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The Study of a Laboratory Screw Press Washer as a Means of Deinking Offset Newsprint at High Consistencies

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THE STUDY OF A LABORATORY SCREW PRESS WASHER AS A MEANS OF DEINKING OFFSET NEWSPRINT AT HIGH CONSISTENCIES

by

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ABSTRACT

The objective of this thesis is to study a laboratory horizontal screw press washer as an effective, yet economical, means of deinking offset newsprint wastes at high consistencies. The theoretical advantages of utilizing a high consistency deinking process include minimal water consumption, reduced and more concentrated filtrate volumes, low effluent solids and fiber loss, and minimal space requirements. The disadvantages include a relatively high unit power consumption, high capital cost, sometimes an inefficient amount of fillers and fines removed, and ink particles may get trapped at consistencies greater than 18%. Results proved many of these theoretical advantages and disadvantages. Also, the screw press did prove to be an effective piece of equipment for removing offset ink at high consistencies. However, further work concerning the screw press is recommended as results were not able to be duplicated due to limiting time factors and mechanical failures of the equipment.

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INTRODUCTION

The objective of my thesis is to study our laboratory screw press washer as a means of deinking offset newsprint at high consistencies. In the past decade or so, many justifications have developed to increase the utilization of secondary fibers in the most economical way. For this reason, I am attempting to study our laboratory screw press washer as a means of obtaining an optimum, economic, high consistency process for deinking offset newsprint wastes.

An optimum, high consistency deinking process is desired for the reason that it will reduce water consumption along with reduce the filtrate volume. Also, this allows for the ink to be highly concentrated, resulting in more practical, less expensive clarification. For these reasons, I feel that there is a justification for high consistency deinking, and that I can accomplish this by studying and trying to optimize our horizontal laboratory screw press washer as a means of deinking.

In the deinking of waste paper, there are three basic phases of ink removal. These phases include:[1]

1. Ink removal from the fiber (chemical addition)
2. Ink removal from the pulp (washing or floatation)
3. Ink removal from the effluent (clarification)

KEYWORDS: Deinking, Washers, High Consistency, Countercurrent Process, Brightness

THEORETICAL DISCUSSION

INK REMOVAL FROM THE FIBER

NEWSPRINT INK CHARACTERISTICS

Newsprint ink consists of a relatively simple formulation. Offset newsprint inks contain 14-20% (by weight) carbon black pigment dispersed in a petroleum or mineral oil vehicle. Offset newsprint inks also can contain as much as 40-50% hydrocarbon resin binder that promotes adhesion and aids in the faster drying required by high speed offset printing.[2] Offset inks are quite viscous, have a paste-like consistency, and contain a relatively high pigment content. Because of this, only a thin film of ink is required, and therefore there is less ink to disperse when deinking.

INK DISPERSION

Fine ink dispersion is the key to maximum ink removal by any washing device, especially those discharging at high consistencies. If a waste furnish contains a large percentage of non-dispersible ink, washing techniques are not practical and a floatation removal method must be considered. Since offset newsprint inks are generally dispersible, this problem should not be encountered.

In utilizing a washing process for deinking, a chemical, not mechanical, dispersion of the ink occurs. The objective in chemical dispersion is to release the individual particles of ink pigment for the ink vehicle,

the liquid that carries the pigment and binds it to the fiber, and to suspend the particles in their natural form and size.

The primary physical limitations of chemical ink dispersion are the type of waste furnish and the type of ink on the fiber. Problems with these physical limitations should not be encountered however when using black offset inks and newsprint. However, some chemical limitations or variables may be encountered. These include the type and quantity of dispersion chemicals added, pH, and the chemical environment in the pulper. Chemical addition must be sufficient to inhibit chemically dispersed ink particles from reagglomerating or redepositing on the fiber.

PARTICLE SIZE

For effective washing, a fine dispersion of homogeneous small particles must exist. A study by Beloit Corporation--Jones Division concluded that a dispersion of particles ranging from 8-50 microns would be adequate for ink removal with low or medium consistency washing.[3] However, these particles would result only in reasonable removal with high consistency washing. With a fine dispersion of offset newsprint, where the largest particles are 8-10 microns in diameter, very effective ink removal with high consistency washing was found. According to Beloit, the effectiveness of newsprint ink dispersion can be readily judged by examining pulper stock, which will be quite black, not

gray, if ink is finely dispersed. Water squeezed from the pulp or effluent from the first washer will also be quite black indicating the presence of a large quantity of ink particles. Ink particles in the pulp that are visible to the naked eye probably reveal either incomplete dispersion or reagglomeration.

DISPERSION CHEMISTRY

Dispersion chemicals are needed in the deinking process to:[4]

1. Remove ink from fiber with minimum fiber damage.
2. Disperse ink particles freely in the aqueous pulp suspension to enable mechanical removal.

Since dispersion chemicals are a significant deinking expense, it is very important to obtain optimum efficiency from minimum chemical usage. Incorrect chemicals, excess chemicals, or unnecessary chemicals represent wasted money.

Chemical addition depends primarily on the waste material, the type of ink, and the process arrangement.[5] In deinking offset newsprint ink, a 1-2% surfactant (detergent) to emulsify the petroleum ink vehicles, releasing the carbon black particles is needed. A sodium silicate must be used with the surfactant to release the resin binder added in offset printing. Different grades of sodium silicate exist. Choosing the optimum grade for a specific process will allow for maximum brightness. Different grades of sodium silicate also provede alkalinity and abrasion. This abrasive nature aids in releasing and dispersing ink particles, along with preventing the

redeposition of ink particles on the fibers.

Hydrogen peroxide may also be a valuable deinking chemical. The use of hydrogen peroxide in the pulper can provide a significant increase in brightness and may provide some assistance with ink removal from the fiber.[6] However, this chemical is expensive and therefore may be more efficiently used as a brightener in a bleaching stage. Sometimes its use in the pulper as a brightening agent may be convenient and effective in small systems where a separate bleaching system is costly, or where only a few points of brightness are required.

Beloit Corporation--Jones Division tested the effect of various concentrations of surfactant, sodium silicate, and hydrogen peroxide on brightness of deinked offset newsprint. This data, shown in the following table, was obtained using a three stage press washing system with a 4% inlet consistency and 34% discharge consistency. The brightness of the unprinted waste margin was 54.1 GE.

TABLE I[7]

TEST	SURFACTANT	SODIUM SILICATE	HYDROGEN PEROXIDE	GE BRIGHTNESS (#3 PRESS CAKE)
A	1%	1.6%	--	47.5
C	1%	1.6%	1%	53.8
E	1%	3.2%	1%	58.2

A single chemical formulation capable of properly dispersing ink of all types of waste paper does not exist. This is because of the fundamental chemical and physical differences in inks. For this reason, testing of each deinking system is desirable to optimize ink dispersion,

ink removal, fiber brightness, and chemical economy.

PULPING CONSIDERATIONS

Miscellaneous variations must be considered when pulping waste paper. The main considerations include the following, as they are specifically related to newsprint wastes:[8]

Temperature- High temperature promotes greater chemical efficiency in deinking. It is usually recommended that pulping temperature be as high as possible subject to equipment and economic limitations but within maximum limits of 150-160°F for groundwood wastes.

Alkalinity- Mildly alkaline conditions, approximately 9-10 pH, generally promote best results in newsprint deinking, since irreversible brightness losses can occur at pH greater than 10. A caustic or sodium silicate can be used to slightly increase pH, while a dilute sulphuric acid (never alum) can be used to slightly decrease pH.

Retention Time- While required retention time for good ink dispersion is dependent on many factors such as chemical formulation, temperature, and type of waste, 40-50 minutes are generally adequate commercially.

Order of Chemical Addition- Addition of all dispersion chemicals to the pulper water prior to fiber addition can possibly increase final brightness as much as two points. The following order of chemical addition is recommended: water conditioner or chelating agent, alkali, surfactant, then bleach.

Water Hardness- Low mineral content in deinking process water is necessary for effective chemical performance and maximum pulp brightness. The most prevalent and harmful hardness ions include iron, calcium, and magnesium.[9] These minerals tend to bind the ink to the fiber and interfere with chemical dispersion. It is very helpful in many cases to add a small percentage of chelating agent to tie up these ions.

INK REMOVAL FROM PULP SLURRY

Once ink has been chemically seperated from the fiber, there are two basic approaches to its removal from the pulp slurry. Dilution washing is the mechanical process of ridding ink particles from the pulp. The other process is a chemi-mechanical process known as floatation.[10] This process of selectively floating ink particles from a very dilute pulp suspension will not be considered.

WASHING SYSTEMS

Washing is the traditional method for removal of chemically dispersible inks for maximum brightness, strength, and ash removal. Various washing devices can be used and must be carefully selected for maximum system efficiency. Basic selection considerations include the type of waste furnish to be used, the final product to be produced, restrictions on the volume and quality of effluent discharged, desired ink and ash removal, required yield, and general operating economy.

Conventional washing devices can be catergorized by their discharge consistencies. Low consistency washing, up to 8% discharge consistency, is usually accomplished by the use of sidehill screens, while high consistency washing, higher than 15% discharge consistency, can be accomplished by utlizing screw presses.[11]

High consistency washing offers a distinct process advantage because it allows for low water consumption, therefore having a tendency to reduce operating costs. Specifically, pumping costs are greatly reduced. High consistency washing may be feasible in any situation where the ink to be removed is chemically dispersible. Newsprint is one situation where proper chemical addition results in finely dispersed ink particles. Particles of this size, whether ink, ash, or dirt, are colloidal in nature and can theoretically be effectively removed at washer discharge consistencies up to 35%. In situations where large particles are present, larger than 15 microns in diameter, complete removal cannot be accomplished efficiently with high consistency washing, and lower consistency washing devices are necessary.

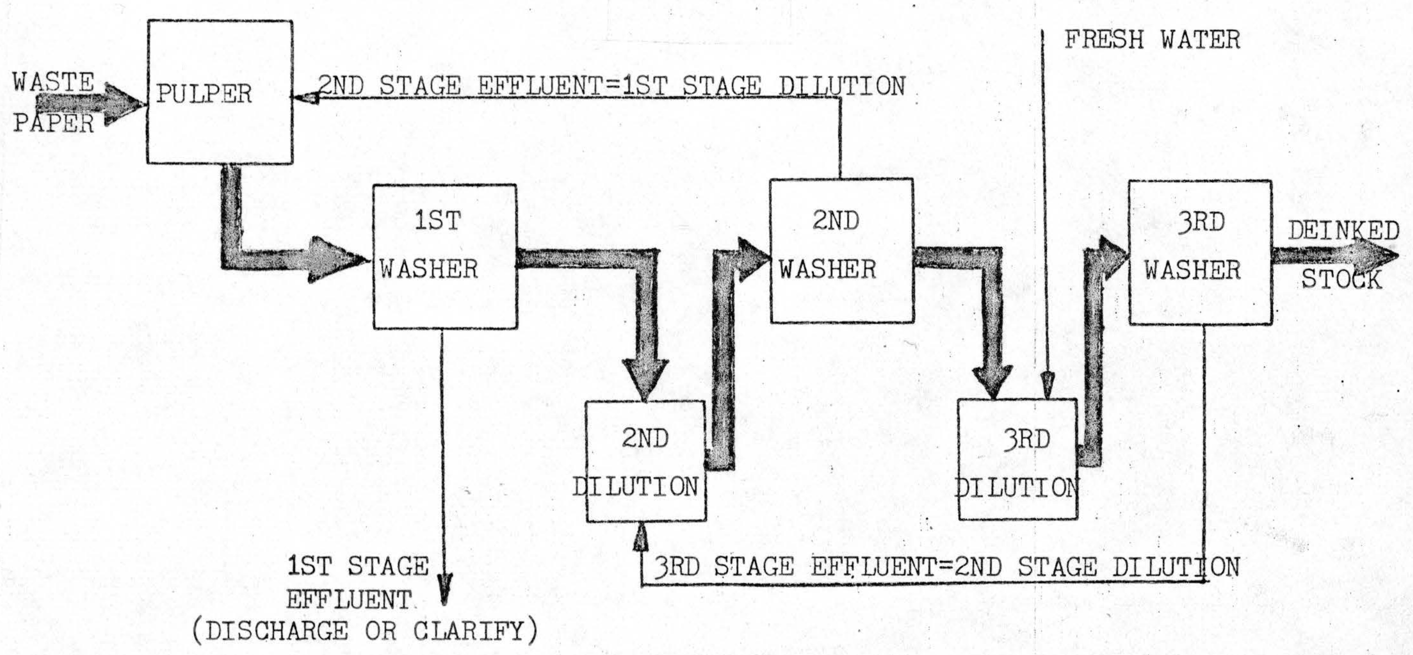
Even though ink particles may be sufficiently dispersed in some cases, many of the clay particles are too large to result in thorough washing at high consistencies. So if particles are too large, or if

substantial ash removal is required, equipment techniques other than high consistency washing must be employed.

COUNTER-CURRENT WASHING THEORY

Most commercial washing systems are generally based on a counter-current flow. This allows for minimum water usage. A counter-current washing system simply involves a flow of wash water opposite from that of the pulp. As illustrated in a three stage washing system below, fresh water is added as dilution prior to the final stage of washing. Effluent from this washer is used as make-up water in the pulper. The first state effluent, the inkiest, is discharged or clarified for continuous use.

FIGURE I[12]



Co-current water flow involves fresh dilution water prior to each washing stage. Water consumption and effluent production from a co-current operation are impractical for commercial operation. For this reason, a counter-current operation is a necessary feature of a dilution washing deinking system.

SIDEHILL SCREEN WASHING SYSTEM

A sidehill washer is unique in that no fiber mat is formed as with other types of washers. Stock slides and tumbles down the wire, continually providing new opportunities for solids removal. Unlike other washers, freeness does not affect capacity significantly.

Sidehill screens are generally constructed from wood, with the shape and arrangement of the screen framework directly affecting water removal efficiency and overall capacity.[13] A stainless steel 80 mesh wire screen is usually recommended to minimize fiber loss and prevent stapling and bending. However, it is not uncommon to see 60 or 100 mesh screens in use. 12 feet screen lengths are most common but range for 8 to 16 feet. Screen width is generally increased to increase capacity. The screen angle is a critical variable in achieving proper operation and maximum drainage. The screen angle varies but 38° from the horizontal is considered optimal in most cases.

Discharge consistencies can be as high as 6%, although 3-4% is more typical. Sidehill screens are desirable for their low capital cost and operation without power. They also are effective in ash removal from heavily filled waste furnishes. Process disadvantages of sidehills include high water consumption and high effluent consistency, resulting in high fiber loss. They also require a large amount of floor space.

SCREW PRESS WASHING SYSTEM

Pulp presses permit operation at high discharge consistencies. Beloit commercially manufactures both vertical and horizontal presses operating in deinking applications within United State industries. These industrial installations include:

Southwest Forest Industries, Snowflake, Arizona
Southeast Paper, Dublin, Georgia
Garden States Paper, Pomona, California[14]

Some Beloit deinking press application also exist in Canada and Mexico, along with screw press applications in European countries that are designed by European manufacturers. However, specific application data was not available to report on. But, it was noted that the newer horizontal press design is the most common and desirable. The horizontal design facilitates feed and discharge, requires less maintenance, and is generally less expensive than other designs.

Several operating variables exist using a horizontal press. The following table summarized the effects of several press operating variables

TABLE II[15]

FOR HIGHER DISCHARGE CONSISTENCY
- Increase Cone Pressure
- Reduce Speed
- Increase Inlet Consistency

FOR HIGHER CAPACITY
- Reduce Cone Pressure
- Increase Speed
- Reduce Discharge Consistency
- Increase Freeness
- Increase Inlet Consistency
- Increase Spindle Compaction Ratio

Inlet and discharge consistency and press capacity are interdependent.

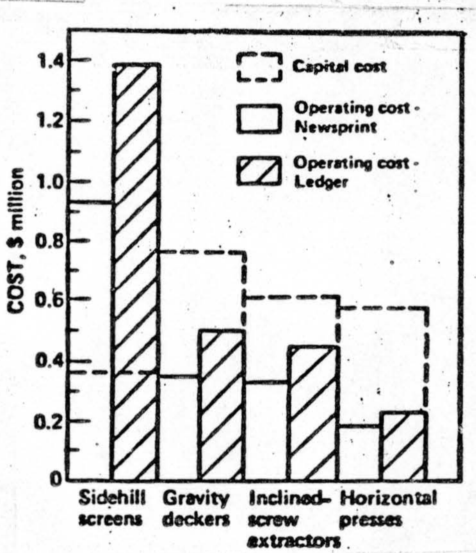
General process advantages of press washing include very low water consumption and effluent discharge, relatively low effluent solids and

fiber loss, and minimum space requirements. Major disadvantages of a press are relatively high unit power consumption and capital cost according to Beloit Corporation.[16] These advantages and disadvantages can also be seen in the following tables by Beloit:

TABLE III:[17] Theoretical ink removal by major washing devices

Washer	Typical consistency, % Inlet	Typical consistency, % Discharge	Theoretical ink removal, % 1 stage	2 stage	3 stage	Filtrate produced (for clarification or discharge), gal/o.d. ton
Sidehill screen	0.8	3.0	73.9	93.2	98.2	19,784
Gravity decker	0.9	5.0	82.7	97.0	99.5	19,664
Inclined screw	3.0	12.0	77.3	94.8	98.8	5,396
Horizontal press	4.0	28.0	89.3	98.9	99.9	4,625

TABLE IV:[18] Relative operating and capital cost of the washing section.



A press is capable of producing deinked pulp discharge consistencies up to 35%. But concern exists that deinking at discharge consistencies greater than 18% may trap and rub ink into the fiber. However, Beloit Corporation has not seen this ink redeposition at discharge consistencies above 18%.[19] However, they recommend that commercial operations deink with a discharge consistency range of 24-28% to allow for more flexibility.

INK REMOVAL FROM EFFLUENT

An important aspect of a commercial deinking process is the clarification of deinking effluents. It is also becoming an ecological necessity in veiw of tightening EPA restrictions.

Clarification of deinking can take either of two forms:

1. Internal Clarification- Clarified water is recycled within the deinking process.
2. External Clarification- Effluent is clarified for clean discharge from the mill.[20]

The first approach is desirable as it can provide a closed loop water system to conserve heat, minimize water discharge, and minimize overall water consumption. Internal clarification utilized dissolved air floatation while external clarification can be dissolved air floatation or sedimentation. Appropriate chemical addition for ink flocculation is necessary for effectiveness in either floatation or sedimentation of deinking effluents.

BLEACHING DEINKED PULP

Some form of additional brightening is usually required in a commercial deinking process to recover brightness lost in recycling, or to increase the brightness above that of the original fiber.[21] Bleaching results with deinked stock depend on fiber characteristecs such as species, age, mineral content, virgin fiber brightness, and bleaching conditions employed before recycling. This stage will not be considered seperately, but will be combined in the chemical addition stage as previously mentioned.

EVALUATION OF DEINKED PULP

BRIGHTNESS

Brightness measurement is the principal means of evaluating deinked pulp. Brightness is a measure of relative reflectance of a monochromatic beam of light reflected from the surface of a sample sheet.

For this reason, brightness is directly affected by the amount of residual or unremoved ink. A high fines content may commercially reduce brightness along with a reduction from fiber storage conditions and the age of the waste furnish. Most importantly, the type of fiber and its initial brightness limits the brightness of deinked pulps.

STRENGTH, FREENESS, AND OPTICAL PROPERTIES

As with brightness, paper properties are usually affected directly from the significant amount of fines removed during the washing stage of deinking pulp. "All the strength properties of the deinked pulp are higher than those of the raw waste, a well known phenomenon attributed to the action of caustic soda on the fiber. The strength, freeness, and optical properties of the pulps are in accordance with the theory that the washing process removes a quantity of fine material which does not contribute to strength, which reduces freeness, but which increases the light-scattering properties of paper made from pulp."[22]

YIELD AND ASH

Yield is generally decreased with a washing deinking process because less fiber fines are present. Fillers and organic materials are also removed, which in turn reduces yeild and the ash content. However, this decrease in yeild is outweighed by the many advantages of high consistency washing. Briefly stated, high consistency washing allows for good strength properties, minimum water consumption, minimum discharge effluents, reduced heat loss, reduced fiber loss, and lower pumping costs.

EXPERIMENTAL PROCEDURE

MATERIALS

"Western Herald" Waste Paper
Non-recycled Newsprint (Groundwood) Fibers
Offset Printing (Black Ink Only)

CHEMICALS

Sodium Silicate ($Na_2SiO_3 \cdot 9H_2O$)
Fisher S-408

Surfactant

Roman Hauss Tritun X-100
Non-Ionic

Hydrogen Peroxide (H_2O_2)
Mallinckrodt
30% Analytical Reagent (Stabilized)

Conditioned Water (H_2O)

EQUIPMENT

Morden Laboratory Slush-Maker
Beloit Laboratory Horizontal Screw Press Washer
Laboratory Sidehill Washer
Noble & Wood Handsheet Maker
Freeness Tester
Buchner Funnel
Mettler Balance
pH Meter
Brightness Meter
Elmendorf Tearing Strength Tester
Mullen (Burst) Tester
Ingstron Tensile Tester

PROCEDURE

ORIGINAL SAMPLE

1. Test the Western Herald offset newsprint for Tappi Standard tear, burst, tensile, and brightness (No repulping).

2. Slush the newsprint waste fibers in the laboratory Morden Slush-maker with conditioned water at 4% consistency without any dispersing chemicals. The retention time in the slusher is constant at 15 minutes with a constant temperature range of 150-160°F.

3. Test the slushed pulp for Tappi Standard freeness and consistency, along with brightness of a Buchner funnel pad.

4. Construct Noble & Wood handsheets and condition them according to Tappi Standards.

5. Test the conditioned handsheets for Tappi Standard tear, burst, tensile, and brightness.

LABORATORY SIDEHILL WASHING

1. Slush the newsprint waste fibers in conditioned water at 4% consistency with a chemical composition of 3.5% Sodium Silicate, 1.0% Surfactant, and 1.0% Hydrogen Peroxide (by weight). The chemical addition order is constant in the sequence above with the fibers being added last. The retention time in the slusher is constant at 15 minutes with a constant temperature range of 150-160°F.

2. Test the slushed pulp for Tappi Standard freeness and consistency, along with pH.

3. Dilute the pulp to 1.0% consistency and deink through a single pass with a laboratory sidehill washer. Dilute again to 1.0% consistency and continue with a second pass. Dilute once again to 1.0% consistency with fresh water and run through a third pass. Note: Dilution follows a three stage standard countercurrent washing sequence.

4. Test the deinked pulp for Tappi Standard consistency and brightness of a Buchner funnel pad.

5. Construct Noble & Wood handsheets and condition them according to Tappi standards.

6. Test the conditioned handsheets for Tappi Standard tear, burst, tensile, and brightness.

LABORATORY SCREW PRESS WASHER

1. Slush the newsprint waste fibers in conditioned water at 4% consistency with a chemical composition of 3.5% Sodium Silicate, 1.0% Surfactant, and 1.0% Hydrogen Peroxide (Condition I). The sequence of chemical addition is as stated above with the fibers being added last. The retention time in the slusher is constant at 15 minutes with a temperature range of 150-160°F.

2. Test the slushed pulp for Tappi Standard freeness and consistency, along with pH.

3. Add a constant volume of pulp to the laboratory screw press at a constant feed pressure. Adjust the press speed, with a constant cone pressure of 1 3/4" spring extension, periodically to try and optimize the washing process performed by the screw press. Dilute the stock from the first pass essentially back to 4% and pass through the press with a constant feed pressure, and the same press speed and cone pressure as the first pass. Dilute back to essentially 4% again with fresh water and pass through as in stage two. Note: Dilution follows a standard three stage countercurrent washing sequence.

4. Test the deinked pulp for Tappi Standard consistency and brightness of a Buchner funnel pad.

5. Construct Noble & Wood handsheets and condition them according to Tappi standards.

6. Test the conditioned handsheets for Tappi Standard tear, burst, tensile, and brightness.

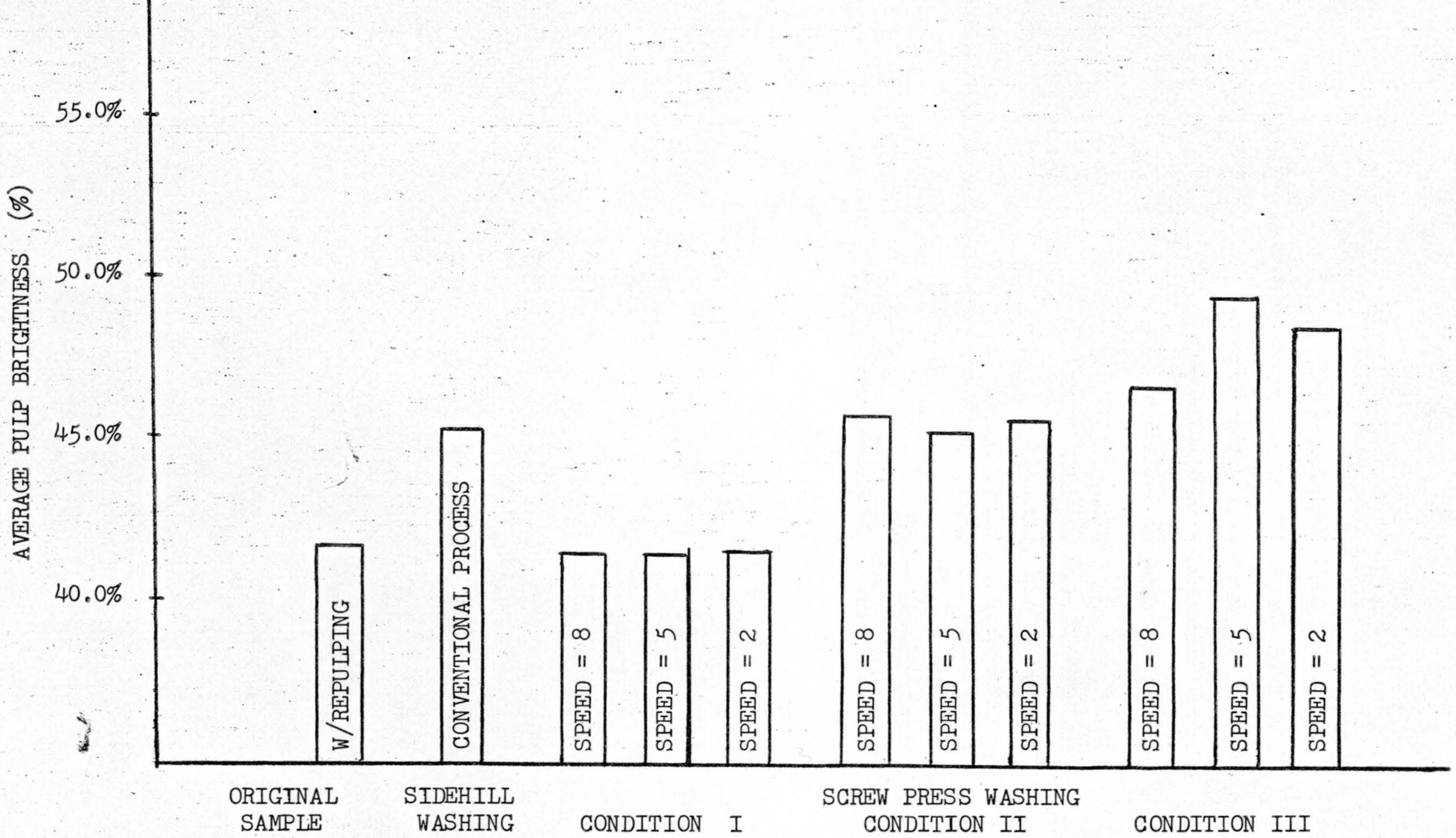
7. Repeat steps 1-6 of this portion for a chemical composition of 3.5% Sodium Silicate, 3.0% Surfactant, and 1.0% Hydrogen Peroxide (Condition II).

8. Repeat steps 1-6 of this portion for a chemical composition of 3.5% Sodium Silicate, 5.0% Surfactant, and 1.0% Hydrogen Peroxide (Condition III).

SUMMARY OF STANDARD VALUES AND RESULTS

PROCESS	FREENESS (ml)	pH	CONSISTENCY INITIAL/FINAL (%)	PULP BRTN. TOP/BOTTON (%)	BRIGHTNESS (%)	TEAR (g-cm)	BURST (psi)	TENSILE (lb/1")	DILUTION RATIO (gal H_2O/ton O.D.)
ORIGINAL SAMPLE (NO Repulping)	--	--	--	--	53.8	25.0	6.13	275/65	--
ORIGINAL SAMPLE (Repulped)	144	--	3.80	42.5/43.8	45.6	55.1	11.3	259	--
SIDEHILL WASHING (Standard)	170	8.75	4.01/3.45	46.5/44.2	47.3	56.0	8.3	212	41,112
SCREW PRESS WASHING									
CONDITION I									
SPEED = 8	170	8.75	4.01/27.8	41.9/42.5	45.7	59.7	7.00	171	12,885
SPEED = 5	170	8.75	4.01/28.6	41.4/43.0	45.6	54.4	6.75	184	12,910
SPEED = 2	170	8.75	4.01/27.9	42.5/43.1	46.4	53.6	6.85	196	12,890
CONDITION II									
SPEED = 8	170	8.45	4.08/32.2	46.5/47.2	49.4	34.6	9.05	201	12,474
SPEED = 5	170	8.45	4.08/31.6	46.3/44.5	50.1	25.9	7.40	173	12,460
SPEED = 2	170	8.45	4.08/32.9	47.0/45.7	50.2	31.0	6.63	148	12,490
CONDITION III									
SPEED = 8	188	8.80	5.60/28.2	48.1/47.0	51.2	35.0	7.05	98	7,711
SPEED = 5	188	8.80	5.60/28.9	49.6/48.7	52.5	32.6	7.48	111	7,731
SPEED = 2	188	8.80	5.60/32.4	49.0/47.9	52.6	30.5	7.10	93	7,821

FIGURE V: AVERAGE TOP AND BOTTOM BUCHNER FUNNEL PULP PAD BRIGHTNESS



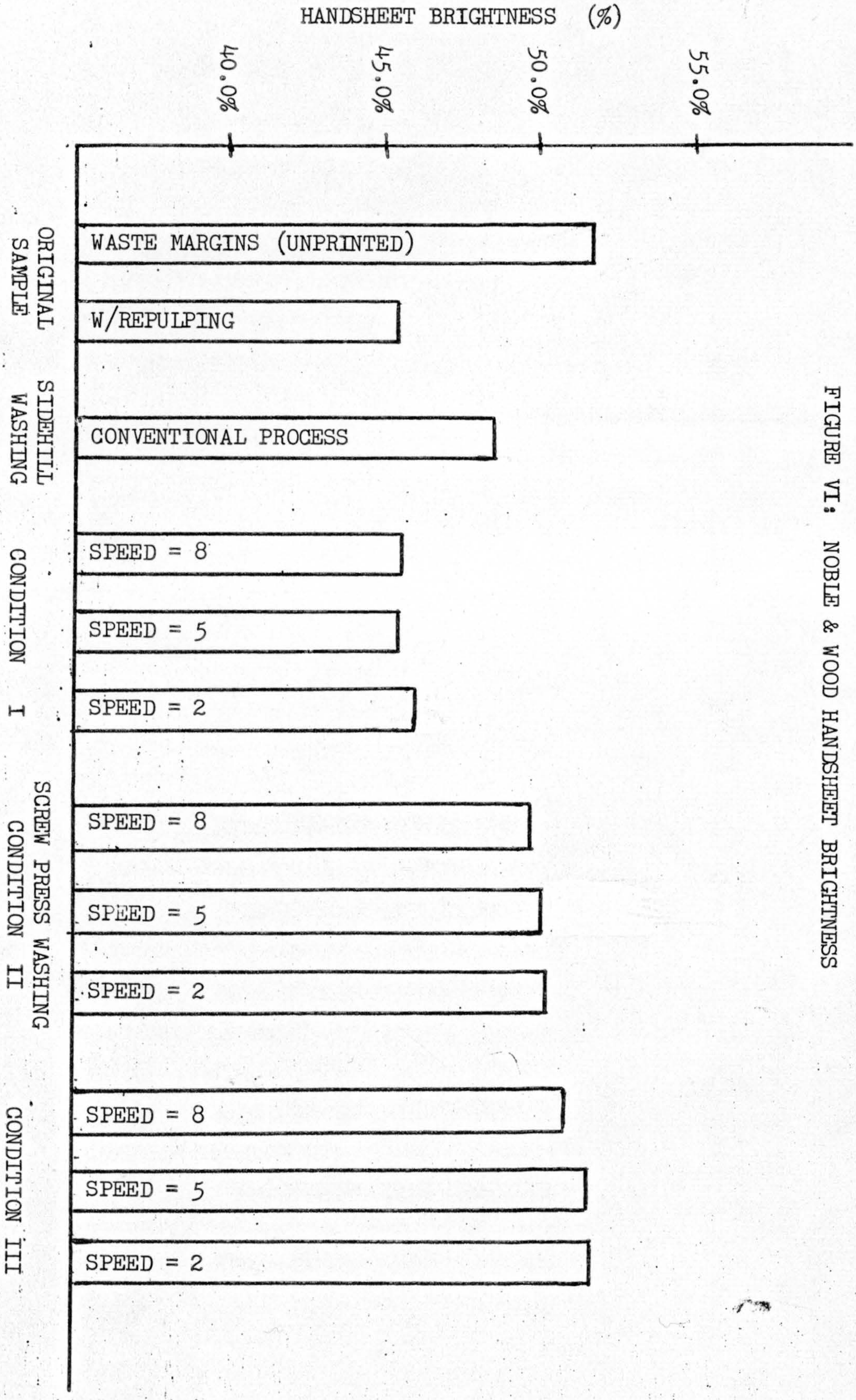


FIGURE VI: NOBLE & WOOD HANDSHEET BRIGHTNESS

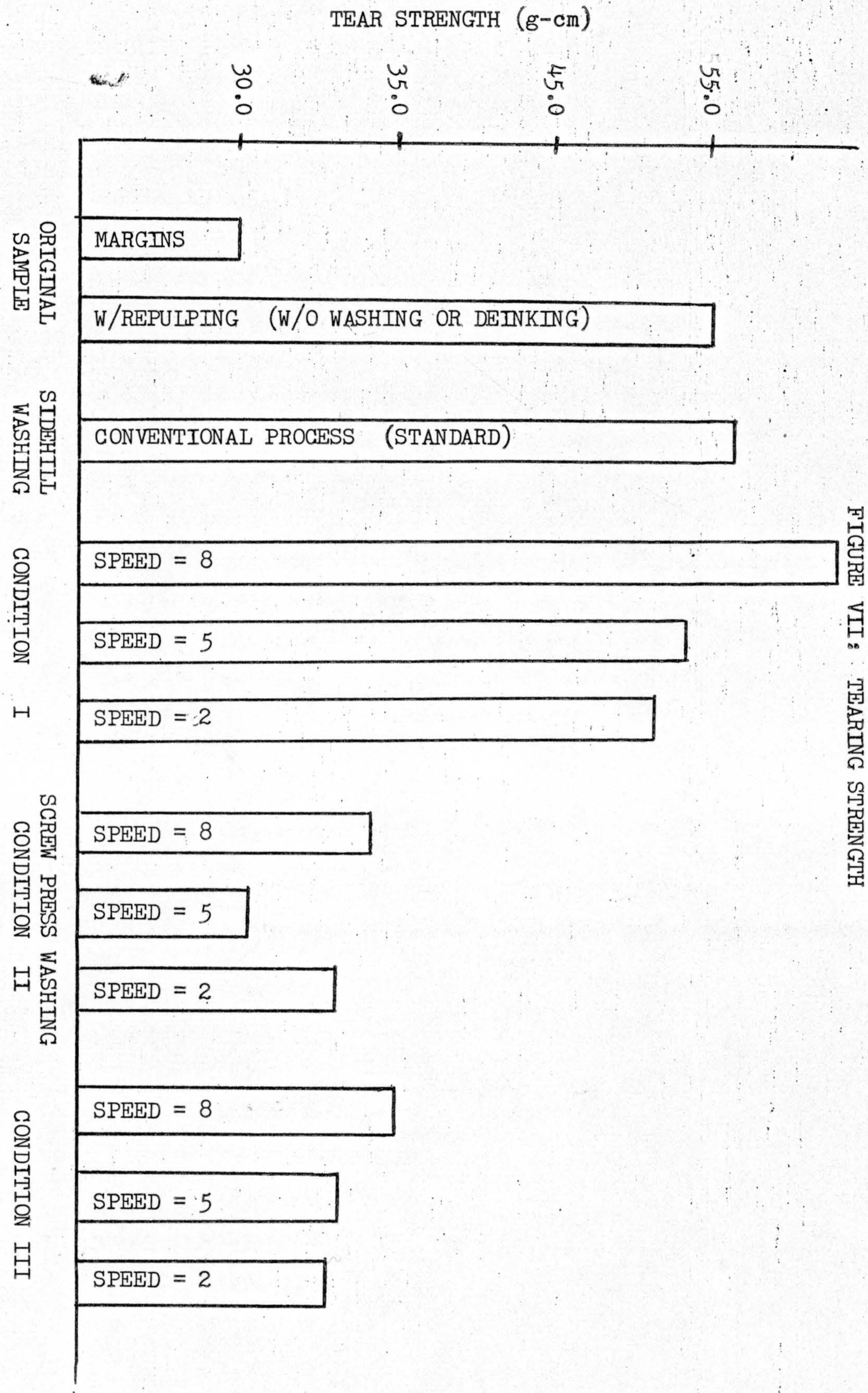


FIGURE VII: TEARING STRENGTH

FIGURE VIII: MULLEN (BURST) STRENGTH

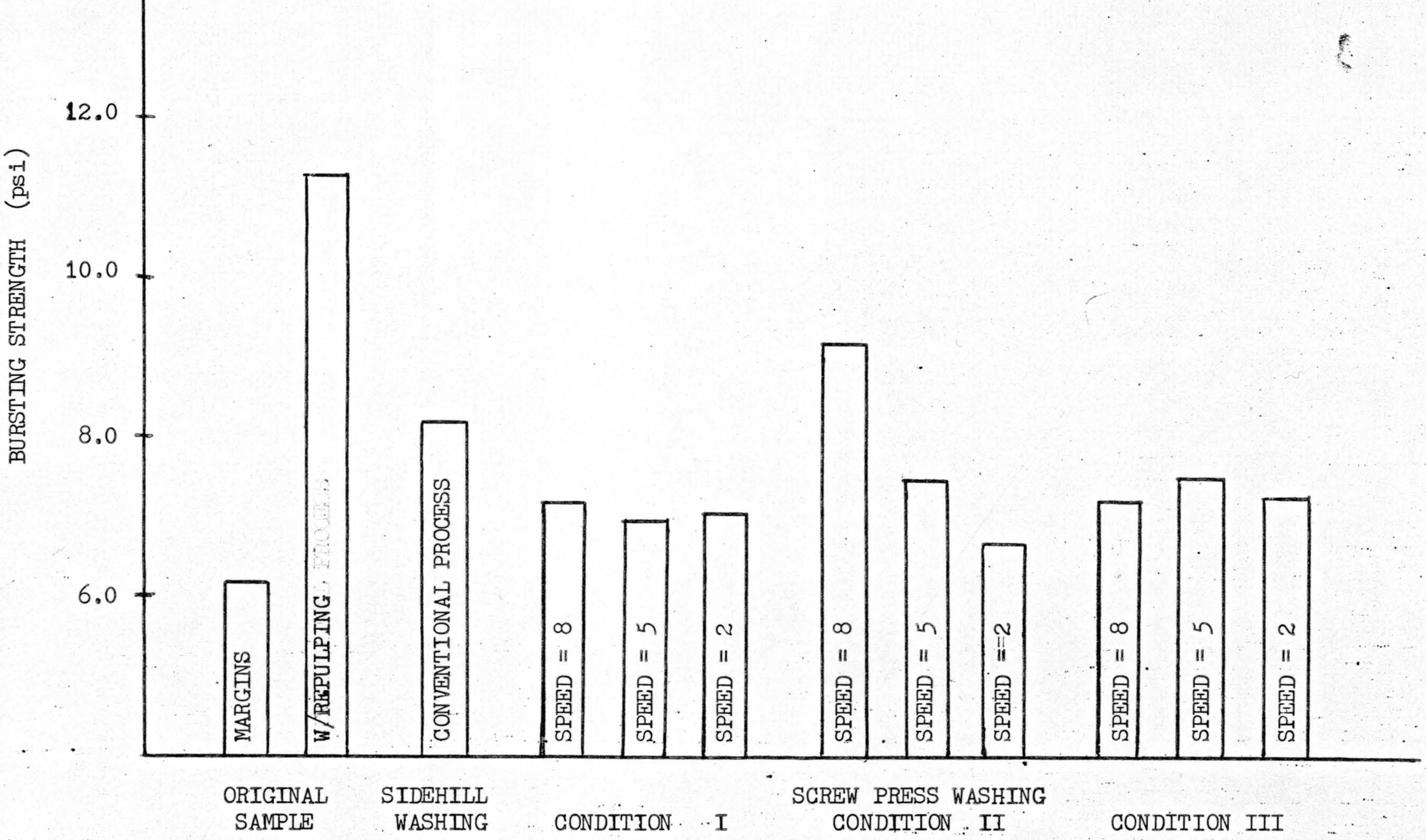
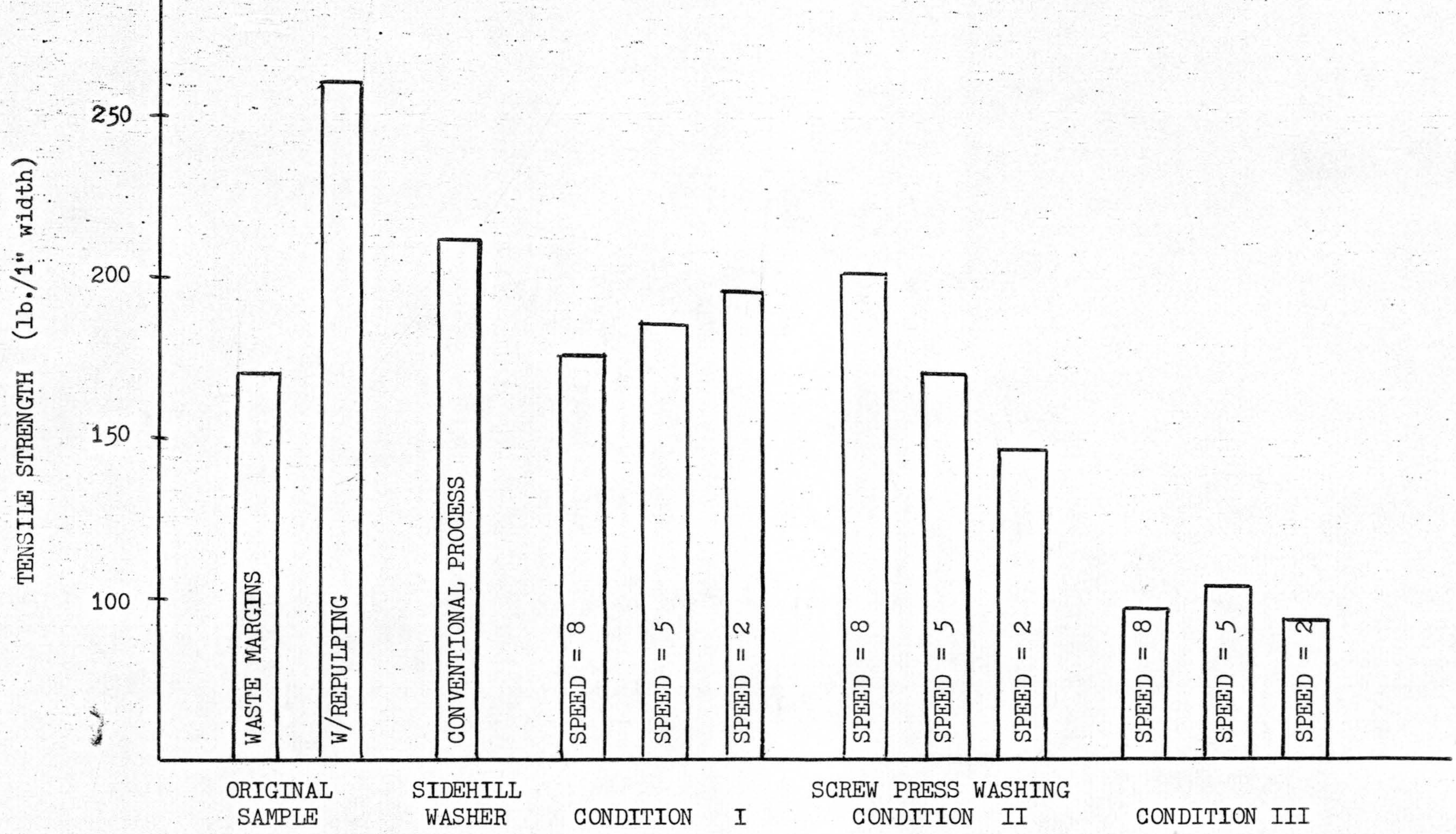


FIGURE IV: TENSILE STRENGTH



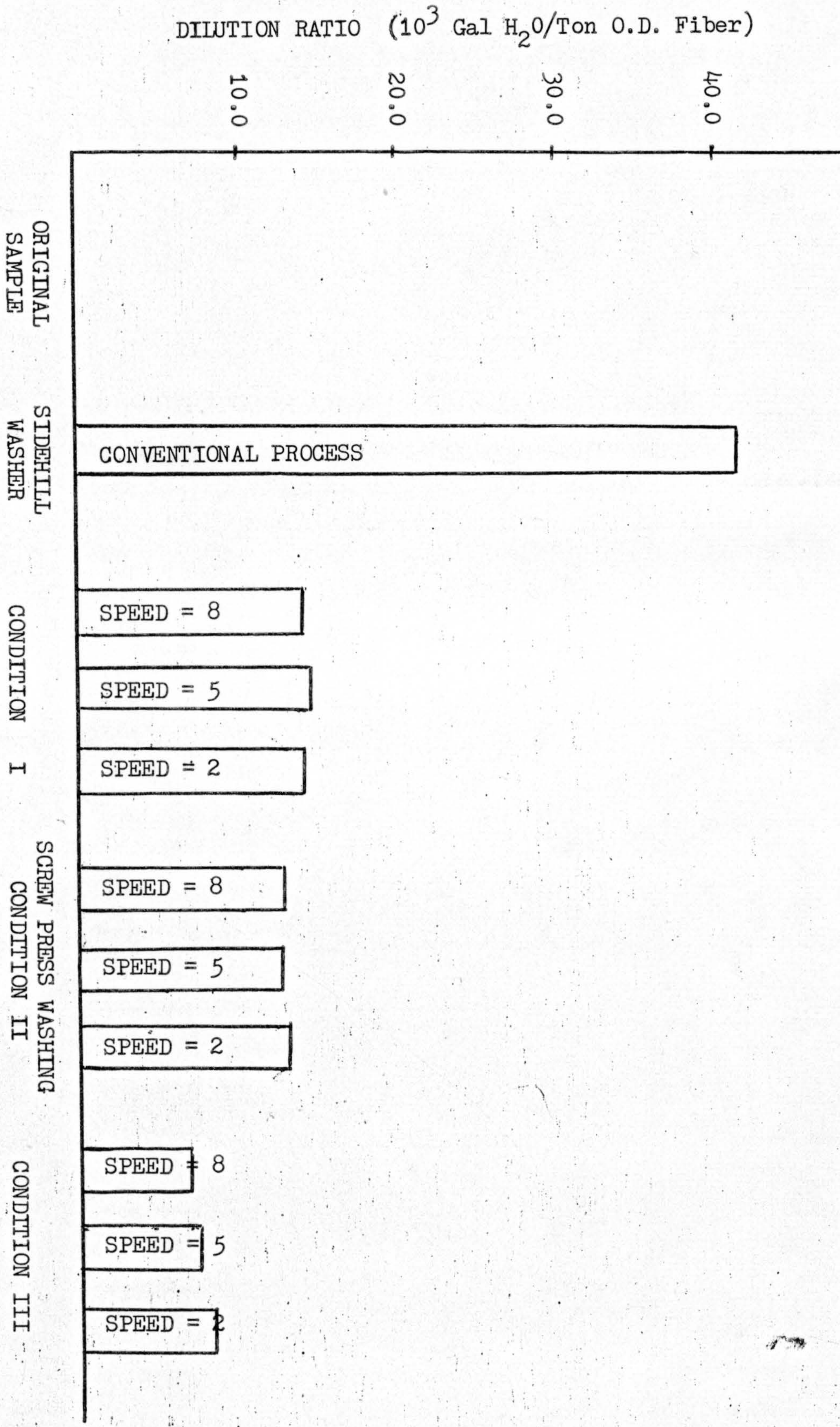


FIGURE V: DILUTION RATIO

DISCUSSION OF RESULTS

BRIGHTNESS

When observing the summary data table and figures of the experimental results, many trends and characteristics seem to result. First, when considering the pulp brightness of a Buchner funnel pad of Condition I, it is seen that a 1.0% surfactant level gives a relatively low pulp brightness. Less ink was removed than with the conventional low consistency sidehill washer and with the use of no deinking chemicals at all. This is due mainly to the fact that with the chemical concentration of Condition I, the ink particles were not finely dispersed. According to the literature, if the ink particles are not finely dispersed, they tend to redeposit or reagglomerate back onto the fibers, and therefore tend to get trapped within the fibers and not removed when utilizing a high consistency process.

When Noble & Wood Handsheets were constructed from the pulp of Condition I, the brightness increased 2 to 3 points over the pulp pad brightness. This is due mainly to the fact that some of the trapped ink particles are washed out with the significant amount of dilution required to make Noble & Wood handsheets. However, a significant amount of the ink was never dispersed or it reagglomerated back onto the fibers during high consistency washing, and therefore was not able to be washed away with the making of handsheets. This accounts for the lower brightness values of Condition I when compared to the standard or conventional low consistency sidehill washing process.

When an additional 2.0% of surfactant was added as in Condition II, the pulp pad and handsheet brightness increased considerably, approximately 5 points over Condition I. This additional level of surfactant allowed for a finer dispersion of ink particles. As noted in the literature,

a fine dispersion of ink particles is needed if they are to be effectively washed away with a high consistency washing process. However, the brightness was still not comparable to the waste margin brightness. This proves that some of the ink particles were never dispersed or that they redeposited on the fibers during deinking. However, the pulp and handsheet brightness was comparable to the standard brightness of the sidehill washer.

When Noble & Wood handsheets were constructed from the deinked pulp of Condition II, the handsheet brightness, as in Condition I, was higher than the pulp pad brightness. As previous noted this is mainly due to the washing of some of the trapped ink particles that takes place with the high dilution required in the making of Noble & Wood handsheets. However, ink removal at this stage is not as desirable in any condition as the ink particles and chemicals removed would contaminate the white water system of conventional papermaking operation.

With another additional 2.0% of surfactant added, as in Condition III, the pulp brightness increased approximately 2 points over Condition II. This increase occured due to the fact that with an additional amount of surfactant added, the ink particles were even more finely dispersed than in Condition I & II, and therefore easier to remove with minimal washing. This brightness increase occurred even with an initial pulp consistency $1\frac{1}{2}$% greater than standards desired and with a lower dilution ratio than Conditions I & II.

The handsheet brightness also increased in Condition III as in Conditions I & II. This, as in the other conditions, occured mainly due to the dilution that takes place in the making of Noble & Wood handsheets. This final handsheet brightness is within 3 points of the

waste margin brightness. With a simple bleaching stage or without, the 50% brightness is essentially as good as should be expected from any deinking operation. Not every one of the ink particles are able to be removed.

STRENGTH PROPERTIES

As noted in the literature, strength properties tend to increase with the utilization of a washing deinking process versus a floatation process. This is due mainly to the fact that a washing process tends to remove a significant amount of fines and fillers which originally adversely affect bonding strength. It is also noted in the literature that a high consistency washing process should theoretically removed less fines and fillers than a convential low consistency wash due to the trapping action that occurs at high consistencies. The removal of less fines may be beneficial as the total suspended solids in the effluent are minimal, which helps to keep operations within EPA limits.

In Condition I, tear values are quite compariable to the tear values of the standard, low consistency process. These tear values were twice as strong as the original waste, due to the significant amount of fines removed in a washing process.

As the level of surfactant increased as in Condition II & III, the tear strength decreased considerably and had a tendency to level off between Conditions II & III. This decrease probably occured because with such high levels of surfactant, all or most of the chemicals were not able to be washed out of the pulp and therefore adversely affected bonding strength. The leveling off effect probably is misleading and occurs because in Condition II, the discharge consistencies are higher than Conditions I & III so it is likely that more fines would be trapped to

adversely affect the strength. Another reason for the leveling off effect is that due to a higher freeness in Condition III, there is initially less fines to adversely affect the bonding strength. The tear of Condition III theoretically should be lower than Condition II.

The bursting or mullen strength seemed to be randomly affected by all three high consistency conditions, but in all but one case burst values were lower than those of low consistency washing and higher than the original waste paper. Bursts did not have a tendency to decrease between the varying levels of surfactant added, which is unexplainable. As the previous states, strength properties should be adversely affected by an additional amount of chemicals added, due to the fact that chemicals tend to interfere with fiber to fiber bonds.

As the literature suggests, tensile strength decreased proportionally with each additional 2.0% of surfactant added in the three conditions. The tensile strength of Condition I was only decreased slightly from the standard low consistency tensile strength of 212 pounds/1" width. However, with a 5.0% surfactant level in Condition III, the tensile strength was decreased by approximately 50% or halved. This is a very significant drop if maximum attainable strength, is desired. For this reason, the highest surfactant level may not be feasible for the 1 or 2 points increase in brightness.

DILUTION RATIO

As the literature states, one of the main advantages of high consistency washing is minimal water usage. As Table III suggests, high consistency washers should theoretically use approximately one-fourth the water of conventional low consistency washers. This is also seen in the data table and Appendix B. The low consistency sidehill washer used approximately 41,000 gallons of water per ton of O.D. fiber. This is an

extreme amount of water to pump and to handle.

With a high consistency washer, the water usage ratio was decreased by one-third to one-fourth as theoretically is suggested for an equivalent or better brightness. This significant decrease in water usage allows for lower pumping and handling costs along with more concentrated effluents. More concentrated discharges in turn allow for more economical, high quality effluent clarification for recycling within a closed system.

CONSISTENCY, pH, FREENESS

The pH stayed essentially constant throughout all of the conditions and the standard so is not a contributing variable. The freeness also stayed essentially constant with the exception of Condition III. The affects that this increase in freeness probably had were previously mentioned.

The inlet consistency also stayed constant throughout all except for Condition III. This increase of about $1\frac{1}{2}\%$ initial consistency was due to the fact that an additional amount of steam was not required to keep the temperature constant as in the other trials. The addition of steam to stabalize the temperature adds condensate which was accounted for but not utilized in the third condition. Therefore, less water was used in pulping and a higher inlet consistency obtained. This initial increase in consistency was not desired, but accounted for.

The outlet consistencies varied depending on the process and the condition. The outlet consistency of the three conditions was uncontrollable as the cone pressure was kept constant throughout the various conditions, but was a contributing factor as previously mentioned.

CONCLUSIONS

Concluding the results, it is seen that the pulp brightness increased significantly, approximately 2 to 3 points, with each additional 2.0% of surfactant added. These additional surfactant levels allowed for finer dispersions of ink particles. If ink particles are not finely dispersed they will become trapped and reagglomerate or redeposit on the fibers, especially when a high consistency washing process is utilized.

However, some of the trapped ink particles are released and washed away from the significant amount of dilution that takes place in the making of Noble & Wood Handsheets. Ink removal at this stage is not as desirable as in the washing stage because it would contaminate the white water system of the paper machine in a conventional papermaking process. High levels of surfactant or other chemicals are also not desired at this stage as they would tend to build up in a closed white water system.

The strength properties of a high consistency washing process were essentially lower than a low consistency washing process. As previously stated, this is partially due to the fact that less fines are removed with a high consistency washing process. Fines do not contribute to bonding strength. For this reason, a high consistency process may not be desired if the highest attainable strength is required.

However, the strength properties were also decreased with the additional amounts of surfactant. With greater levels of chemical addition, less of the chemicals are able to be washed away and therefore adversely affect bonding strength. As with fines, most chemicals do not contribute to bonding strength.

Less than one-third to one-fourth of the dilution water of low consistency washing is needed to reach a comparable or better brightness with high consistency washing Conditions II & III. This was not seen

however in Condition I because the ink particles must be finely dispersed before an equivalent or better brightness can be achieved.

Finally, a lower press speed generally seems to allow for a greater amount of ink particles to be removed. However, with lower press speeds, strength properties are lowered slightly. This is probably due to the fact that there is more mechanical action on the fibers; therefore more fines, as the fibers are in contact with the screw press for a greater length of time with lower press speeds. But, it may not be feasible to operate at such a low press speed for only a few tenths brightness increase and a small decrease in strength properties. Also, some operations desire large outputs in a given time period so would operate at the greatest speed possible without too much affect on paper properties.

In summary, there seems to be significant proof that the high consistency deinking or washing process is very effective and has some advantages over a conventional low consistency sidehill washing process. The advantages that the experimental data indicates include:

1. Reduced dilution water consumption. This therefore reduces pumping and operating costs, and allows for more concentrated effluent discharges.

2. Relatively low fiber loss. Therefore a higher yeild is obtained.

3. High brightness attainable with chemical and speed variations.

The disadvantages that seemed to be revealed include:

1. The ink particles must be finely dispersed or they are not effectively removed at high consistencies.

2. May not remove enough fines so strength properties are adversely affected more than tolerable.

These advantages and disadvantages seem to correlate with the theoretical advantages and disadvantages previously stated in the literature, and do indicate that the screw press washer is an effective and efficient means of deinking newsprint wastes, as long as the proper chemicals and conditions are utilized to give maximum dispersion of the ink particles.

RECOMMENDATIONS

Due to mechanical problems with the equipment and limited time the experimental work was not able to be taken as far as originally desired. For this reason it is recommended that further work be done utilizing the laboratory horizontal screw press in the following areas. First, it would be desirable to duplicate the best conditions of the data. This would allow for a verication of data as it will probably vary between batches.

It is also recommended that further work be completed on the general study and optimization of the screw press. In particular, studying the affects of varying the screw press cone pressure and/or studying the affect of varying the pulping chemicals, besides the surfactant level. Changing other chemicals will also vary the pH which may prove interesting.

Another study, unrelated to this thesis, that may prove interesting is the study of each partition of the screw press to see exactly where most of the ink is removed within the press. It is guessed that most of the effluent is removed within the first few inches of the screw press.

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APPENDIXES

APPENDIX A -- PRELIMINARY CALCULATIONS

INITIAL CONSISTENCY CALCULATIONS

4.0% Consistency with 20 liters of water minimum per batch:

Consistency = Dry Wt./Wet Wt.

Density H_2O = 1.0g/cm

$$.04 = \frac{X}{20{,}000g + X} \qquad X = 833.3g \text{ fiber}/20 \text{ liters } H_2O$$

CHEMICAL CONCENTRATION CALCULATIONS

Sodium Silicate:

3.5% (by weight): (.035g/g fiber) (833.3g fiber) = 29.2g/batch

Surfactant:

1.0% (.01) (833.3) = 8.3g/batch

3.0%: (.03) (833.3) = 25.0g/batch

5.0%: (.05) (833.3) = 41.7g/batch

Hydrogen Peroxide:

1.0%: (.01) (833.3) = 8.3g/batch @ 100% concentration

$$(8.3) \times \frac{30\%}{100\%} = 27.7g/\text{batch @ } 30\% \text{ concentration}$$

APPENDIX B -- DILUTION CALCULATIONS

LABORATORY SIDEHILL WASHER

4.01% Initial Consistency with a 500ml. Sample:

(500ml.) (.0401) = 20.05g O.D. Fiber
500ml. - 20.05g = 479.95ml H_2O
Dilution Water: 1520ml in stage 1
1000ml in stage 2 & 3
Total Water: 479.95 + 1520 + 1000 + 1000 = 3999.95ml

3.45% Final Consistency:

.0345 (20.05 + X) = 20.05 X = 561.11ml H_2O
Total Water Used for Dilution: 3999.95 - 561.11 = 3438.84ml

Dilution:

$$\frac{3438.84ml}{20.05g} \times 239.7 = 41,112 \text{ Gallons } H_2O/\text{Ton O.D. Fiber}$$

LABORATORY SCREW PRESS WASHER

CONDITION I

SPEED = 8: 4.01% Initial Consistency with a 2000ml Sample
27.80% Final Consistency
2600ml Water to Dilute Stages 2 & 3
4311.5ml H_2O Total Dilution for 80.2g O.D. Fiber
Dilution:

$$\frac{4311.5ml}{80.2g} \times 239.7 = 12,885.2 \text{ Gallons } H_2O/\text{Ton O.D. Fiber}$$

SPEED = 5 4.01% Initial Consistency with a 2000ml Sample
28.6% Final Consistency
2600ml Water to Dilute Stages 2 & 3
4319.58ml Total Dilution Water for 80.2g O.D. Fiber
Dilution:

$$\frac{4319.58ml}{80.2g} \times 239.7 = 12,910 \text{ Gallons } H_2O/\text{Ton O.D. Fiber}$$

SPEED = 2 4.01% Initial Consistency with a 2000ml Sample
27.9% Final Consistency
2600ml Water to Dilute Stages 2 & 3
4312.54ml Total Dilution Water for 80.2g O.D. Fiber
Dilution:

$$\frac{4312.58ml}{80.2g} \times 239.7 = 12,890 \text{ Gallons } H_2O/\text{Ton O.D. Fiber}$$

Appendix B continued.

CONDITION II

SPEED = 8: 4.08% Initial Consistency with a 2000ml Sample
32.2% Final Consistency
2500ml Water to Dilute Stages 2 & 3
4246.6ml H_2O Total Dilution for 81.6g O.D. Fiber
Dilution:

$$\frac{4246.6\text{ml}}{81.6\text{g}} \times 239.7 = 12{,}474 \text{ Gallons } H_2O \text{ O.D. Fiber}$$

SPEED = 5 4.08% Initial Consistency with a 2000ml Sample
31.60% Final Consistency
2500ml Water to Dilute Stages 2 & 3
4241.8ml H_2O Total Dilution for 81.6g O.D. Fiber
Dilution:

$$\frac{4241.8\text{ml}}{81.6\text{g}} \times 239.7 = 12{,}460 \text{ Gallons } H_2O\text{/Ton O.D. Fiber}$$

SPEED = 2 4.08% Initial Consistency with a 2000ml Sample
32.90% Final Consistency
2500ml Water to Dilute Stages 2 & 3
4252.0ml H_2O Total Dilution for 81.6g O.D. Fiber
Dilution:

$$\frac{4252.0\text{ml}}{81.6\text{g}} \times 239.7 = 12{,}490 \text{ Gallons } H_2O \text{ O.D. Fiber}$$

CONDITION III

SPEED = 8 5.60% Initial Consistency with a 2000ml Sample
28.2% Final Consistency
2000ml Water to Dilute Stages 2 & 3
3602.8ml H_2O Total Dilution for 112g O.D. Fiber
Dilution:

$$\frac{3602.8\text{ml}}{112\text{g}} \times 239.7 = 7711 \text{ Gallons } H_2O \text{ O.D. Fiber}$$

SPEED = 5 5.60% Initial Consistency with a 2000ml Sample
28.9% Final Consistency
2000ml Water to Dilute Stages 2 & 3
3612.5ml H_2O Total Dilution for 112g O.D. Fiber
Dilution:

$$\frac{3612.5\text{ml}}{112\text{g}} \times 239.7 = 7731 \text{ Gallons } H_2O \text{ O.D. Fiber}$$

SPEED = 2 5.60% Initial Consistency with a 2000ml Sample
32.4% Final Consistency
2000ml Water to Dilute Stages 2 & 3
3654.3ml H_2O Total Dilution for 112g O.D. Fiber
Dilution:

$$\frac{3654.3\text{ml}}{112\text{g}} \times 239.7 = 7821 \text{ Gallons } H_2O \text{ O.D. Fiber}$$

APPENDIX C -- AUXILIARY DATA

ORIGINAL SAMPLES REPULPED WITHOUT THE ADDITION OF CHEMICALS AND WITHOUT THE UTILIZATION OF A WASHING PROCESS FOR INK REMOVAL

	TRIAL I	TRIAL II	TRIAL III
FREENESS (ml)	114	168	150
CONSISTENCY (%)	3.8	4.0	3.6
PULP BRIGHTNESS (%) (TOP/BOTTOM)	38.3/40.7	45.9/47.7	43.4/43.1
HANDSHEET BRIGHTNESS (%)	45.6	46.6	44.5
TEAR (g-cm)	55.5	53.3	56.5
MULLEN (BURST) (psi)	12.0	10.6	11.3
TENSILE (lb/1" width)	260	245	272