A Simple, Systematic Approach to Screen and Select Drainage and Retention Aids.

Dathathreya C.T. and Wasi Ahmed Mohd.

ABSTRACT

Though sophisticated methods using costly instruments are available for evaluation of retention and drainage aids, they are expensive and need special handling. However, for this work we have used a simple procedure to evaluate retention and drainage aids. This procedure helped us to screen a large type of aids available. The principle of the procedure is to (i) measure drainage time for known volume of filtrate using the standard Schopper Freeness Tester, (ii) Test the suspended solids of filtrate (iii) Observe the formation of hand sheets made - with and without additive. This procedure has given us meaningful results for the head box sample of one of our machines with low first pass retention. From these studies it is observed that a combination of amphoteric starch and non-ionic polyacrylamide gives optimum results.

With respect to the polyethyleneimines tried to improve drainage of filler pulp of our board machine, only one type polyethyleneimine gave significant improvement. Statistical procedure using 't-statistic' has been used to ascertain the significance of the improvement in drainage with an without the additives. This procedure has helped to arive at proper conclusions.

INTRODUCTION

Retention and or drainage aids have now been generally accepted by the paper maker as useful functional wet end additives. As per Fisher (1) of Allied Colloids, the main reason for the increase in usage of retention aids can be summarized as follows.

i) Increased machine speeds.

ii) The demand for improved machine efficiency.

iii) Higher ash content papers.

iv) Pollution reduction.

v) Cost savings.

The main types of retention/drainage aids available today are generally of four types (a)

The Sirpur Paper Mills Ltd.,
Sirpur-Kaghaznagar-504 296 (A.P.)

Polyacrylamides (b) Polyamides/Polyamines (c) Polyethyleneimines (d) Cationic Starches, (e) Dual Polymer systems such as "Hydrocol' of allied colloids, compozil of EKa Nobel. The first three come in different types namely cationic, anionic and non-ionic and high charge density, medium charge density and low charge density. Again they are available in high molecular mass, medium molecular mass and low molecular mass. To put it simply, the product range available to the paper maker is quite wide and proper selection is required to get optimum results on the paper machine. This brings us to the necessity of carrying out simple screening tests in the laboratory which are reliable and based on which plant trials can be taken to achieve desired results.

There are many methods available for evaluation, selection and screening the polyelectrolytes. The more frequently used techniques are Minidrinier (1) Dynamic Paper Chemistry jar (2) Drainage Test using Schopper Reigler Freeness Tester (3,4). In addition to the above techniques, Zeta Potential analyzers, charge demand titrations (CDT) (5) Specific Filtration Resistance, (SFR) (6), Streaming Potential (7) G/W drainage-retention Tester (8) have been helping in understanding and controlling wet end chemistry for optimization of the process.

In the present work we have used the simple procedure using Schopper Reigler Freeness Tester for drainage measurement. This is augmented by measurement or observation of turbidity of the filtrate and also observing the formation of hand sheets with and without additives.

EXPERIMENTAL

In our mill, one of our machines which is generally run at a speed of 220 to 240 m/min., it is found that the 1st pass retention is poor. Hence, studies were carried out to improve the 1st pass retention for this machine (First part of the work).

In the 2nd part of the work, studies were carried out to improve drainage characteristics of the filler pulp on our Board Machine.

EXPERIMENTAL PROCEDURES

Drainage Test: As required for °SR testing a slurry of 2 g/l of slice box pulp (consisting of pulp, filler and fines) was prepared by diluting with water whose pH had been adjusted to that of the sample with sulphuric acid. this was poured into the drainage cylinder (with its bottom closed with the cone provided). As soon as cone is lifted stopwatch was started. The bottom orifice is kept closed with a finger throughout. Time taken to collect 500 ml filtrate is reckoned as "Drainage Time".

The suspended solids in the filtrate was determined using a Glass fibre filter paper (If suitable Turbidity meter is available, it can be used instead).

An estimate of achievable retention improvement was determined by making standard hand sheets on the standard sheet apparatus. the slurry with and without addition of retention aid was diluted to 3 litres (with water whose pH is adjusted to the same value as that of the slice box sample) and standard hand sheets of 60 g/m^2 were made without any further dilution with the stirring part being maintained same for all sheet making. The sheets were pressed as per standard procedure and dried in air. These dried sheets were conditioned for 24 hours in the standard environmental laboratory (65 ± 2% R H and 27 + 1°C temp.). The average mass of eight sheets was determined. The improvement in retention was calculated by the difference in the average mass of 8 sheets of blank and 8 sheets of test. This procedure gave fairly accurate results.

RETENTION STUDIES

DISCUSSIONS:

From the screening results of Table-I, it is observed that except the anionic polyacrylamide (900) others have given significant reduction in drainage time. Also from the results of suspended solids in the filtrate, the retention is found better with non-ionic and Anionic-cum-non ionic polyacrylamides. Based on these results, these three polymers were selected for further study.

In addition to polyacrylamides, four types of starches were also studied. Results are given in Table-II. From these results it is observed that 315-Amphoteric starch has shown the best improvement with respect to drainage improvement and retention improvement (lower suspended solids in the filtrate). Hence, 315 was considered for further study.)

Table-III gives the results of retention studies. From the results it is observed that improvement in 1st pass retention has ranged from 6.06 % to 11.44%. The combination of 315, 3 kg/t and N, 200 g/t has given the best improvement. The formation was quite

TABLE - I

Retention studies by using Polyacrylamides for furnish samples from head box of paper machine

Type of polycryalamide	Nonionic N-10				Cationic -815P				Nonionic -720				Anionic -900				Anionic-cum-nonionic 851			
1. Slice box sample used																				
a) Consistency%	0.780				0.675				0.615				0.735				0.756			
b) pH	5.15				5.32				5.36				4.05				4.55			
2 Dosage, g/t	Blank	100	200	300	Blank	100	200	300	Blank	100	200	300	Blank	100	200	300	Blank	100	200	300
3. Drainage time, sec. (Average of 5 readings)	103	56	40	32	84	63	55	46	99	48	36	31	113	109	107	105	117	75	48	45
4. Std. Deviation of 5 drainage readings	2.38	1.56	1.37	1.58	1.82	1.20	1.20	1.02	2.05	1.42	1.33	1.24	2.90	2.81	1.82	1.84	2.6	1.54	1.48	1.4
5. t-statistic	..	36.9	51.3	55.6	..	21.5	29.7	40.73	..	45.7	57.6	63.4	..	2.21	3.91	5.20	..	31.1	51.6	54.4
6. Statistical significance of change -Drainage time ** of blank as compared to additive dosed sample at																				
a) 95% confidence level	..	HS	HS	HS	..	HS	HS	HS	..	HS	HS	HS	..	NS	S	S	..	HS	HS	HS
b) 99% confidence level	..	HS	HS	HS	..	HS	HS	HS	..	HS	HS	HS	..	NS	NS	S	..	HS	HS	HS
7. Suspended solids in the filtrate, mg/l	320	226	140	80	370	260	228	150	280	160	80	60	444	436	430	498	472	280	200	80

**HS - Highly Significant, S - Significant, NS - Not significant.

Furnish and other details + Approx.composition - 60% Hardwood bleached pulp, 40% Bamboo bleached pulp, 10-15% Filler
Paper quality : Creamwove and Coloured Printing, 47 g/m²
Machine speed : 215 to 225 m/min.

TABLE - II

Retention studies by using Starches for furnish samples from head box of paper machine.

Type of Starch	315 Amphoteric				734 Cationic				T-25 Cationic				T-25 Cationic			
1. Slice box sample used																
a) Consistency%	0.670				0.724				0.766				0.85			
b) pH	5.12				5.0				4.75				4.95			
2. Dosage, kg/t.	Blank	5	10	15	Blank	5	10	15	Blank	5	10	15	Blank	5	10	15
3. Drainage time, sec (average of 5 readings)	143	92	87	75	100	80	77	70	117	111	107	101	106	103	101	99
4. Standard deviation of 5 drainage readings	2.05	1.32	1.49	1.33	1.92	1.62	1.50	1.40	2.20	1.94	1.83	1.74	1.88	1.68	1.55	1.40
5. 't' Statistic	–	44.7	49.4	62.2	–	17.8	21.1	28.3	–	4.57	7.81	12.7	–	2.66	4.58	6.67
6. Statistic significance* of change at																
95% confidence level	–	HS	HS	HS	–	HS	HS	HS	–	S	S	HS	–	NS	S	S
99% confidence level	–	HS	HS	HS	–	HS	HS	HS	–	NS	S	S	–	NS	NS	S
7. Suspended solids of filtrate, mg/L.	252	192	150	102	386	336	322	280	447	340	303	263	442	385	377	330

*HS = Highly significant, S = Significant, NS = Not significant.

Furnish ad other details : Approx. composition - 60% Hardwood bleached pulp, 40% Bamboo bleached pulp, 10-15% Filler
Paper quality - Creamwove and Coloured Printing, 47 g/m^2
Machine speed - 215 to 225 m/min.

TABLE - III

Retention studies by using Polyacrylamides, Starches and combination of both for furnish samples from head box of paper machine.

1. Slice box sample used						
a) Consistency %	0.56	0.59	0.67	0.56	0.70	0.62
b) pH	4.62	4.50	4.65	4.42	4.41	4.72
2. Type of retention aid added with dosage level	N-10 200g/t (nonionic Polycryalamide)	815P 200g/t (cationic Polyacrylamide)	315 3 kg/t (amphoteric Starch)	315 3 kg/t (amphoteric starch) +N-10, 200g/t (nonionic Polyacrylamide)	315 3 kg/t (amphoteric Starch) 900, 200g/t (anionic Polyacrylamide)	815P 200 g/t +851p, 100 g/t (anionic-cum cationic Polyacrylamide)
3. Drainage time's before addition of retention aid. (Blank)	85.2	117.5	96.0	86.2	98.7	79.5
After addition of retention aid	59.2	87.5	73.5	53.2	80.0	63.5
4. Increase in Ist pass retention, %	6.88	6.06	8.67	11.44	8.28	6.65
5. Observation of formation of sheet.	good	good	good	good	good	good

Furnish and other details : Approx. composition - 60% Hardwood bleached pulp, 40% Bamboo bleached pulp, 10-15% Filler
Paper quality - Creamwove and coloured Printing, 47 g/m^2
Machine speed - 215 to 225 m/min.

TABLE - IV

Drainage studies by using polyacrylamides for furnish of filler pulp of board machines.

1.	Head box sample																							
	a) Consistency %				4.5						4.5						4.5						4.5	
	b) pH				6.9						6.9						6.9						6.9	
2.	Type of drainage aid used	Cationic Polyacrylamide-140						Cationic Polyacrylamide-160						Cationic Polyacrylamide-162						Cationic Polyacrylamide-168					
3.	Dosage g/t	50	100	150	200	250	300	50	100	150	200	250	300	50	100	150	200	250	300	50	100	150	200	250	300
4.	Drainage time, Sec. (Average of 5 tests)																								
	a) Before aid addition (Blank)	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6
	b) After aid addition	26.8	26.9	26.9	28.5	28.8	29.5	27.2	26.1	26.9	27.4	25.6	24.4	25.8	26.9	27.4	26.7	27.6	27.1	27.0	24.4	26.7	25.8	26.7	24.2
5.	Std. deviation																								
	a) Blank	0.548	0.548	0.548	0.548	0.548	0.548	0.548	0.548	0.548	0.548	0.548	0.548	0.548	0.548	0.548	0.548	0.548	0.548	0.548	0.548	0.548	0.548	0.548	0.548
	b) Test	1.643	0.894	0.224	0.500	0.274	0.791	0.837	0.742	0.132	0.548	1.095	0.548	0.570	0.548	1.342	0.758	0.548	0.821	0.354	1.673	0.671	0.758	0.570	0.758
6.	t-statistic	1.03	1.49	2.64	2.71	4.37	2.09	0.89	3.64	1.08	0.57	3.29	9.23	5.09	2.01	0.308	2.15	--	1.133	2.05	4.06	2.32	4.30	2.55	8.13
7.	Statistical significance of change in drainage time of Blank as compared to test at																								
	95% confidence level	NS	NS	NS	NS	NS	NS	NS	S	NS	NS	S	S	NS	NS	NS	NS	NS	NS	NS	S	NS	S	NS	S
	99% confidence level	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	S	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	S
	confidence level																								

Furnish and other details : Approx. composition of Filler pulp : 100% mixed waste paper with 6-8% filler.
Board quality : White Duplex Board, 280-350 g/m²
Machine speed : 20-52 m/min.

TABLE - V

Drainage studies by using polyacrylamides for furnish of filler pulp of board machines.

1.	Head box sample												
	a) Consistency %				4.6				4.7			4.49	
	b) pH				6.8				7.05			6.60	
2.	Type of drainage aid used				Cationic Polyethyleimine - 4554				Polyethyleimine - SK			Polyethyleimine - SK	
3.	Dosage of drainage aid g/t	50	100	150	200	250	300	1000	1500	2000	1000	1500	2000
4.	Drainage time, sec. (Average of 5 tests)												
	a) Before aid addition (Blank)	29.4	29.4	29.4	29.4	29.4	29.4	10.08	10.08	10.08	9.16	9.16	9.16
	b) After aid addition	29.7	29.2	27.5	27.7	27.4	26.2	10.28	11.57	10.84	9.47	9.22	9.39
5.	Standard deviation												
	a) Blank	0.418	0.418	0.418	0.418	0.418	0.418	0.5158	0.5158	0.5158	0.1346	0.1346	0.1346
	b) Test	0.274	0.274	0.500	0.447	0.962	0.274	0.2479	0.5402	0.7612	0.3694	0.1470	0.0717
6.	t-statistic	-1.34	0.895	6.52	6.21	4.26	14.32	-0.781	-4.460	-1.848	-1.763	-0.673	-3.372
7.	Statistical significance of change in drainage time of blank as compared to test at												
	a) 95% confidence level	NS	NS	S	S	S	HS	NS	NS	NS	NS	NS	NS
	b) 99% confidence level	NS	NS	S	S	NS	HS	NS	NS	NS	NS	NS	NS

Furnish and other details : Approx. composition of Filler pulp : 100% mixed waste paper pulp with 6-8% filler.
Board quality : White Duplex Board, 280-350 g/m²
Machine speed : 20-52 m/min.

OK indicating only microflocculation.

DRAINAGE STUDIES

In addition to their usefulness as retention aids, polyacrylamides can also be used for improving drainage. One more class of polymers used as drainage aids and also as 'anionic trash' collectors are polyethyleneimines.

Both polyacrylamides and polyethyleneimines have been evaluated for their efficiency to improve drainage of filler pulp of board machine.

The results of the drainage studies are given in Table-IV and Table-V.

From these data it is observed that 140,160,162, are not effective in improving drainage. 168 is effective at very high dosage level of 300 g/t below that it is ineffective. 4554 is effective from 150 g/t to 300 g/t. S K is found ineffective at 1000 to 2000 g/t.

From these results it is observed that only 4554 is effective in improving drainage which can be considered for further plant trials.

CONCLUSIONS

1. A simple procedure using Schopper Freeness Tester has been used to evaluate retention and drainage aid. In addition to drainage, the suspended solids of the filtrate and the formation of sheets made on standard sheet machine with higher consistency have helped the evaluation.

2. Based on the above procedure, a number of polyacrylamides modified starches and polyethylenimines have been evaluated for their effectiveness as retention and drainage aids. It has been possible to screen these additives and to select suitable ones for plant trials.

3. From the evaluations carried out, it is found that a combination of amphoteric starch and non-ionic polyacrylamide combination at dosage levels of .3 kg./t and 200 g/t respectively is found to improve 1st pass retention to the extent of 11.4% over that of the blank for one of our paper machines with poor 1st pass retention. We plan to take trial of this combination.

4. From the drainage studies carried out for filler pulp of our board machine, only one polyethyleneimine was found to be effective (4554). We carried out a small plant trial which was inconclusive. We plan to take a longer trial.

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Legend for statistical terms used

't' statistic = $$\frac{\bar{x}_b - \bar{x}_t}{\sqrt{\frac{s_b^2}{N_b} + \frac{s_t^2}{N_t}}}$$

where $\bar{x}_b$ = Arithmetic mean of 'blank' readings.

$\bar{x}_t$ = Arithmetic mean of 'test' readings.

s_b = Standard deviation of 'blank' readings.

s_t = Standard deviation of 'test' readings.

N_b = Number of tests carried out for 'blank' readings

N_t = Number of tests caried out for 'test' readings

The critical value of significance of 't' statistic:

At 95% confidence level : 2.776 for 4 degree of freedom.

At 99% confidence level: 4.604 for 4 degree of freedom.

Hence if the calculated value of 't' statistic is higher than these critical values, the difference in drainage time of blank and test is significant at the corresponding confidence level.