Separation of Fibres and Fillers From Fibrous Sludge

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ABSTRACT: *Possibility of utilizing mill fibrous sludge from primary clarifier by separating the inorganic contaminants and shives following to sieving, classification and bleaching methods, has been examined. Separation of fibres in a vibratory strainer and of filler material by incineration have been attempted. The reclamation pulp from the paper machine has been added upto 50% with mill bleached pulp for producing quality paper.*

INTRODUCTION

It has been advocated recently that (1-2) the fibrous sludge can be composted and incorporated with the soil so as to amend it and make it suitable for increased production of agricultural crops, namely:

Onion

Brinjal

Tomato

Ladies finger

Banana.

The composted sludge has been applied abroad (3-5) for cultivation of:

Corn

Tomato

Pepper

Grape and

Food crops.

It is reported that sludge pots can be fabricated (6) using the sludge for seedlings of eucalyptus grandis. It is claimed that these pots are more suitable than the plastic pots used normally in clonal propagation technique.

Fibrous sludge generated from the primary clarifier is presently used in some industry for producing card board paper.

The fibrous sludge has also been in use as a source of energy (7-16). The sludge is required to be briquetted (10-13) before burning so as to increase the calorific value. Two methods are used for burning:

1. Fluidized bed incineration method (13).
2. Hogged fuel boiler method (8, 14).

It is recently reported (15) production of 30-35 tpd of $1\,^3/_8$" diameter pellets from 100 to 125 tpd mill sludge in USA with a calorific value of 5000 Btu/lb. The future research aimed is in pelletization efficiency from 7% to 20% blending.

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On careful incineration of the sludge, the ash produced can be recycled for use in the stock preparation. As the filler materials used abroad are mostly china clay whose thermal resistance is very high, such incineration does not bring any structural disorganisation in the filler material.

EXPERIMENTAL

Two types of fibrous sludge have been used from mill using bamboo-hard wood pulp and producing quality paper:

I. From primary clarifier effluent and

II. From paper machine effluent.

Sludge - I was collected from the sludge well of primary clarifier and sludge - II from the clarifier underflow. Both were in slurry form. The solid content in sludge - I was 4% while in II it was 1.1%.

The incineration has been carried out in a muffle furnace at 300°C to 800°C. From the ash content value, the LOI (Loss on Ignition) has been determined.

The fibre classification has been carried out in Bauer McNett classifier. A vibratory strainer procured from Universal Engineering Company (slit width 0.15mm) has been employed for separation of fibrous and non-fibrous part:

a. With flow of water

b. Without flow of water

c. Maintaining different timings for vibration (10-300 secs.).

The CEHH sequence of bleaching process has been used for bleaching the pulp, obtained on

a. 250 mesh

b. Vibratory screen overflow pulp.

The bleaching conditions are mentioned in Table 5A and B.

The various physical properties of the hand sheets have been determined according to standard TAPPI method (17).

RESULTS AND DISCUSSION

The fibrous sludge is composed of:

a. Long fibres

b. Short fibres

c. Filler material (Talc)

d. Shives

e. Sand particles

f. Soil (Clay).

The fibres can be bleached or unbleached. (a) to (c) above are materials which are intended to be recovered. Because of the difference in particle size and density, it appears that the materials can easily be separated but in practice, it has rarely been successfully carried out and the sludge is disposed off as waste material.

The filler and inorganic materials may be present in the following ways:

a. Inside the lumen (18)

b. Get entrapped in the fibre net work (19-21).

From the qualitative properties of the constituents, it can be seen that the possible separation method is by:

a. Sieving or classification and

b. Incineration.

Both the methods have been tried here.

Separation of fibres through classification

The fibre classification values of the sludge-I is given in Table-1. The major fraction passes at 100 mesh (68.9%) while the portion at +16 mesh is mostly the shive portion. Only 3.6% is retained in the fraction -50 to +100 mesh. It was observed that the fraction between -16 and +50 mesh, amounting to 24.8% is the fibre fraction. The fraction passing through -100 mesh consists of mostly the inorganic material along with fine fibres. It is inferred therefore that the sludge should be passed through a 16 mesh to remove the shive portion and than through a 100 mesh sieve. The middle fraction of about 28% contains fibres of fairly good quality. The fibre classification analysis of the +250 mesh after washing is given in Table-1 (2nd column).

Table-1.

Fibre classification of the sludge

Fraction (in mesh no.)	% Retained I	% Retained II	% Retained III
+16	2.6	16.5	4.5
-16 , +30	12.0	21.0	24.6
-30 , +50	12.8	17.8	21.0
-50 , +100	3.6	15.5	17.6
-100	68.9	30.2	32.3

I As such

II After washing manually (+250 mesh fraction)

III Over flow fraction in the vibratory strainer.

Separation of fibres in vibratory strainer

As the filler, soil and sand are likely to pass through 250 mesh, the sludge slurry was firstly passed through 250 mesh. The +250 mesh fraction has been employed for separation of the fibre part in a vibratory strainer (Fig. 1A).

a. Without flow of water (Table-2)

b. With flow of water (Table-3).

Table-2.

Separation in vibratory screen (without flow of water)

Time of vibration (Sec.)	% Retained	%Passed	Loss in wt (%)
30	59.7	25.1	15.2
60	49.1	34.5	16.4
90	39.5	44.3	16.2
120	30.7	46.4	22.9
180	24.5	43.4	32.1
240	13.7	46.0	40.3
300	10.5	52.3	37.2

Table-3.

Separation in vibratory screen (with flow of water)

Time of vibration (Sec.)	Top fraction (Wt.%)	Overflow fraction (Wt.%)	Underflow fraction (Wt.%)
10	15.8	16.1	52.4
20	15.4	16.5	48.8
30	3.3	16.7	47.3
40	1.2	28.4	43.7
50	0.9	29.6	44.9
60	0.5	37.7	41.4

Table-4.

Ash content in solids separated in vibratory screen (with flow of water)

Time of vibration (Sec.)	Top fraction (Wt.%)	Overflow fraction (Wt.%)	Underflow fraction (Wt.%)
10	11.07	15.46	15.36
20	9.18	14.52	14.12
30	--	13.68	13.29
40	--	13.80	12.39
50	--	13.52	12.10
60	--	13.38	12.03

Table-5A.

Bleaching conditions of sludge pulp

Particular		I	II
1. **Kappa No.**		11.4	10.0
2. **Chlorination (C):**			
Chlorine added,	%	3.3	3.0
Chlorine consumed,	%	2.1	2.0
End pH		2.4	3.0
3. **Alkali extraction (E):**			
Alkali added,	%	1.17	1.0
End pH		10.1	10.4
4. **Hypochlorite (H_1):**			
Hypo added (as available Cl_2)	%	1.1	1.0
Buffer added,	%	0.4	0.4
Hypo consumed (as available Cl_2)	%	0.88	0.91
End pH		8.2	8.4
5. **Hypochlorite (H_2):**			
Hypo added (as available Cl_2)	%	1.1	1.0
Buffer added,	%	0.2	0.2
Hypo consumed (as available Cl_2)	%	0.7	0.6
End pH		8.0	8.2
6. **Brightness,**	% El	73.0	73.4

I On 250 mesh

II Vibratory screen overflow

Table-5B.

Conditions during bleaching (I and II)

Sl.No.	Particular		C	E	H_1	H_2
1.	Consistency,	%	3	10	10	10
2.	Temperature,	°C	Ambient	55±2	40±2	40±2
3.	Retention time,	min.	45	120	150	90

The vibration time was varied from 30 to 300 seconds without flow of water from the sprayer. It was observed that the optimum separation of fibre part amouts to 46.4% in 120 seconds.

When water is sprayed through the sprayer, the optimum time of vibration is 40 seconds. The top fraction contains mostly shives. The overflow fraction contains mostly fibres while the underflow fraction is accompanied by small amout of shives and sand. The top, overflow and underflow portions were dried and solid content was determined (Table-3). The ash content of the three fractions after 10 to 60 seconds of vibration is given in Table-4. It can be seen that ash content of 12-15% is in all the fraction. Visual examination of the fractions showed that the overflow fraction contains fibres which can be recovered for reuse.

The fibre classification analysis results of overflow fraction is given in Table-1 (3rd column).

Bleaching of sludge pulp

The CEHH sequence bleaching condition of sludge pulp are given in Table 5A and B.

The properties of the sludge pulp +250 mesh fraction after bleaching are shown in Table-6. The brightness of the sludge pulp after bleaching was 73.0% El. It can be seen that the bulk values are on the higher side. The burst factor was found to be highest (17.9) at 35 °SR. The tear factor is also found to be maximum (59.9) at 19 °SR. The breaking length is optimum at 35 °SR (3250 m).

Table-6.

Properties of bleached sludge pulp

Property		Freeness (°SR) (Initial) 19°SR	30°SR	35°SR	40°SR
Bulk,	cc/g	2.16	2.10	2.00	2.05
Burst Factor		12.6	17.6	17.9	16.9
Tear factor		59.9	42.8	43.3	39.2
Breaking length,	m	2470	3130	3250	2720
Double fold,	no.	3	5	4	3
Drainage time,	sec.	4	6	7	8

Table-7.

Properties of hand sheets from vibratory screen overflow pulp after bleaching

Property		(Initial) 22°SR	30°SR	40°SR
Bulk,	cc/g	2.17	1.93	1.91
Burst factor		11.25	14.21	15.06
Tear factor		47.57	39.56	37.08
Breaking length,	m	2095	3105	2895
Double fold,	no.	3	3	2

Table-8.

LOI of sludge at different temperatures

Temperature (°C)	LOI Values (%)
300	58.54
400	58.99
500	60.34
600	62.40
700	63.66
800	64.59

Properties of hand sheets from vibratory screen overflow pulp after bleaching, are given in Table-7. The strength properties remain more or less same in this pulp also.

The flow diagram for optimum separation of pulp from primary clarifier sludge for producing low quality paper is given in Fig. 1B.

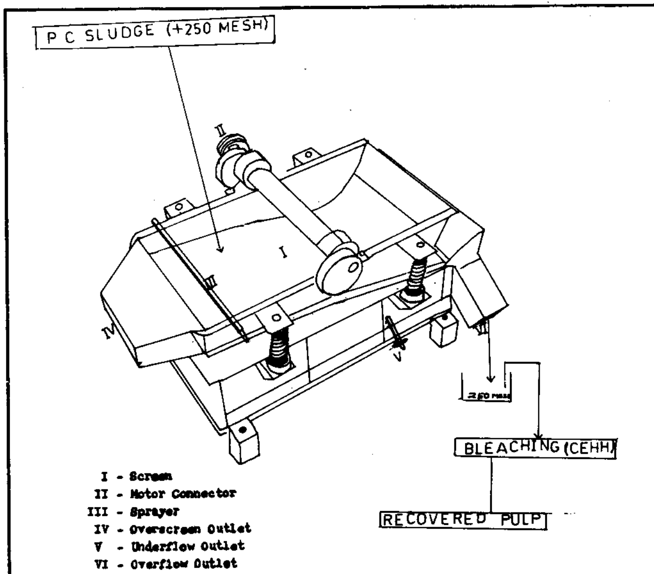

Fig. 1B. Schematic diagram of Separation Process.

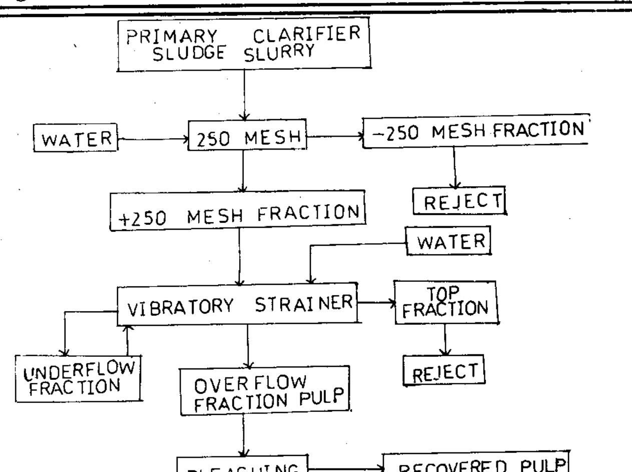

Fig. 1B. Flow diagram for optimum Separation of Pulp from primary clarifier sludge.

Separation by incineration

The results of incineration at various temperatures are shown in Table-8. The complete elimination of the fibre part is accomplished at 700-800°C. However, the difference of LOI values between 300 and 800°C is 8% which is about 4% between 300 and 600°C. As the filler material here is talc and it is likely to get dehydroxylated on heating accompanied by structural disorganisation, there will be degradation in brightness. The remaining 2% of fibrous fraction should not interfere in the paper properties. Incineration (22,23) has been widely carried out abroad for reuse of the filler part as china clay is mostly used which is costlier than talc. The objective of incineration (7-16) is for generation of energy essentially where the filler material comes out as a by-product. The optimum brightness (Fig. 2) is attained at 600-700°C (53% El) which degrades to 49% El at 800°C. The colour of the sludge upto 100°C remains brown which on heating from 300-500°C becomes gray and finally cream in colour from 600-700°C. It can be seen in Fig. 2 that the brightness of the product incinerated at 300°C is only 26.6% El. Thus incinerating the sludge at 600°C improves its brightness by about double of the initial value.

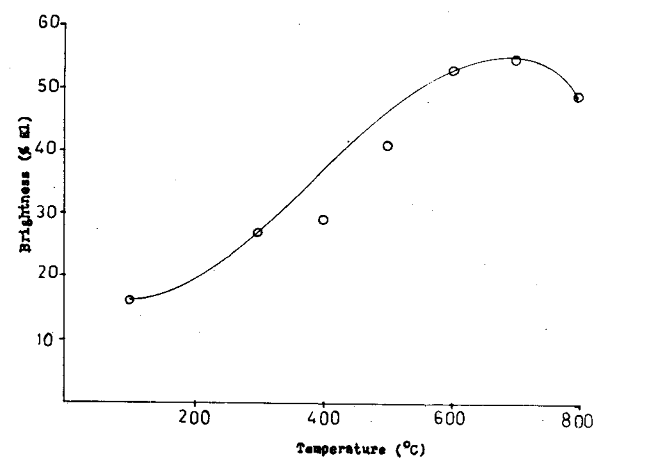

Fig. 2. Brightness of incinerated product.

Pulp waste from paper machine (Reclamation Pulp)

The properties of hand sheets from mill pulp replaced with different proportion of reclamation pulp are shown in Figs. 3-5 and Table-9-11 at 21, 30 and 40°SR respectively. It can be seen from the results that paper of fairly good strength can be produced by adding reclamation pulp upto 40%. At 40°SR (Table-10) a breaking length of 3830 m is found with 40% replacement of reclamation pulp. The tear factor of this furnish is 33.3 while burst factor is 20, which indicates that reclamation pulp can be utilized for production of quality paper. The drainage time is however 8 seconds instead of 5.5 for the mill pulp. The higher amount of fines present in the reclamation pulp increases the drain-

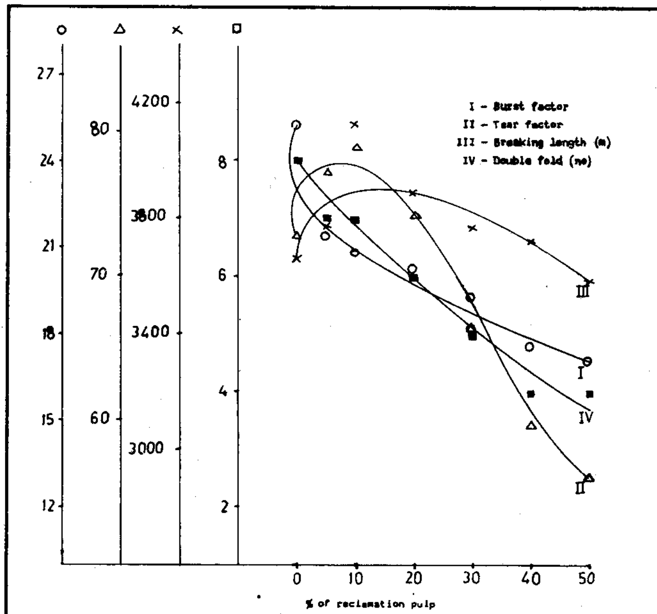

Fig. 3. Strength properties of hand sheets of mill pulp (21° SR) with reclamation pulp.

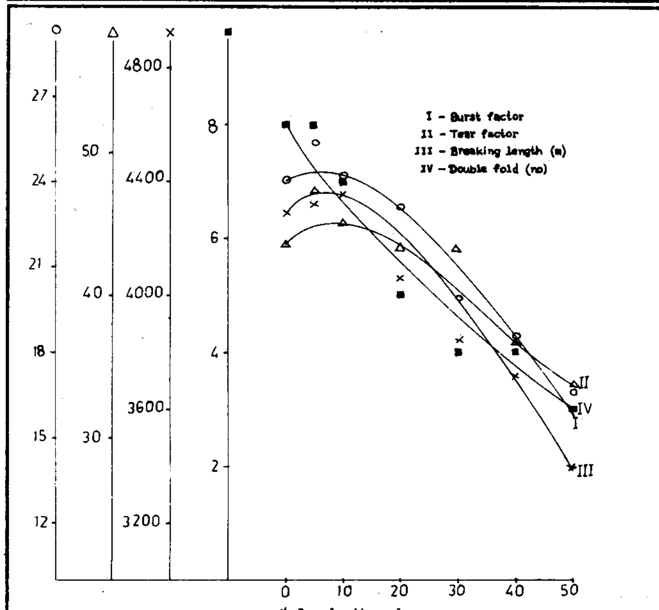

Fig. 4. Strenght properties of hand sheets of mill pulp (30° SR) with reclamation pulp

Table-9.

Properties of hand sheets from mill pulp (Initial 21°SR) and reclamation pulp

Set		1	2	3	4	5	6	7
Mill pulp,	%	100	95	90	80	70	60	50
Reclamation pulp,	%	0	5	10	20	30	40	50
Bulk,	cc/g	1.79	1.82	1.83	1.84	1.84	1.82	1.72
Drainage time,	Sec.	3.8	3.9	4.0	4.3	4.5	4.8	5.0
Ash,	Wt. %	0.35	1.85	3.09	4.84	7.40	11.41	14.06

Table-10.

Properties of hand sheets from mill pulp (30°SR) and reclamation pulp

Set		1	2	3	4	5	6	7
Mill pulp,	%	100	95	90	80	70	60	50
Reclamation pulp,	%	0	5	10	20	30	40	50
Bulk,	cc/g	1.58	1.59	1.62	1.59	1.61	1.57	1.56
Drainage time,	Sec.	4.8	4.8	5.0	5.5	6.0	6.5	7.2
Ash,	Wt. %	0.37	1.81	2.98	5.36	8.72	12.19	15.76

Table-11.

Properties of hand sheets from mill pulp (40°SR) and reclamation pulp

Set		1	2	3	4	5	6	7
Mill pulp,	%	100	95	90	80	70	60	50
Reclamation pulp,	%	0	5	10	20	30	40	50
Bulk,	cc/g	1.55	1.50	1.56	1.52	1.55	1.52	1.54
Drainage time,	Sec.	5.5	6.0	6.4	7.0	7.5	8.0	9.0
Ash,	Wt. %	0.35	2.05	3.18	6.55	9.51	12.31	16.15

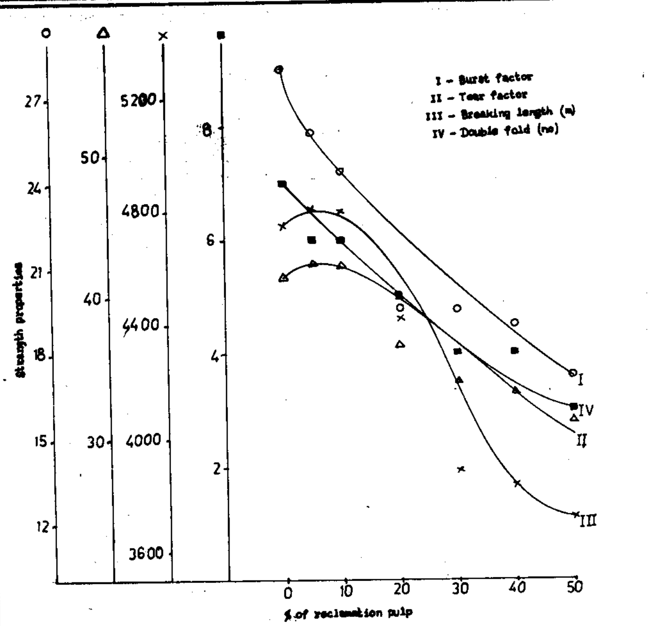

Fig. 4. Strenght properties of hand sheets of mill pulp (40° SR) with reclamation pulp

age time significantly. The ash content of 12.3% also accounts for the higher drainage time.

CONCLUSION

The filler part of the sludge can be separated by incineration of the sludge at 600°C with an yield of 37.6% and brightness of 53% El. The brightness of the filler (talc) increases with increase in temperature upto 700°C and then it is lowered. The undesirable contaminants in the sludge are shives and sand particles which can be separated fairly in the vibratory strainer with a fibre yield of 28.4% in the overflow. The sludge has low kappa no. with a brightness of 36.8% El. The sludge on bleaching through CEHH sequence can produce low quality paper (brightness 73% El, breaking length 3250 m). The reclamation pulp itself being of high brightness and free from contaminants, it can be effectively mixed upto 40% with mill pulp for manufacturing quality paper.

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