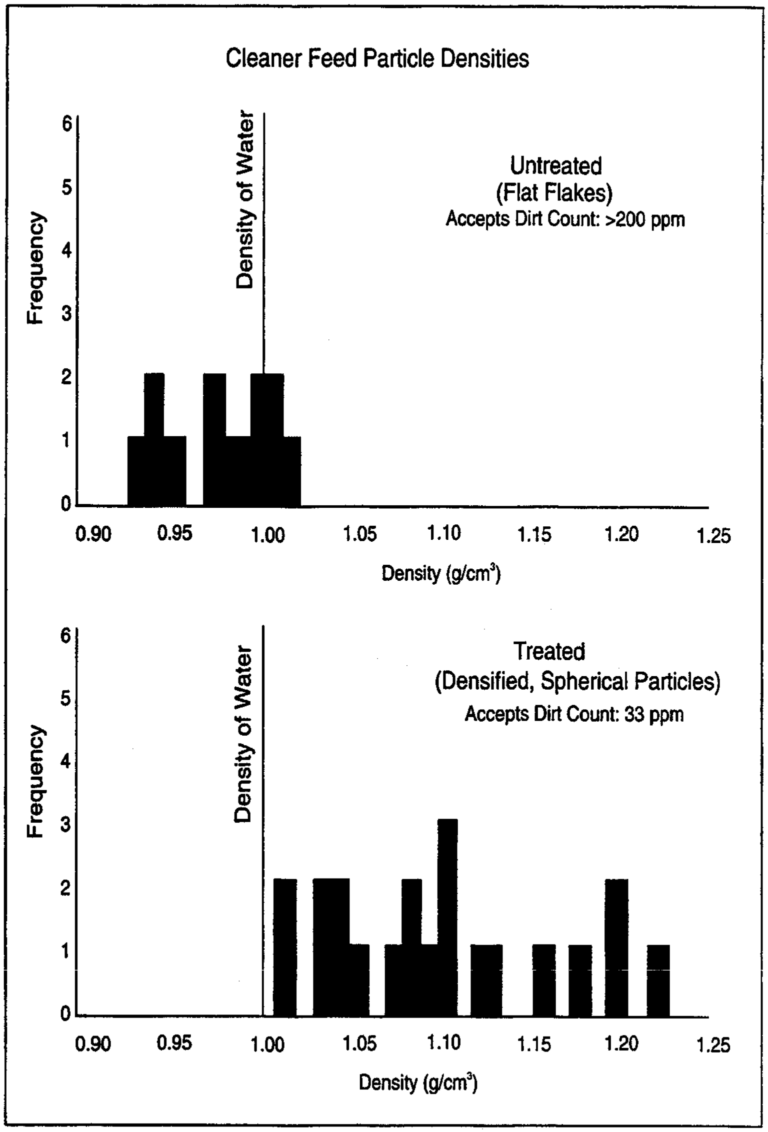
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