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Selective Recovery of Corrugated Clippings

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Selective recovery of waste corrugated into the kraft and NSSC fractions is gaining in popularity. This selective reuse of fibers enables the papermaker to use more recycled fiber in the linerboard portion of corrugated boxes. It is well documented that 100% recycled paper can be used in the medium while the highest percentage of secondary fibers in the linerboard is 30%. Greater than 30% recycled fiber in the linerboard results in poor runnability. Since reuse of secondary fibers in the medium is already at a maximum, this paper will place more emphasis on the reuse in the linerboard.

The objective of this thesis is to develop a system of selective recovery of corrugated clippings. The ~~proposed~~ system will fractionate the recycled fibers into long and short fiber fractions. "Fractionation, or more properly, fiber fractionation is the separation of pulp into two separate fractions on the basis of fiber length."[1] Ideally the linerboard would be made from only the recycled long fibered fraction. The method of separation will be screening and centrifugal cleaning.

The most important literature found is a patent dealing with the selective recovery of corrugated boxboards.[2] This procedure separates the softwood kraft liner with high water resistance from the corrugating layer with low water resistance made of hardwood semichemical pulp. The dry paperboard is reduced to intermediate sized pieces which are then dispersed in water. The dispersion is subjected to mechanical action while controlling temperature, time, and energy input levels so as to cause the corrugated layer to separate from the liner and to reduce the corrugated layer to fibers or very small pieces while leaving the linerboard in the larger form. The fibers and small pieces of the corrugated layer are then separated from the larger pieces of the linerboard.

Black Clawson Company [3] developed a process which will separate the long and short fiber fractions from corrugated boxboards. This process,(parts of which are proprietary), is described in economic terms. A I000 ton per day urban recycling mill could be built for $I5 million compared to a conventional pulp mill at $I25 million. There remains the problem of economically supplying such a plant with the necessary quantities of recovered corrugated containers. A detailed study of United States population distribution shows that their are several areas in the country where such a mill would be feasible.

A study was made for the E.P.A. [4] to determine if market pulp could be competitively produce from old corrugated containers. Three model cases were prepared. First was the NSSC hardwood furnish. About I5% to 20% softwood kraft fiber is generally added to virgin NSSC to increase paper machine runnability. This analysis used I5% kraft obtained from new double lined kraft clippings, which is common industry practice. Second was the use of I00% old corrugated containers for the bogus medium. The third model is a combination of 33% old corrugated containers, I5% new double lined kraft clippings and 52% NSSC pulp.

While the basic models are approximately comparable in return on investment, with NSSC pulping the most attractive the relationship changes dramatically as the cost of secondary fiber drops. Bogus medium would be the most attractive alternative with a stable, low cost source of old corrugated containers.

The Chesapeake Corporation [5] of Virginia uses a flexible series-screening system enabling waste corrugating medium to be used as a supplementary pulp supply for virgin kraft pulp. Two primary screens are used in series or parallel, depending on production requirements and/or quality of the secondary fiber. The third stage is a slotted vibratory screen with accepts feeding backward to the second stage screen.

20% to 30% secondary fiber in unbleached kraft board and paper grades can be run with no runnability or dirt buildup problems. The total system rejection rate is around 10%.

Tests showed that series screening with slots with feedforward rejects is an efficient method for utilization of secondary fiber in high quality unbleached kraft products. Other tests showed that the smaller the slot size used the higher the cleaning efficiency. The disadvantages are; reduced capacity, and fractionation, which reduces the C.S. Freeness of accepted stock.

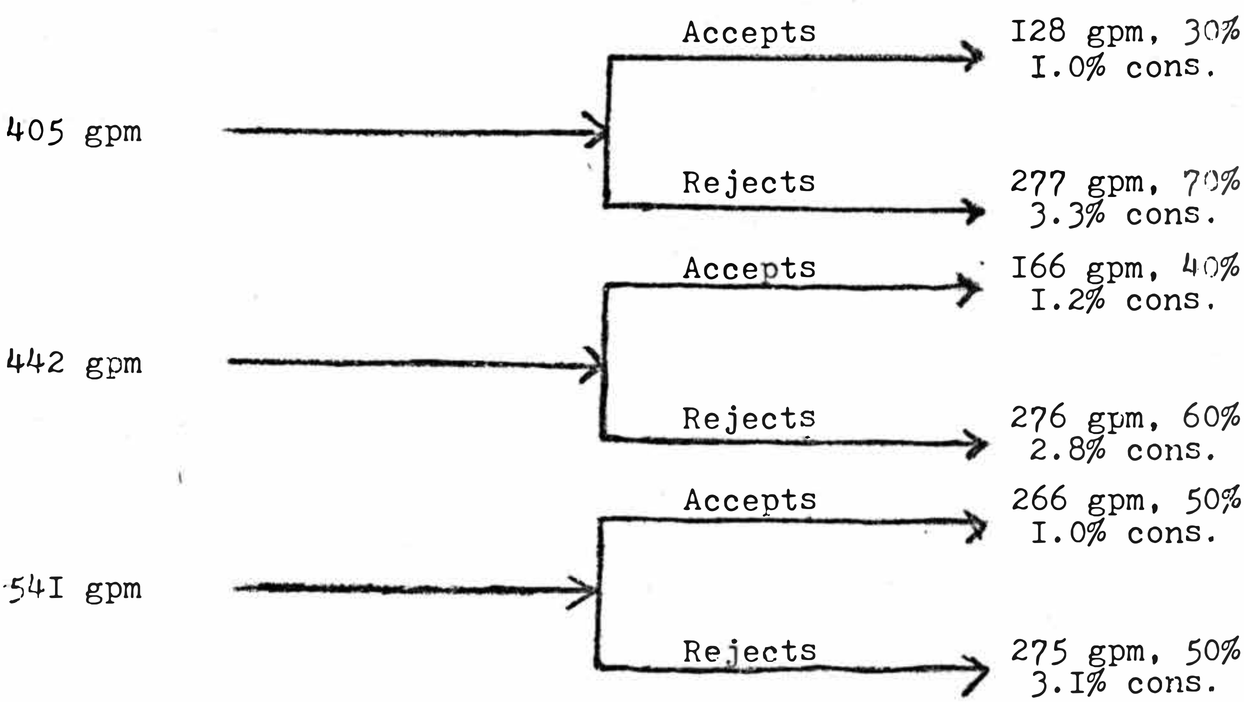
Another example of post consumer waste corrugated boxboard usage is at Green Bay Packaging. [6] This system was developed in cooperation with Black Clawson Company. The first step is pulping to remove coarse contaminants. Slotted screens are used next for the removal of fine contaminants. Reverse cleaning is the final step, which removes wax and other floatables. This system utilizes up to 30% recycled fibers.

Operation of the rotary pressure screen is quite simple. Stock is fed into the inside of the rotary screen basket. A pressure drop is maintained accross the screen forcing flow through the screen. A high velocity air jet then continuously removes the rejected stock away from the screen. Consistencies used are between I% and 4%. When the consistency is to high plugging will occur.

Separation with centrifugal cleaners depend on a number of factors. "While specific gravity is an important factor in separating contaminates from pulp, the shape of the particle is significant. Pulp fibers are accepted by centrifugal cleaners because the hydraulic drag is greater than the centrifugal force. If a contaminate is disk shaped, its chances of responding to the hydraulic drag are greater than if it is spherical where the ratio of surface to mass is low. Even the type of pulp and its contaminates affect the outcome." [7]

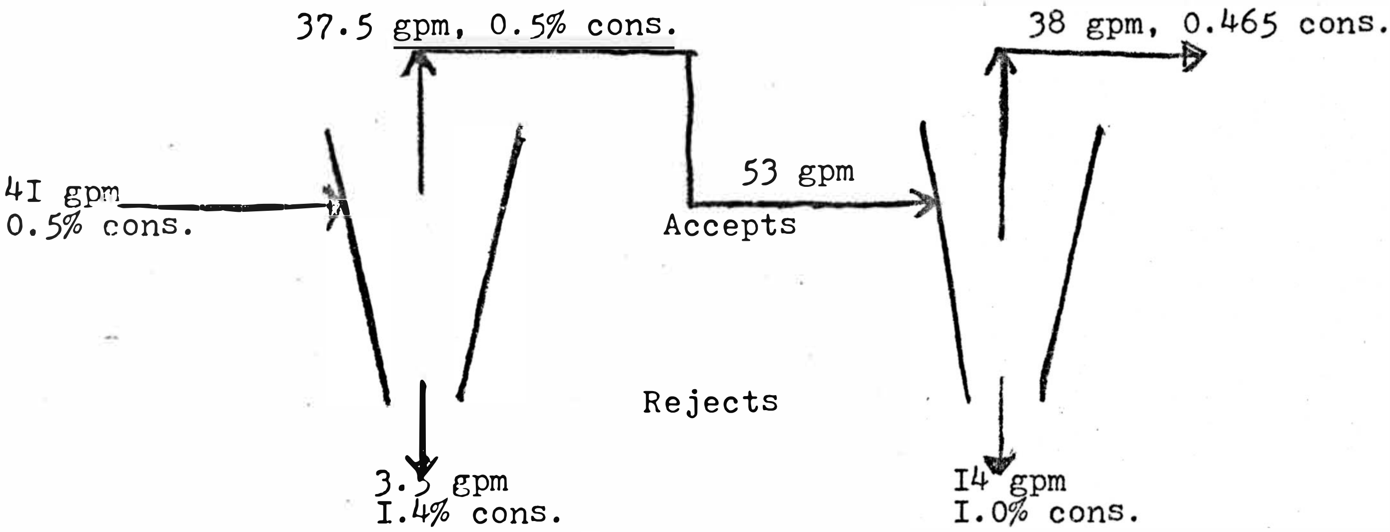
Experimental Procedure

Fractionation of pulp with the rotary pressure screen with .0I4 inch slots at three different levels of rejection. Accepted pulp will be controlled to 30, 40, and 50 percent levels. An inlet consistency of 2.24 was used.



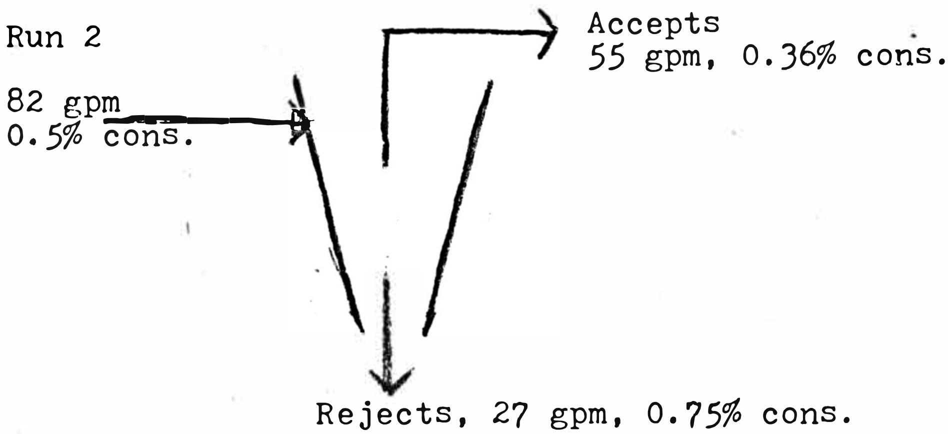
Three cyclones will be used, two direct cleaners,(Albia and Celluclone) and one reverse cleaner (Baur Bergstrom). A consistency of 0.5% at the inlet was used. The Albia has spiral configuration on its inner surface. A schematic of the Albia is given in the Appendix.

Celluclone Direct Cleaner

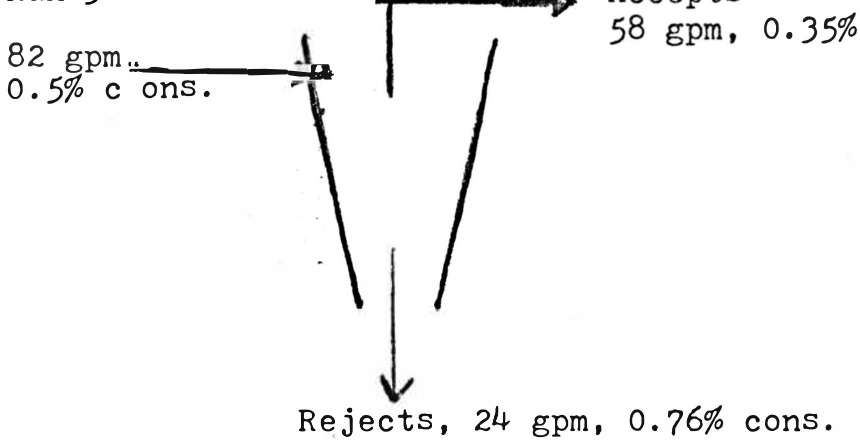


Albia Direct Cleaner

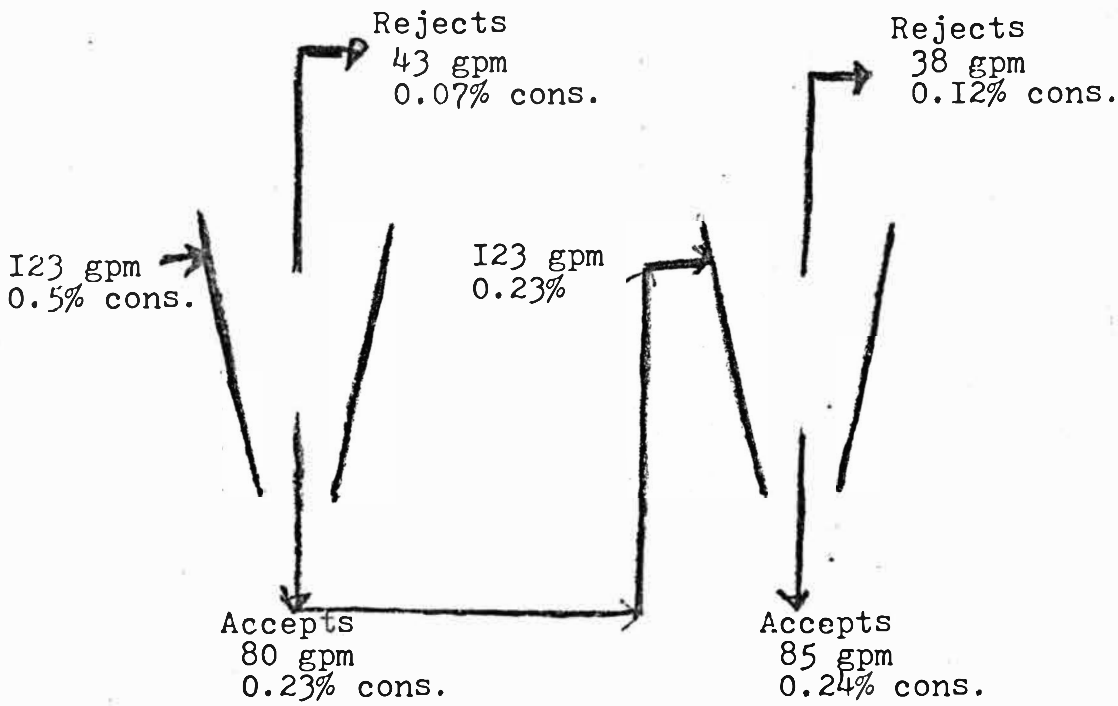
Run 2



Run 3



Baur Bergstrom Reverse Cleaner



Samples will be taken from the accepts and rejects after each stage. These samples will then be classified on the Clark Classifier and handsheets will be made with the Noble and Wood Handsheet apparatus. (Sample size will be 5 gallons.)

RESULTS

Observation of Figure I shows that the Selectifier rejects were very close in fractionation ratio (% retained on the I4mesh screen divided by the % lost times I00) to the liner. The largest difference was with the 60% Selectifier rejects. Figures II and III show that strength properties were also very close. From the centrifugal cleaner results only the Albia rejects showed results similar to the liner. Observation of Table I show that all results close to the liner had freness's that were almost identical to each other.

Observation of Figure IV show that all the Selectifier accepts and the Celluclone rejects had a fractionation ratio close to the medium.

Figure V shows that the Albia and Celluclone accepts were very close in fractionation ratio to the clippings. Observation of Table I shows that the Baur Bergstrom Reverse cleaner rejects were the strongest and had the lowest freeness.

In conclusion, selective recovery of corrugated clippings can provide a long fiber fraction that exhibits properties very close to the liner. The method of seperation is fractionation by screening.

The Albia rejects exhibited properties close to the liner but the Albia accepts showed results close to the clippings. Therefore these results are inconclusive.

The Baur Bergstrom reverse cleaner proved to be an effective cleaner but it did not produce the results desired for this study. The Celluclone rejected a small amount of short fibers but the accepts were very close to the clippings

My recommendation for future work would be to use the pressure screen to fractionate clippings. Then run the long fibered rejected fraction on the Pilot Plant paper machine in varying percentages with virgin unbleached kraft softwood. Based on my results I think considerably more than 30% recycled fiber could be used without operating problems.

FIGURE I

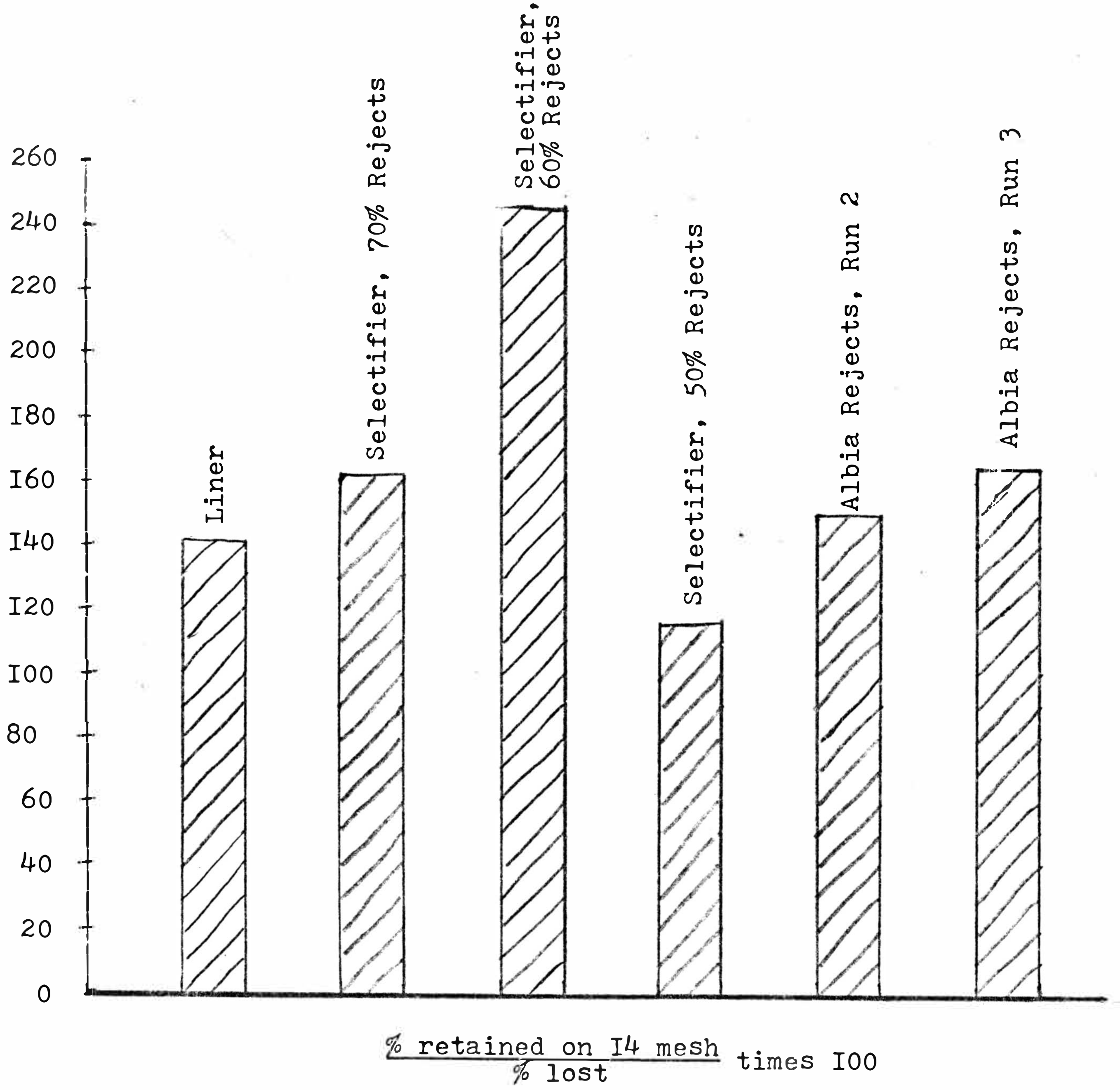
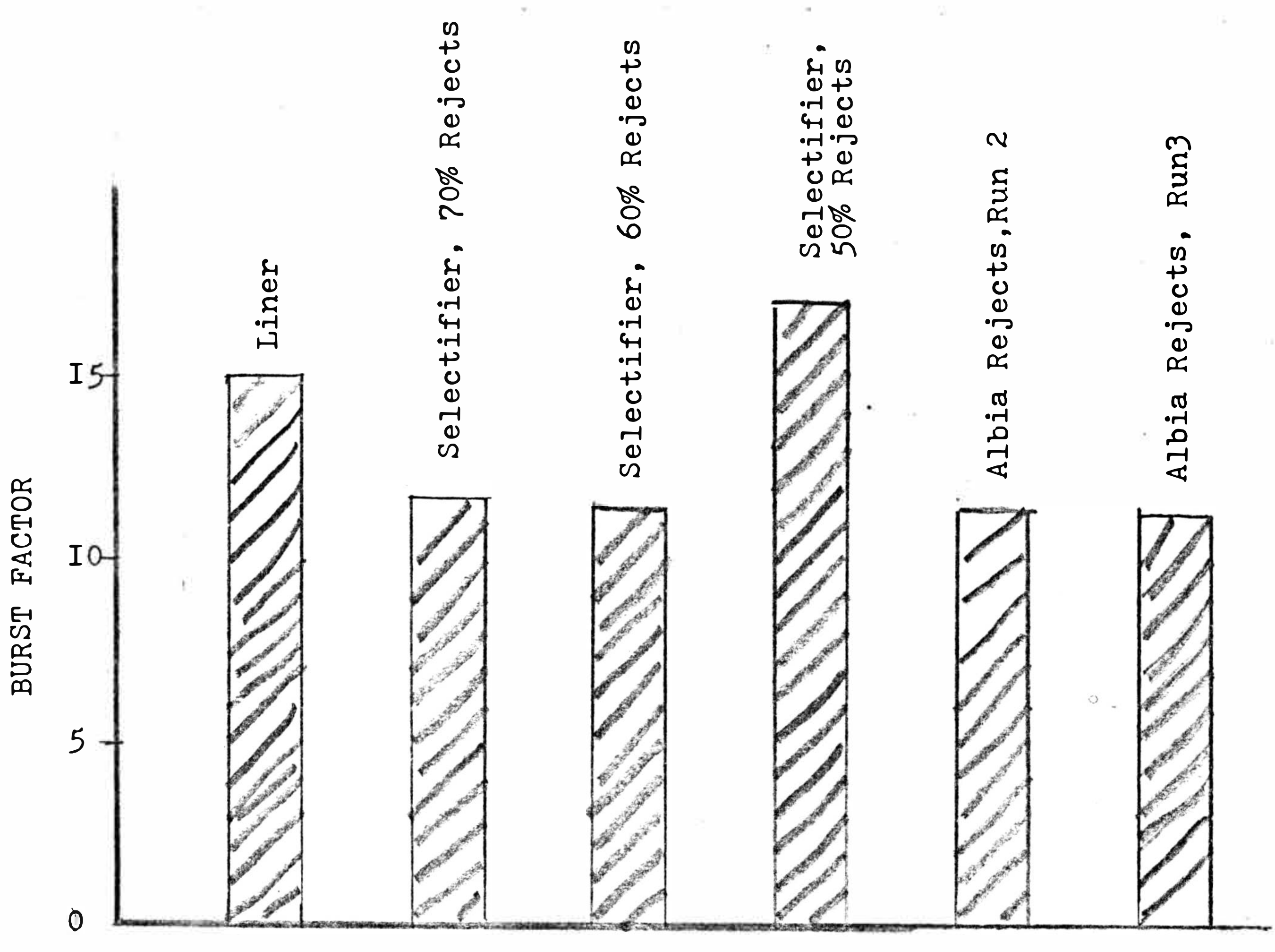
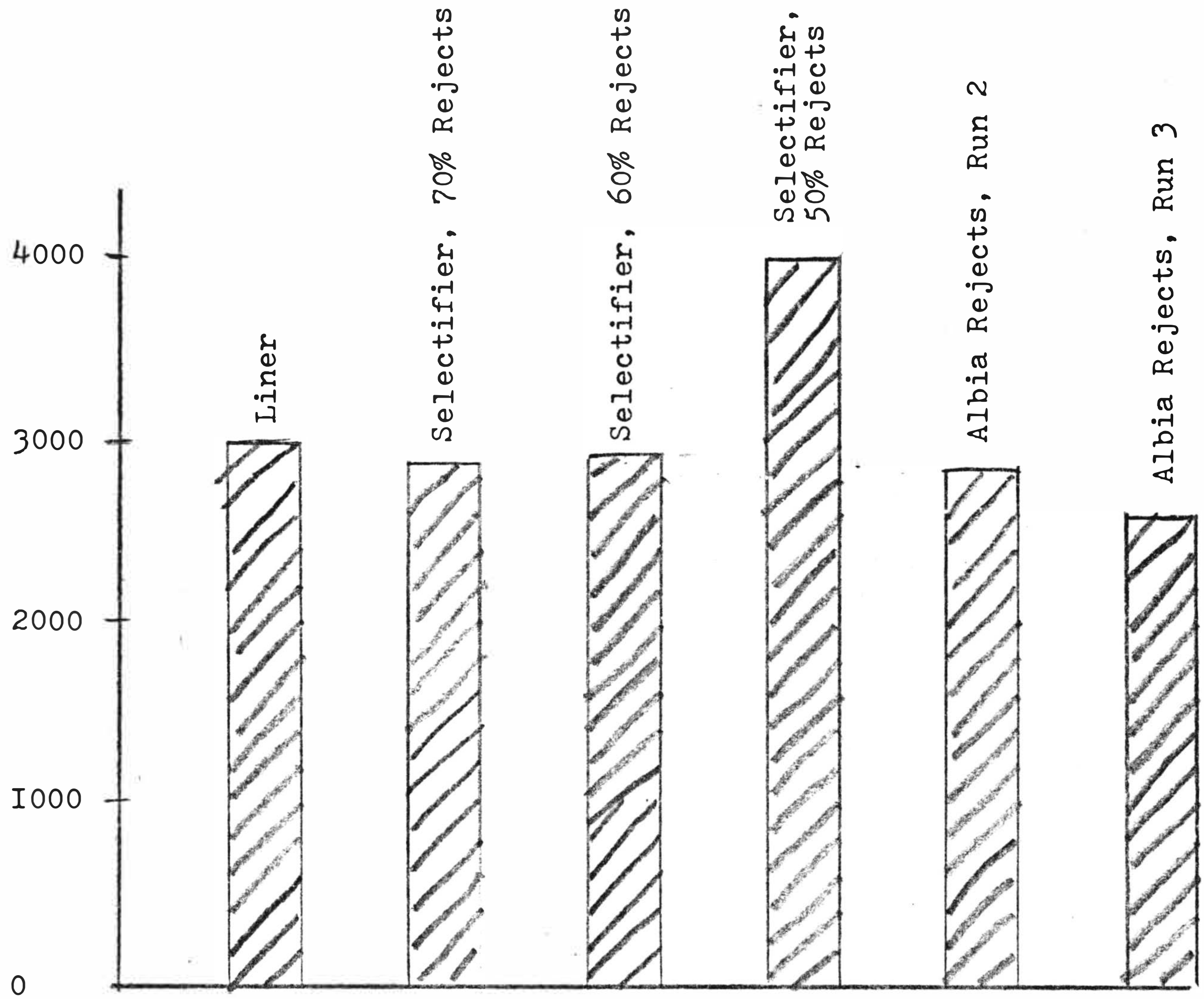

260
240
220
200
I80
I60
I40
I20
I00
80
60
40
20
0
Liner
Selectifier, 70% Rejects
Selectifier, 60% Rejects
Selectifier, 50% Rejects
Albia Rejects, Run 2
Albia Rejects, Run 3
% retained on I4 mesh / % lost times I00

FIGURE II



BURST FACTOR
15
10
5
0
Liner
Selectifier, 70% Rejects
Selectifier, 60% Rejects
Selectifier, 50% Rejects
Albia Rejects,Run 2
Albia Rejects, Run3

FIGURE III



4000
3000
2000
1000
0
Liner
Selectifier, 70% Rejects
Selectifier, 60% Rejects
Selectifier, 50% Rejects
Albia Rejects, Run 2
Albia Rejects, Run 3

FIGURE IV

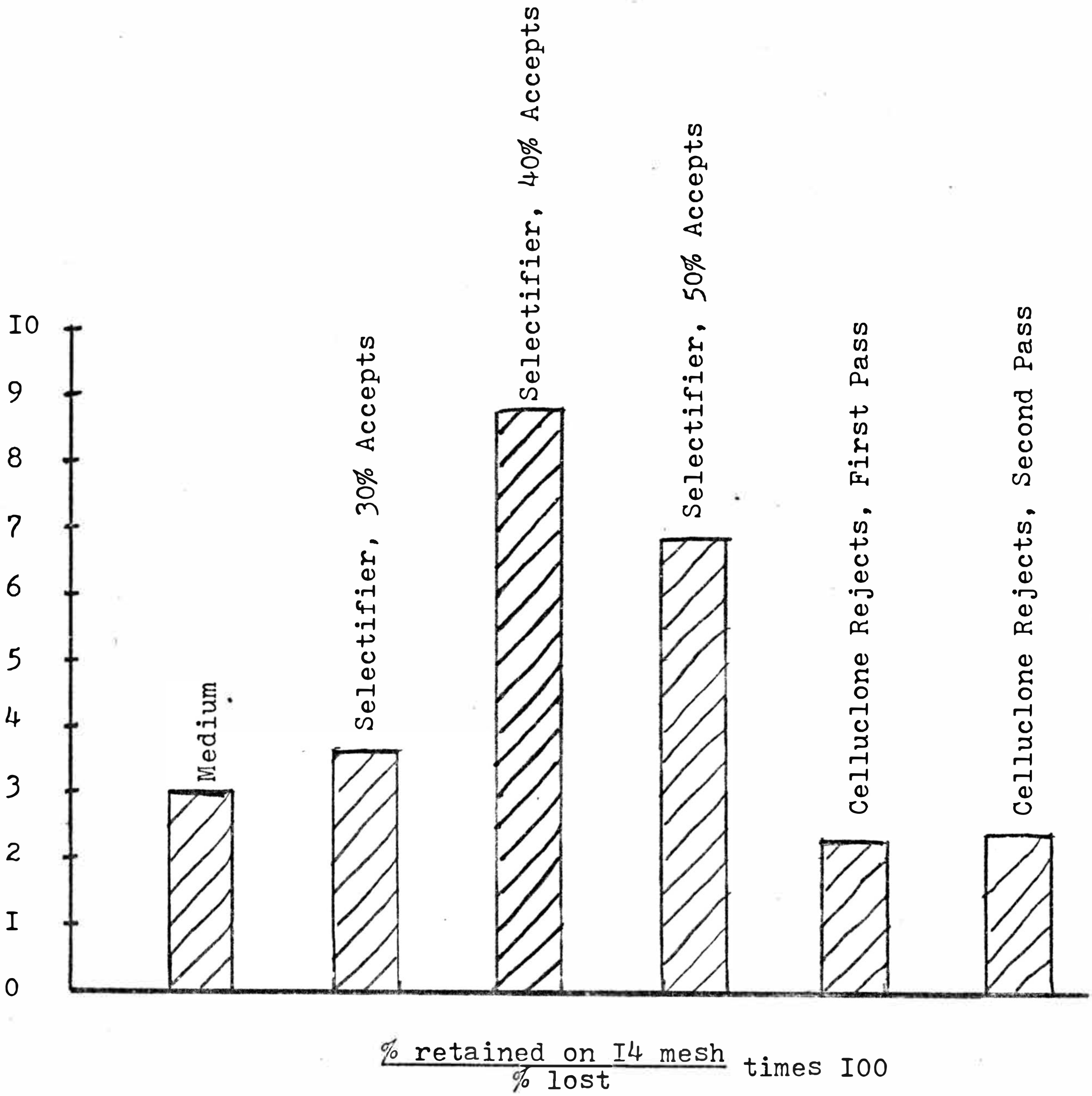
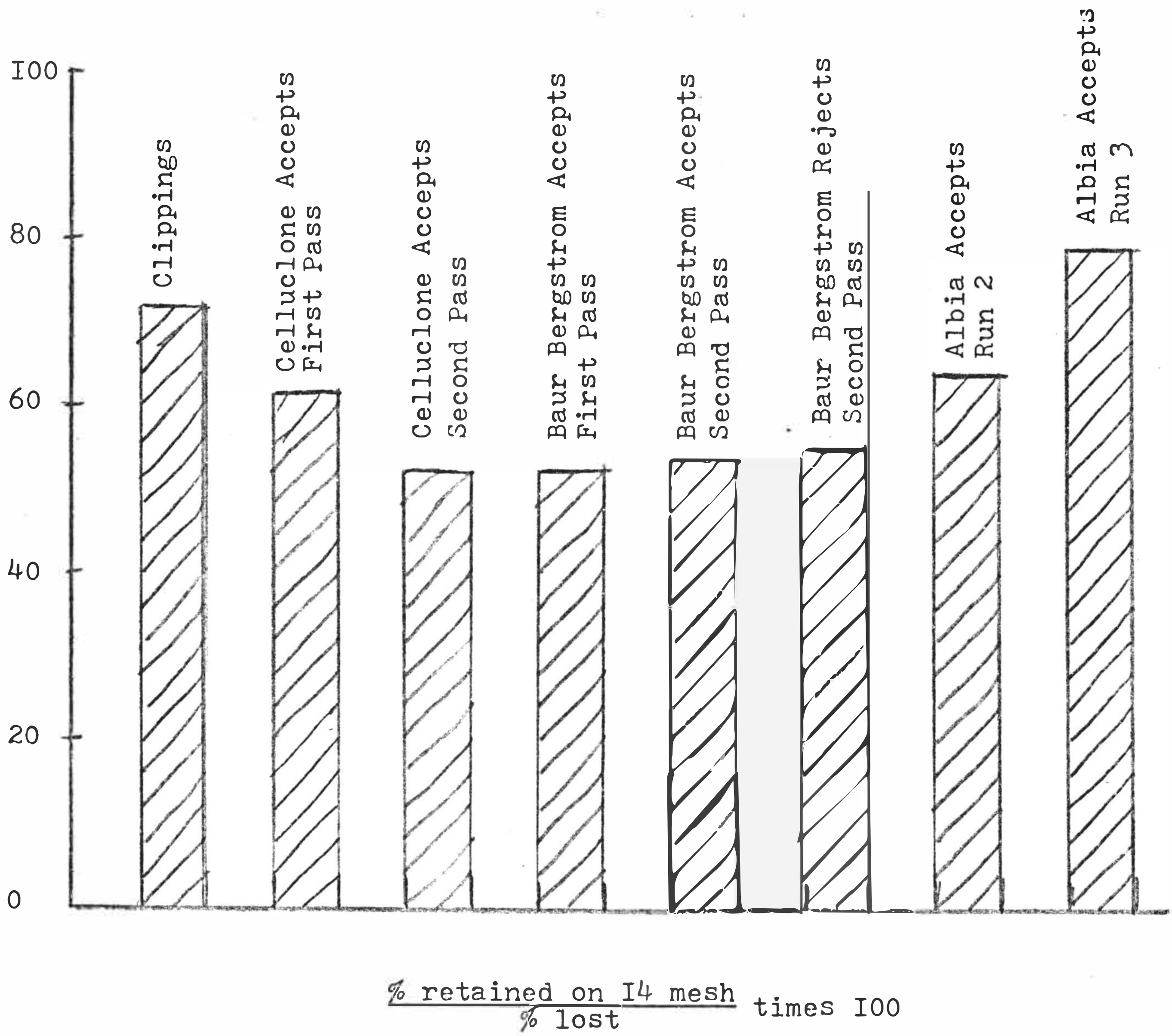

IO
9
8
7
6
5
4
3
2
I
0
Medium
Selectifier, 30% Accepts
Selectifier, 40% Accepts
Selectifier, 50% Accepts
Celluclone Rejects, First Pass
Celluclone Rejects, Second Pass
% retained on I4 mesh / % lost times IOO

FIGURE V



I00
80
60
40
20
0
Clippings
Celluclone Accepts First Pass
Celluclone Accepts Second Pass
Baur Bergstrom Accepts First Pass
Baur Bergstrom Accepts Second Pass
Baur Bergstrom Rejects Second Pass
Albia Accepts Run 2
Albia Accepts Run 3
% retained on I4 mesh / % lost times I00

TABLE I

STRENGTH PROPERTIES OF HANDSHEETS* AND C.S. FREENESS

	Burst Factor	Tensile Factor	Tear Factor	Stiffness (Gurley)	C.S. Freeness
Clippings	20.0	4139	99	5.0	400
Medium	6.9	2131	147	4.0	214
Liner	14.9	2987	124	5.1	640
Selectifier 30% Accepts	16.4	3823	86	3.8	260
Selectifier 70% Rejects	11.7	2842	130	4.2	682
Selectifier 40% Accepts	16.5	3658	88	3.8	251
Selectifier 60% Rejects	11.4	2908	108	3.2	624
Selectifier 50% Accepts	17.0	4051	92	3.5	210
Selectifier 50% Rejects	13.9	3175	139	4.1	614
Celluclone 1st Pass Accepts	16.2	3998	129	4.2	551
Celluclone 1st Pass Rejects	4.8	1748	61	5.6	637
Celluclone 2nd Pass Accepts	20.2	4312	133	3.9	537
Celluclone 2nd Pass Rejects	9.1	2448	86	4.1	610
Baur Bergstrom 1st Pass Accepts	10.8	2768	96	3.9	610
Baur Bergstrom 2nd Pass Accept	11.7	2867	81	4.1	668
Baur Bergstrom 2nd Pass Rejects	26.7	5565	78	3.1	116
Albia Accepts #2	21.4	4381	115	4.0	412
Albia Rejects #2	11.4	2822	118	4.6	611
Albia Accepts #3	20.2	4301	118	3.8	459
Albia Rejects #3	11.2	2587	118	4.3	614

TABLE II

CLARK CLASSIFIER DATA

Percent Retained

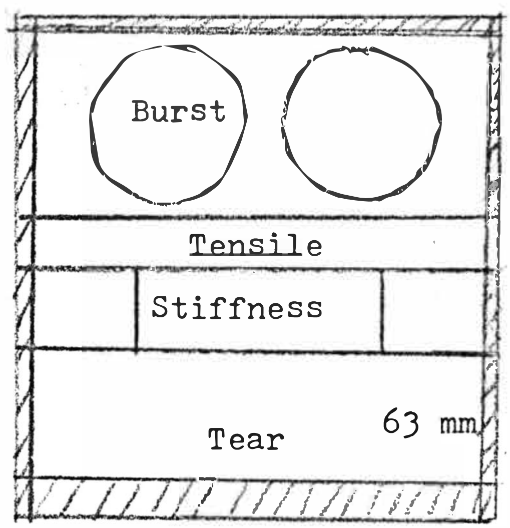
	I4 mesh	30 mesh	50 mesh	I00 mesh	Lost
Clippings	I3.8	30.8	22.3	I3.8	I9.I
Medium	I.0	I2.5	30.2	22.9	33.3
Liner	I6.7	36.I	24.3	II.I	II.8
Selectifier 30% Accepts	I.0	22.I	28.8	20.2	27.9
Selectifier 70% Rejects	20.2	30.8	23.I	I3.5	I2.5
Selectifier 40% Accept	2.3	2I.6	28.4	2I.6	26.I
Selectifier 60% Rejects	26.I	28.3	22.2	I2.8	I0.6
Selectifier 50% Accepts	2.I	20.2	27.7	I9.I	30.9
Selectifier 50% Rejects	I7.6	28.9	22.6	I5.7	I5.I
Celluclone Ist Pass Accepts	I3.7	27.5	20.6	I5.7	22.5
Celluclone Ist Pass Rejects	3.9	30.4	33.3	I5.7	I6.7
Celluclone 2nd Pass Accepts	I2.5	27.I	2I.9	I4.6	24.0
Celluclone 2nd Pass Rejects	4.I	29.6	30.6	I8.4	I7.3
Baur Bergstrom Ist Pass Accepts	7.9	32.5	27.0	I7.5	I5.I
Baur Bergstrom 2nd Pass Accepts	8.5	3I.I	26.4	I7.9	I6.0
Baur Bergstrom 2nd Pass Rejects	I8.8	I9.8	I4.6	I2.5	34.4
Albia Accepts #2	9.4	32.3	27.I	I6.7	I4.6
Albia Rejects #2	I0.2	35.2	25.4	I9.3	6.8
Albia Accepts #3	II.5	3I.3	27.I	I5.6	I4.6
Albia Rejects #4	II.I	33.3	28.9	20.0	6.7

TESTING PROCEDURE USED ON NOBLE AND WOOD HANDSHEETS

Weigh each sheet and choose the 5 best sheets (from appearance, freedom from thin spots, and weight closest to 2.5 grams A.D.).

Weigh thes 5 sheets together (A.D.) to the nearest 0.0I grams.

Cut sheet as follows:



I5 mm strips for tensile.

Stiffness sample 50 by 70 mm.

Discard and do not use all outside edges.

Make 2 burst tests on each of the 5 sheets. Average readings (in psi).
Make Instron tensile tests on the 5 strips, I5mm wide. Average readings. (in Kg/I5 mm width)
Make 5 tears on book of 5 sheets. Average the values. Multiply this average by 3.2 to determine the grams force to tear I sheet. (The number on the pendulum must be multiplied by I6 to obtain the force in grams when tearing a single sheet so I6/5= 3.2)
Make 2 Stiffness on each of the 5 samples, one in each direction. (50 mm deflection distance will be used)

CALCULATIONS

Basis Weight (A.D.) wt in grams X 4.84 (for 8" X 8" sheet)
Basis is reported in grams per square meter.
Basis Weight (O.D.) A.D. weight X 0.93. (Assuming 7% moisture)

$$\text{Burst Factor} = \frac{70.3 \times \text{burst in psi}}{\text{O.D. basis weight}}$$

$$\text{Tensile Factor} = \frac{200{,}000 \times \text{Tensile in kg. for I5 mm width}}{\text{O.D. basis weight} \times 3}$$

$$\text{Tear Factor} = \frac{100 \times \text{grams to tear I sheet (value calculated above)}}{\text{O.D. basis weight}}$$

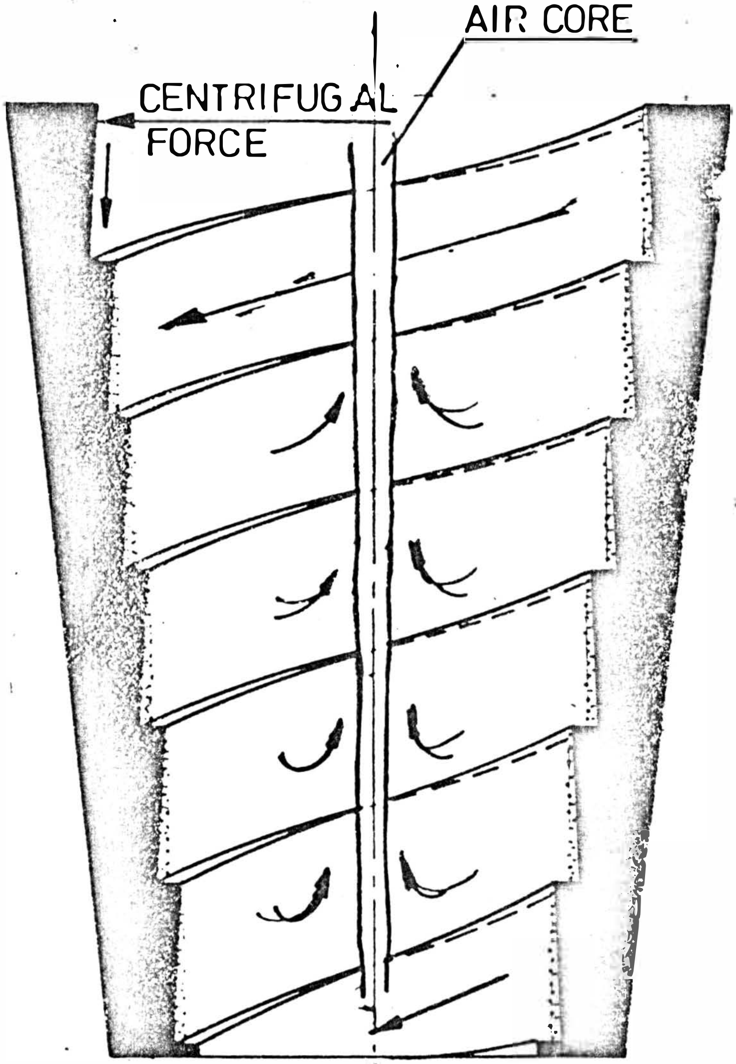


FIG. 7 FLOW CONFIGURATION IN SPIRAL CONE

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