Alkaline Sizing - A Tool for Quality Improvement of Bagasse Paper : Century Pulp & Paper Case Study

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ABSTRACT

Sizing is one of the most critical properties of Writing & Printing Paper, which decides the quality of printing at press room. Degree of sizing depends on end use of paper and influenced by various factors viz. type of raw material, type of sizing material, machine configuration and operating conditions .Paper Makers are always under pressure to strike the balance between desired sizing level and cost. Balancing the wet end chemistry is the key to success. Over the last 50 years sizing technology has undergone various developments. This paper deals with our experience with various types of sizing materials used for sizing our bagasse based papers.

INTRODUCTION

Rosin Alum have been the most widely used sizing chemicals till now in Indian Paper Industries. Since late nineties Mills have started changing to Alkaline for various reasons. Whatever the sizing material, optimum pH,good first pass retention is a prerequisite. Degree of sizing depends on end use of Paper and influenced by various factors viz. type of furnish, type of sizing material, type of filler, machine configuration and operating conditions..Bagasse pulp is derived from an agriculture residue sugar cane. It contains more fines than Hardwood(Graph-1) which leads to higher sizing chemical requirement for desired sizing level of 20-22 gm/m^2.Sizing values are one of the important properties determining the performance of paper at press room. At Century Pulp And Paper we have tried almost all available sizing chemicals on Bagasse to achieve this target. This paper deals with our experience with various types of materials used for sizing our Bagasse based papers with greater emphasis on Alkaline sizing.

Experimental

Our Bagasse unit was commissioned in the year of 1995.It is equipped with a elaborate arrangement for depithing(Dry and Wet) & storage of bagasse. Bagasse is cooked in an continuous digester and bleached in a unique bleaching sequence of C/D-EOp-D up to 88% ISO brightness. At stock preparation 80 % Baggase pulp and balance 20 % softwood and Hardwood pulp is used. Sizing chemicals were evaluated in laboratory before going into plant scale trials.60 gsm hand sheets prepared in a British hand sheet making machine (with back water re circulation facility) pressed twice at 50 psi for 5 & 3 minute respectively in a laboratory sheet press and dried in oven for 10 minutes at 105 ^{o}C.The sheet was conditioned at ambient temperature for 30 minutes before testing the cobb $_{60}$value.

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Table I

ACID SIZING

Lab Study and Optimisation :

Furnish : Bagasse pulp Pulp pH : 6.4

			1	2	3	4	5	6	7	8	9
a	Talcum	%	15	15	15	15	15	15	15	15	15
b	OBA	%	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
c	Non Ferric Alum	%	5.0	5.0	5.0	6.0	6.0	6.0	7.0	7.0	7.0
d	Fortified Rosin	%	1.2	1.5	1.8	1.2	1.5	1.8	1.2	1.5	1.8
e	Retention Aid (Liquid)	%	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
f	Stock pH		4.45	4.47	4.42	3.92	3.92	3.92	3.72	3.72	3.72
g	Back Water pH		4.65	4.67	4.62	4.16	4.15	4.12	3.84	3.82	3.81
Properties :											
Gsm		gm/m^2	60.5	60.7	60.1	60.1	60.2	59.8	59.6	60.4	60.5
Cobb $_{60}$		gm/m^2	32	30	28	28	26	25	26	23	22

Plant Wet End Chemical Consumption Pattern :

a	Talcum	%	14 - 16
b	OBA	%	0.5 - 0.8
c	Non Ferric Alum	%	6 - 7.5
d	Fortified Rosin	%	1.5 - 2.0
e	Retention Aid (Liquid)	%	0.02 - 0.035
f	Stock pH		4.1
g	Back Water pH		4.4
h	F.P. R	%	80.16 - 83.14
I	F.P.A. R	%	47.67 - 51.81

Dosing Point

a:	Talcum :	Primary Fan pump outlet
b:	OBA :	Blending Stand pipe
c:	Non Ferric Alum :	S.R.Box Accept
d:	Fortified Rosin :	S.R.Box Accept
e:	Retention Aid :	Pressure Screen outlet

Average Paper Sizing Value (Cobb $_{60}$) gm/M^2

26 - 30

Table II

NEUTRAL SIZING

Lab Study and Optimisation :

Furnish : Bagasse pulp Pulp pH : 6.5

			1	2	3	4	5	6	7	8	9
a	Talcum	%	15	15	15	15	15	15	15	15	15
b	OBA	%	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
c	Non Ferric Alum	%	1.8	1.8	1.8	2.0	2.0	2.0	2.2	2.2	2.2
d	Neutral Size	%	1.5	1.8	2.2	1.5	1.8	2.2	1.5	1.8	2.2
e	Retention Aid (Liquid)	%	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
f	Stock pH		6.11	6.12	6.16	5.92	5.94	5.94	5.71	5.68	5.72
g	Back Water pH		6.22	6.21	6.24	6.07	6.10	6.05	5.82	5.84	5.83

Properties :

Gsm	gm/m^2		60.4	60.1	59.8	59.9	60.2	60.5	60.5	58.9	60.8
Cobb $_{60}$	gm/m^2		32	30	29	30	28	27	29	27	25

Plant Wet End Chemical Consumption Pattern :

a	Talcum	%	14 - 18
b	OBA	%	0.3 - 0.8
c	Non Ferric Alum	%	2.4 - 3.5
d	Neutral Size	%	1.9 - 2.5
e	Retention Aid (Liquid)	%	0.02 - 0.03
f	Stock pH		5.94
g	Back Water pH		6.18
h	F.P. R	%	81.14 - 84.12
I	F.P.A. R	%	48.68 - 53.45

Dosing Point

a:	Talcum :	Primary Fan pump outlet
b:	OBA :	Blending Stand pipe
c:	Non Ferric Alum :	M/C Chest +S.R.Box Accept
d:	Neutral Size :	Fan pump inlet
e:	Retention Aid :	Pressure Screen outlet

Average Paper Sizing Value (Cobb $_{60}$) gm/M^2

24 - 27

Table III

CATIONIC ROSIN SIZING

Lab Study and Optimisation :

Furnish : Bagasse pulp Pulp pH : 6.5

			1	2	3	4	5	6	7	8
a	Talcum	%	15	15	15	15	15	15	15	15
b	OBA	%	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
c	Fixing Agent	%	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
d	Non Ferric Alum	%	0.5	0.75	1.0	1.25	0.5	0.75	1.0	1.25
e	Cationic Rosin	%	2.5	2.2	2.0	1.8	2.2	2.2	2.2	2.2
f	Retention Aid (Powder)	%	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
g	Stock pH		6.5	6.4	6.3	6.0	6.4	6.2	6.2	6.04
h	Back Water pH		6.67	6.52	6.43	6.18	6.55	6.31	6.26	6.18

Properties :

Gsm	gm/m^2	60.5	60	60	60.2	60.6	58.9	59.7	60.3
Cobb $_{60}$	gm/m^2	28	30	30	28	27	27	25	24

Plant Wet End Chemical Consumption Pattern :

a	Talcum	%	14 - 18
b	OBA	%	0.3 - 0.8
c	Fixing Agent	%	0.1 - 0.2
d	Non Ferric Alum	%	0.8 - 1.4
e	Cationic Rosin	%	1.8 - 2.6
f	Retention Aid (Powder)	%	0.01 - 0.015
g	Stock pH		6.14
h	Back Water pH		6.47
h	F.P. R	%	81.75 - 84.36
I	F.P.A. R	%	48.75 - 53.96

Dosing Point

a: Talcum	:	Primary Fan pump outlet
b: OBA	:	Blending Stand pipe
c: Fixing Agent	:	Bagasse feed chest
d: Non Ferric Alum	:	M/C Chest +S.R.Box Accept
e: Cationic Rosin	:	M/C Chest .
f: Retention Aid	:	Pressure Screen outlet

Average Paper Sizing Value (Cobb $_{60}$) gm/M^2

24 - 27

Our observations with various sizing methods are listed below.

Acid Sizing

We have started acid sizing with mill cooked Rosin which was replaced by Fortified Rosin. Details of processing conditions laboratory and plant scale are given in Table- I

RESULTS AND DISCUSSION (Plant Scale)

1. $Cobb_{60}$ value of paper achieved 28-30 gm/m^2.Increasing the Rosin dose up to 30 kg/T could not reduce the $cobb_{60}$ value further. However there was no complaint of high $cobb_{60}$ from customer. This is because of low porosity of paper(90-100 ml/min).
2. 2 % brightness drop from pulp to paper observed.
3. Shade variation observed particularly due to pH variation.
4. High CaO content in Talcum affected sizing adversely resulting increase in Rosin Consumption. Addition of Alum before rosin helped to reduce this phenomenon.
5. Very fast reversion of shade observed.

Neutral Sizing

Our Copier Paper was awarded Eco Mark by BIS .The requirement of $Cobb_{60}$ value for Copier Paper labeled with Eco mark the maximum limit is 25

Table IV

ALKALINE SIZING

Lab Study and Optimisation :

Furnish : Bagasse pulp Pulp pH : 6.38

			1	2	3	4	5	6	7	8
a	Talcum	%	15	15	15	15	15	15	15	15
b	OBA	%	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
c	Fixing Agent	%	0.025	0.025	0.025	0.025	0.05	0.05	0.05	0.05
d	AKD	%	0.8	1.0	1.2	1.5	0.8	1.0	1.2	1.5
e	Retention Aid (Powder)	%	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
f	Stock pH		7.24	7.3	7.32	7.34	7.51	7.51	7.64	7.55
g	Back Water pH		7.36	7.42	7.45	7.46	7.62	7.66	7.76	7.69

Properties :

Gsm	gm/m^2		58.6	59.8	60.4	60.7	61.2	60.4	60.2	58.6
Cobb $_{60}$	gm/m^2		30	28	26	24	27	25	22	20

Plant Wet End Chemical Consumption Pattern :

a	Talcum	%	16 - 20
b	OBA	%	0.2 - 0.6
c	Fixing Agent	%	0.02 - 0.05
d	AKD	%	1.2 - 1.4
e	Retention Aid (Powder)	%	0.01 - 0.015
f	Stock pH		7.64
g	Back Water pH		7.92
h	F.P. R	%	82.67 - 85.42
I	F.P.A. R	%	49.86 - 55.42

Dosing Point

a: Talcum	:	Primary Fan pump outlet
b: OBA	:	Blending Stand pipe
c: Fixing Agent	:	Bagasse feed chest
d: AKD	:	Fan pump inlet
e: Retention Aid	:	Pressure Screen outlet

Average Paper Sizing Value (Cobb $_{60}$) gm/M^2

22 - 25

gm/m^2.To improve the sizing and optical properties of our paper, we evaluated various dispersed rosin available. Results were found encouraging and plant trial was taken accordingly. Details of processing conditions are given in Table II.

RESULTS AND DISCUSSION (Plant Scale)

1. $Cobb_{60}$ value of paper achieved 24-27 gm/m^2.It is also observed that Cobb value reduces by 1 point after 24 hrs of natural ageing.
2. The best sizing values were obtained at 5.8-6.2 pH of Back water.
3. Improvement in shade observed. Brightness improved by 0.5 points.
4. OBA consumption also reduced by 0.5-1.0 Kg/T for same brightness level.

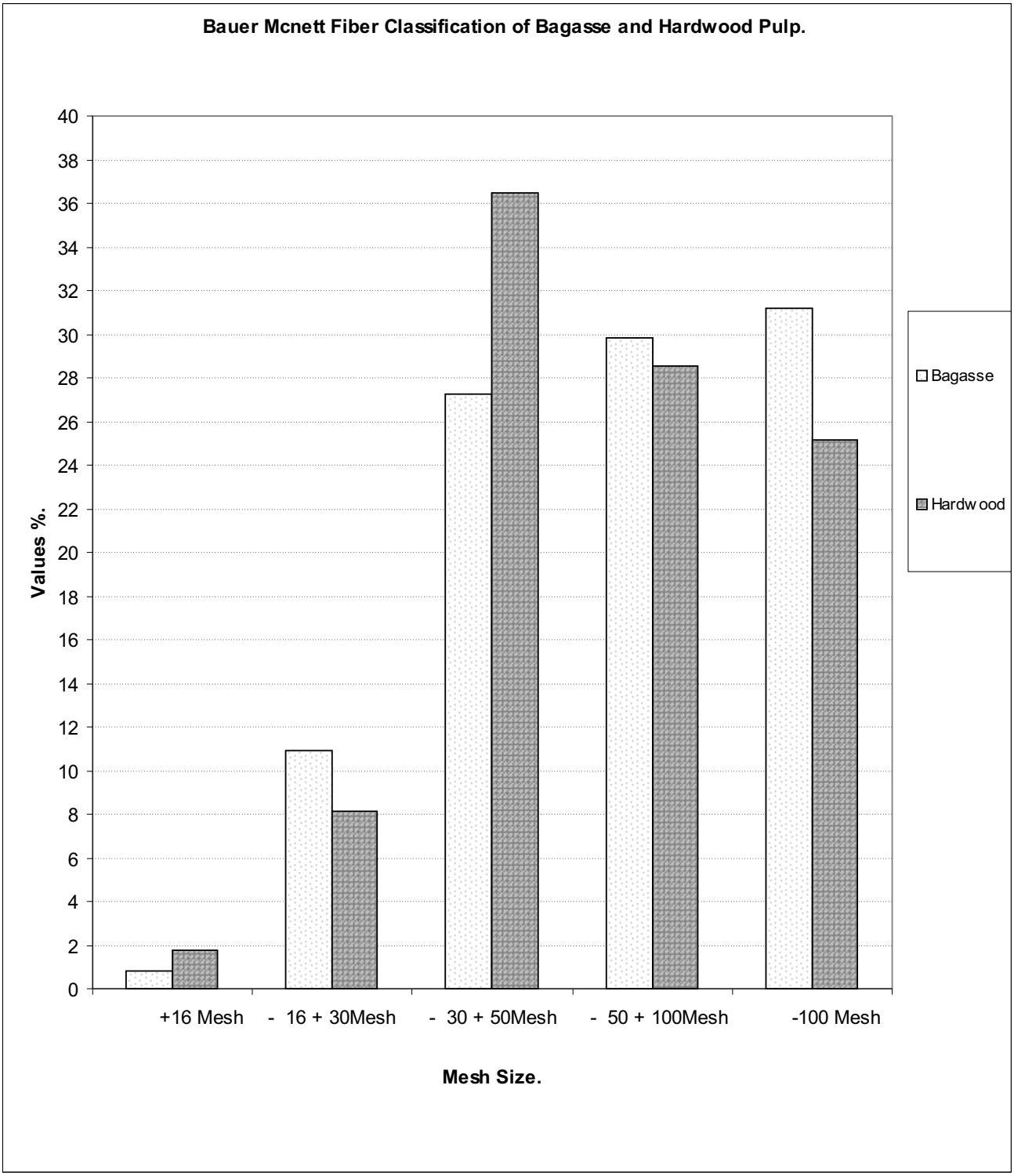
Cationic Dispersed Rosin

Cationic Dispersed Rosin was also tried in place of Neutral dispersed Rosin. Details of processing conditions are given in Table III.

RESULTS AND DISCUSSION AT PLANT

1. No significant change was observed in size consumption but

Graph I



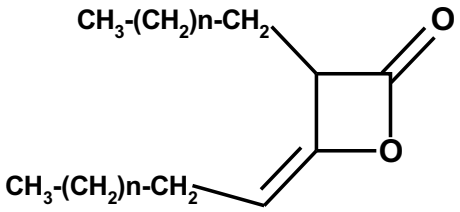
Alum consumption was less reduced significantly.

2. Cationic Fixing agent was also used.
3. Retention aid consumption reduced by half compare to normal neutral sizing with same level of FPR
4. $Cobb_{60}$ value improved by 1 point.

Alkene ketene dimer (**A**KD) has the

Table III

Alkaline sizing (AKD)



alkyl **k**etene **d**imer
(n = 12 / 14)

Table V

BINARY SIZING

Lab Study and Optimisation :

Furnish : Bagasse pulp Pulp pH : 6.64

a	Talcum	%	15	15	15	15	15	15	15	15
b	OBA	%	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
c	Fixing Agent	%	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
d	AKD	%	0.6	0.6	0.6	0.6	0.7	0.8	0.9	1.0
e	ASA	%	0.075	0.1	0.125	0.15	0.1	0.1	0.1	0.1
	Retention Aid	%	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
f	(Powder)									
g	Stock pH		7.86	7.88	7.88	7.92	7.79	7.83	7.95	7.95
h	Back Water pH		7.92	7.93	7.96	8.12	7.86	7.94	8.14	8.02

Properties :

Gsm	gm/m^2	61.5	60.4	60.4	60.7	61.2	60.7	58.9	59.6
$Cobb_{60}$	gm/m^2	26	25	23	22	26	24	22	20

Plant Wet End Chemical Consumption Pattern :

a	Talcum	%	16 - 20
b	OBA	%	0.2 - 0.5
c	Fixing Agent	%	0.02 - 0.05
d	AKD	%	0.5 - 0.7
e	ASA	%	0.06 - 0.1
	Retention Aid (Powder)	%	0.01 - 0.015
f	Stock pH		7.89
g	Back Water pH		8.20
h	F.P. R	%	82.85 - 86.15
I	F.P.A. R	%	51.24 - 55.96

Dosing Point

a: Talcum	:	Primary Fan pump outlet
b: OBA	:	Blending Stand pipe
c: Fixing Agent	:	Bagasse feed chest
d: AKD	:	Fan pump Outlet
e: ASA Emulsion	:	Fan pump Outlet
f: Retention Aid	:	Pressure Screen outlet

Average Paper Sizing Value ($Cobb_{60}$) gm/M^2

20 - 24

general structure as given in fig 1.It is synthesized by dimerizing fatty acid chlorides and resulting product has melting point of about 50 ^{o}C and is a waxy water soluble material at room temperature. In order to facilitate its addition and distribution in the paper furnish AKD is converted into emulsion. AKD emulsion contains AKD, Cationic starch or cationic polymers and other stabilizing additives. The pH is 3.0 4.5 and shelf life is about 1 month at 24 ^{o}C. Over the last years lot of developments took place in AKD technology and the shelf life has increased up to 3 months.

AKD was first introduced in 1953 as sizing agent in paper industry but its use picked up after 1986 onwards. At Century we have started using AKD in 1997 to achieve $Cobb_{60}$ values less than 25 gm/m^2 after initial laboratory trials. Details of processing conditions are given in Table VI.

RESULTS AND DISCUSSION

(Plant Scale)

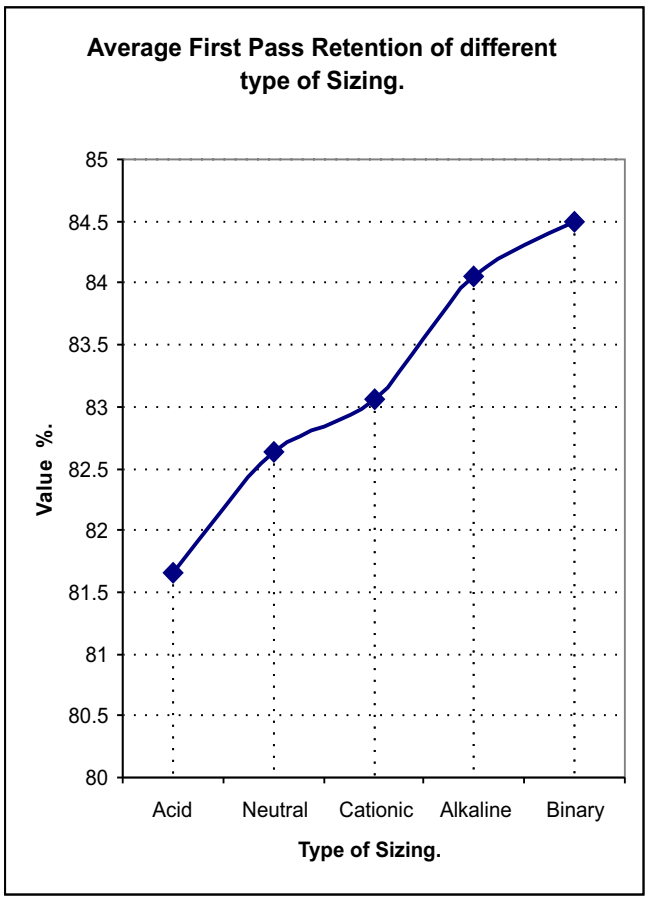
$Cobb_{60}$ value of 24-25 gm/m^2 achieved with 10 Kg-12 Kg/Ton dose of AKD at 7.5-8.0 pH

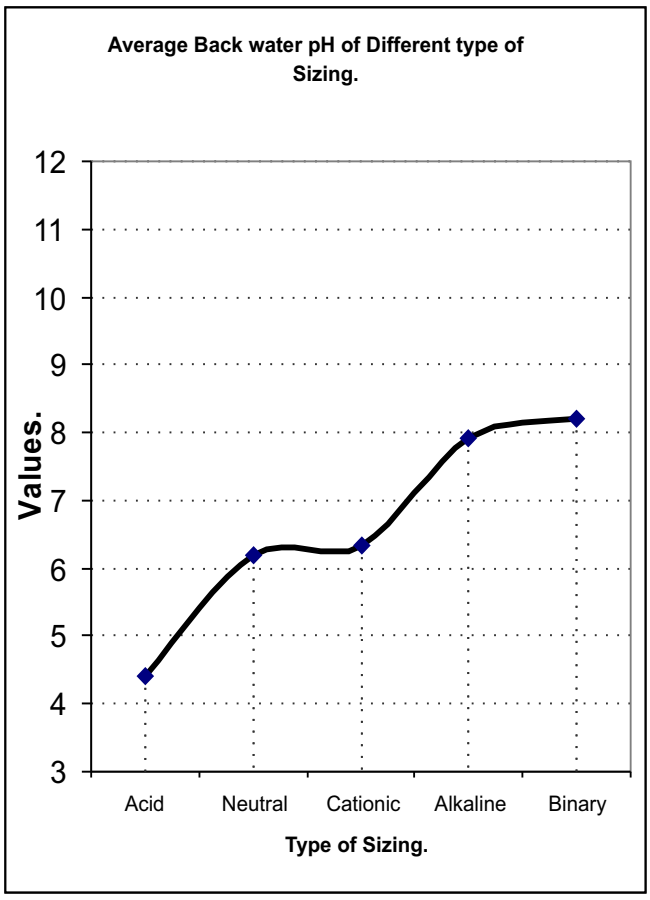
It is observed that following factors affects the sizing significantly and should be properly addressed.

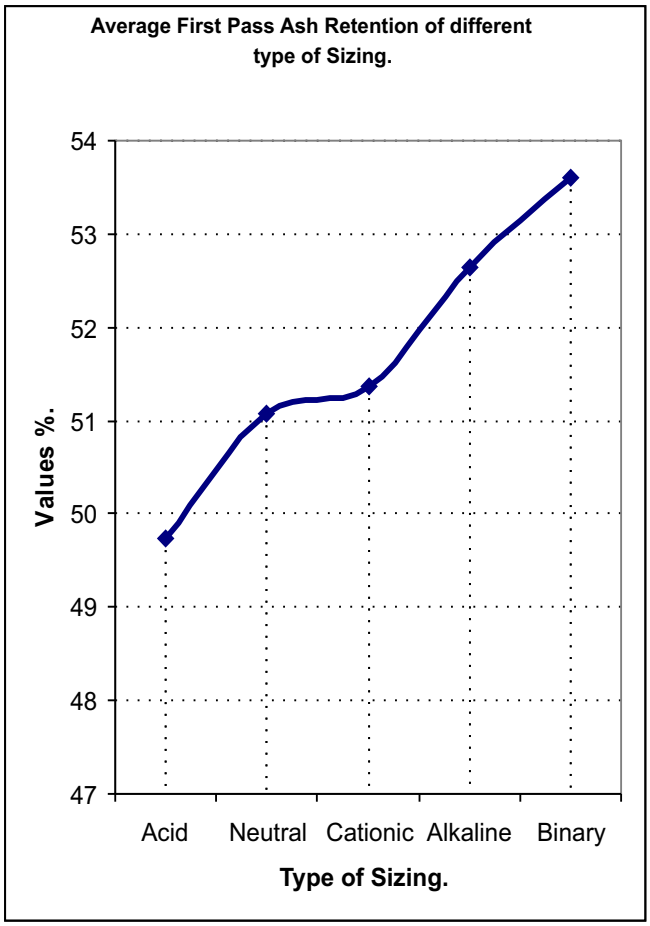
System pH and Alkalinity

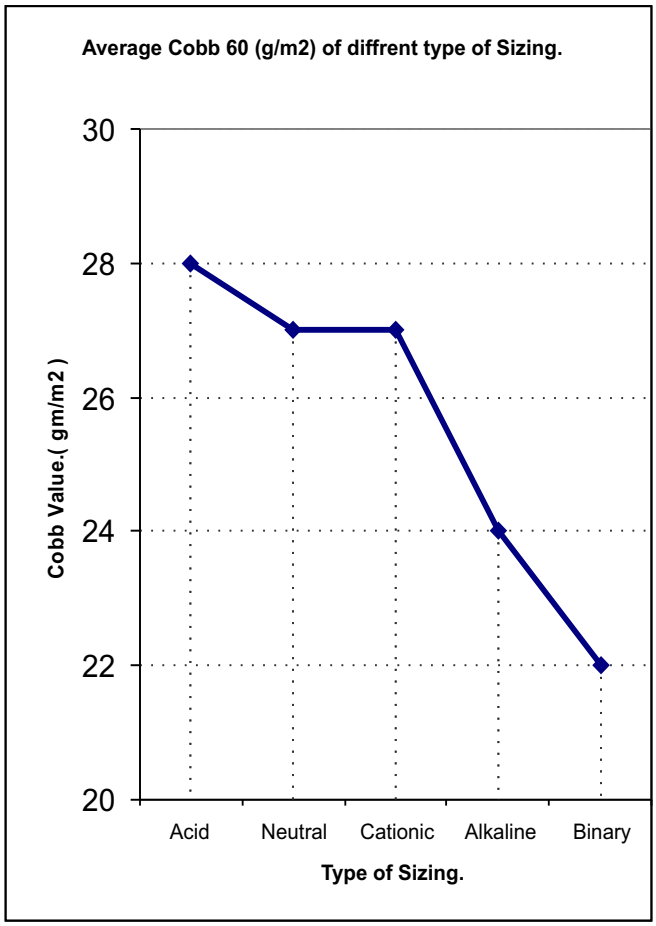
AKD reacts with Cellulose under

Graph II

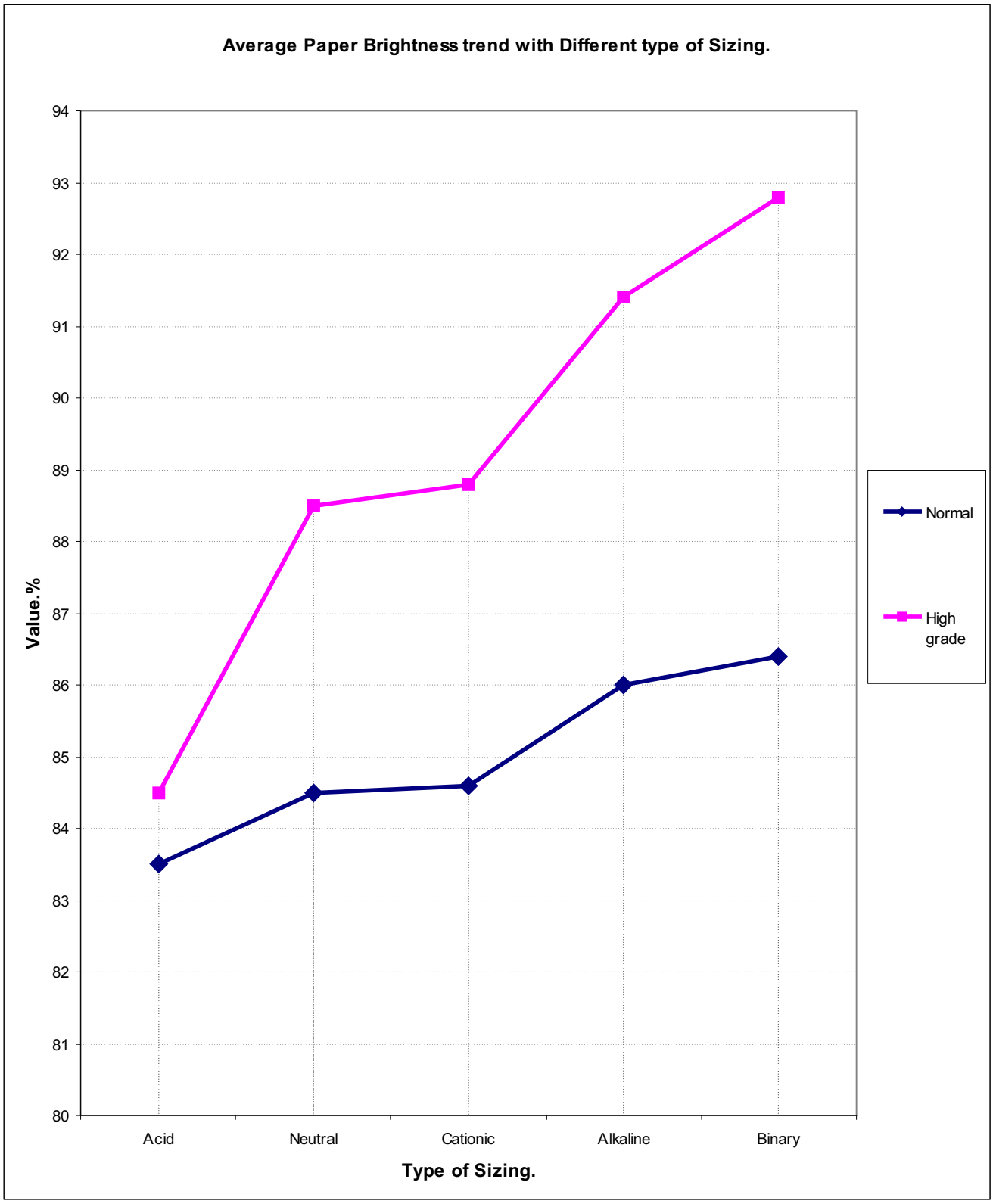

Average First Pass Retention of different type of Sizing.
Value %.
85
84.5
84
83.5
83
82.5
82
81.5
81
80.5
80
Acid
Neutral
Cationic
Alkaline
Binary
Type of Sizing.


Average Back water pH of Different type of Sizing.
Values.
12
11
10
9
8
7
6
5
4
3
Acid
Neutral
Cationic
Alkaline
Binary
Type of Sizing.


Average First Pass Ash Retention of different type of Sizing.
Values %.
54
53
52
51
50
49
48
47
Acid
Neutral
Cationic
Alkaline
Binary
Type of Sizing.


Average Cobb 60 (g/m2) of diffrent type of Sizing.
Cobb Value.(gm/m2)
30
28
26
24
22
20
Acid
Neutral
Cationic
Alkaline
Binary
Type of Sizing.

Graph III

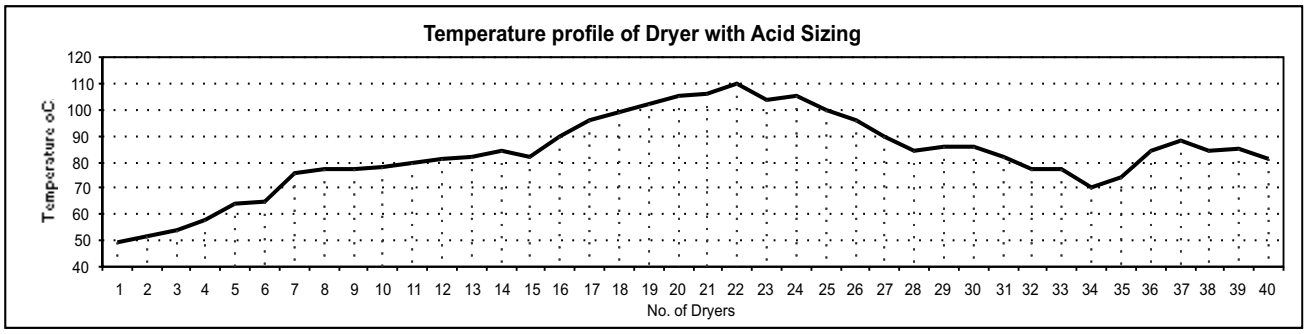


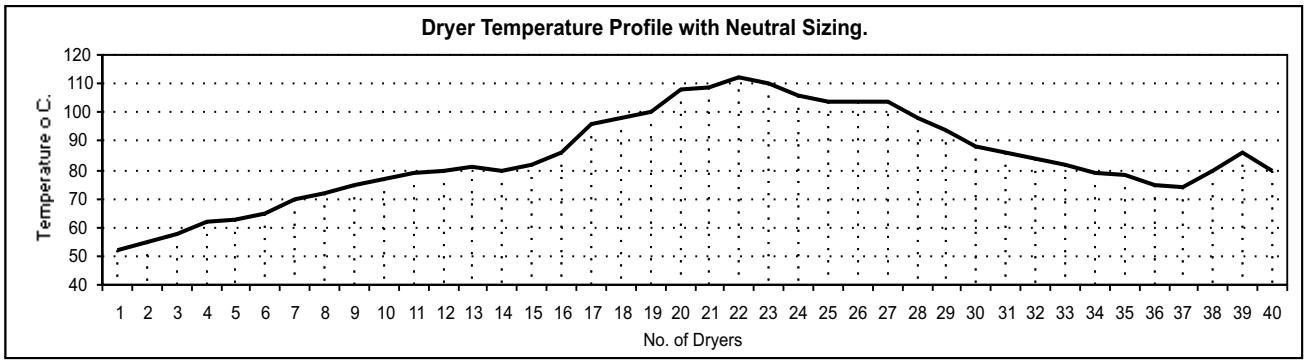
alkaline conditions and rate of reaction depends on pH. It was observed that at pH more than 8.5(alkalinity 280 ppm)the off machine cobb value was found 35 gm/m^2 which was reduced to 30 gm/m^2 after 24 hours natural ageing . At pH 7.5-8.0 (Alkalinity 150-200ppm) the off machine cobb value was 90 gm/m^2, which reduced to 24 gm/m^2 after 24 hrs natural ageing.

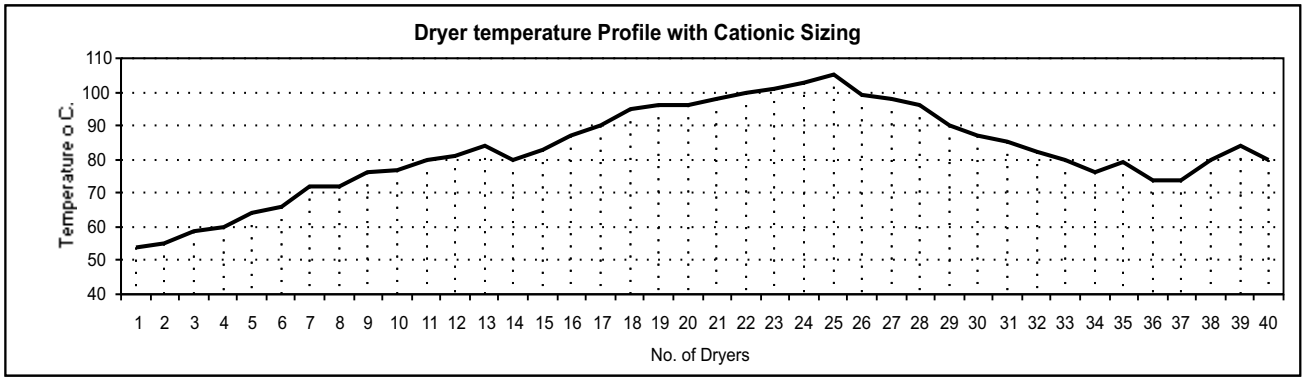
System Charge

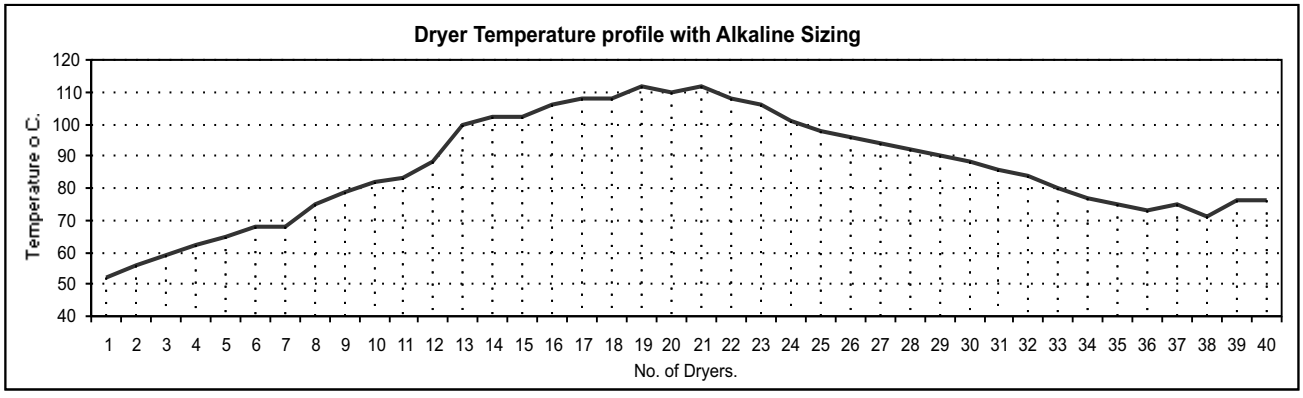
Fibre,Fines, and fillers are anionic in nature. In addition to that anionic trash also contribute negative charge to the system. AKD emulsions, retention aid, dry strength resins are cationic in nature. In order to achieve the optimum sizing values this anionic charge is to be neutralized. Press picking and fluff

Graph IV


Temperature profile of Dryer with Acid Sizing
Temperature oC
No. of Dryers


Dryer Temperature Profile with Neutral Sizing.
Temperature o C.
No. of Dryers


Dryer temperature Profile with Cationic Sizing
Temperature o C.
No. of Dryers


Dryer Temperature profile with Alkaline Sizing
Temperature o C.
No. of Dryers.

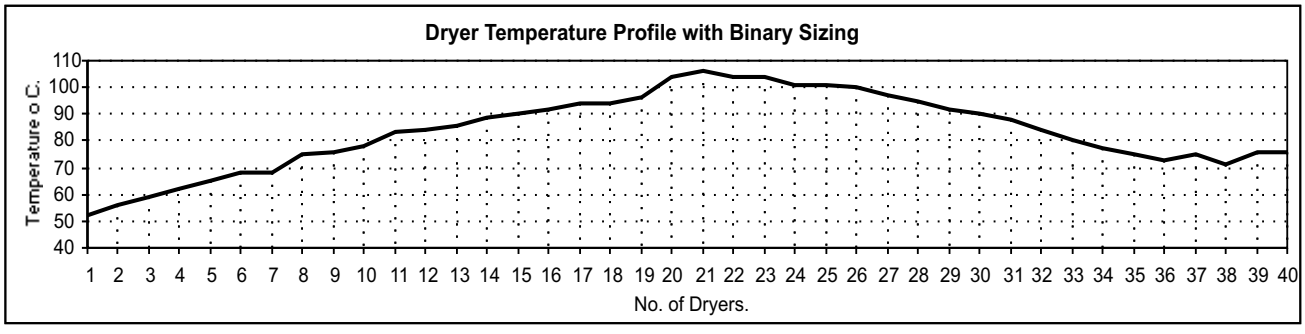

Dryer Temperature Profile with Binary Sizing
Temperature o C.
No. of Dryers.

Table No VI
PROS & CONS OF DIFFERENT SIZING METHODS

S.No	Particulars	Acid	Neutral	Cationic	Alkaline	Binary
1	Sizing Chemical	Fortified Rosin,Alum Retention aid	Dispersed rosin Non Ferric Alum Retention aid	Dispersed Rosin(Cationic) Non Ferric alum,Coagulant Retention aid	AKD,Coagulant ,Retention Aid	AKD,,ASA Coagulant ,Retention Aid
a	Cost	Low	Moderate	Moderate	High	High
b	Shelf Life(Size)	Good	Good	Good	3 months	ASA(Good) Emulsion 4 hrs
c	Dozing System	Simple	Simple	Simple	Simple	Sophisticated.
2	Quality					
a	Cobb Value	Higher	Higher	Higher	Within norms	Within norms
b	Size Development	Off Machine	Off Machine	Off Machine	After 24 hrs	After 8 hrs
c	Optical Properties	Less	Slight better	Slight better	Better	Better
d	Shade	Variation High	Less Variation	Less Variation	Uniform	Uniform
e	Physical Properties	Weaker	Slight better	Slight better	Better	Better
f	Slipperiness	Nil	Nil	Nil	High	Less Slippery
g	Deposit Problem	Not significant	Not significant	Not significant	Less Prone to deposits	Prone to deposits(if hydrolysis takes place)
h	CaCO3/Imported waste paper	Can not be used	Restricted quantity	Restricted quantity	High level can be used	High level can be used
i	Reversion of shade and strength	Maximum	less	less	Negligible	Negligible

problem was observed when the system was cationic and size consumption increased when the system was anionic. The optimum results were obtained by running the system slightly anionic i.e maintaining cationic demand of 0.08 to 0.15 Meq/L.Bagasse pulp is more anionic due to higher fine content. Cationic fixing agent is added in the Bagasse supply pulp.

Fines & Filler Retention

Bagasse pulps contain more fines than hardwood. Fines have high specific surface area than fibers means that more size is required to achieve a given degree of sizing. Size adsorbed on the fines can react and contribute to sizing.Therefore retention of fine i.e a good first pass retention is very vital for sizing . 80 -85 % FPR was found to be optimum in our case. We experienced fluff problems with high FPR values. At present sizing programs are offered in a package which normally includes three components viz. Coagulant,AKD and retention aid. Prior Screening of components of package in the laboratory with mill's furnish is necessary before going to the

plant trial.

Like fines, fillers also adsorb size significantly due to high specific surface area.AKD attached to filler does not contribute significantly but some of the size adsorbed by the filler can be redistributed to fiber surfaces. If the filler is not retained this size get lost with filler and hydrolysis of un retained size will occur ultimately leading to the deposit problems. A good first pass ash retention is must for achieving desired sizing values.

Other Factors

Other additives used at wet end like defoamers, surfactants & felt cleaners have negative effects on sizing. On the other hand fixing agents, retention aid ,Dry strength resin and Cationic starch are beneficial to the sizing, Dozing point and sequence of dozing of chemical can significantly affect the sizing and other properties of paper.OBA addition close to fixing agent results in brightness drop due to quenching. Suitable dozing points needs to be established for optimum performance by the mill.

For alkaline sizes(AKD/ASA) the role of drying is different than acid and neutral sizing, where the main function of drying is to spread and fix the rosin. Due to low melting point wax spreading of AKD is not a problem, the importance of drying section is to break the size particle and allow to react with fibre.AKD is slow to hydrolyze and react therefore it takes time to develop full sizing(up to 24 hrs). Sizing values are therefore controlled by checking the cobb values by artificial curing in oven at 105 oC for 10 minutes. Mill should obtain the correct dryer profile for individual machine to balance sizing performance and energy input.

ASA is synthesized by addition of Maleic anhydride to an alpha olefin is an amber color liquid at room temperature, not miscible with water and have very good shelf life. It has to be emulsified with cationic starch/Polymer in the ratio of 1:2 (starch)using a high shear turbine pump for using it as a sizing agent. Particle size and pH of the emulsion are very critical properties to be maintained for optimum sizing values.pH of the emulsions is maintained 3.4-3.9 with organic acid (Adipic acid) and particle size in the range of 1-3 microns. Shelf life of the emulsion is only few hrs therefore it has to be prepared at site.

We have used the AKD sizing for long time and $cobb_{60}$ values and other Paper properties were improved significantly compared to Rosin sizing, but slipperiness of Paper is matter of concern at converting and finishing sections. Also there was apprehension that due to high $cobb_{60}$ values before size press with AKD could affect the run ability of film press. We tried AKD from all leading suppliers to reduce the problem of slipperiness but results were not up to our satisfaction level. A moderate degree of sizing before film press and low wax content (AKD) on paper were required to solve this problem. Since ASA gives off machine sizing and the wet end conditions are similar to AKD sizing we decided to use both together. After establishing the conditions in the laboratory plant trial was taken. ASA Preparation and dozing system was provided by supplier.
Details of processing conditions are given in Table V.

RESULTS AND DISCUSSION

1. AKD was reduced to 5-7 kg/t & ASA consumption was 600 gm/T to achieve the same degree of sizing compare to single AKD sizing(12-14 kg/t AKD).
2. Other properties optical and physical remained same as in AKD sizing.
3. Slipperiness not observed in finishing section.
4. Film press taken into operation and run ability was good.
5. M/c Runnability was satisfactory.
6. We were able to use PCC without any significant increase in sizing chemical consumption.

Comparative results of pH Back water , FPR & FPAR , Brightness and Dryer Temperature Profile with different sizing chemicals are annexed in Graph No. II ,III and IV respectively.

Pros and Cons of different sizing methods are tabulated in Table No. VI

CONCLUSION

Better sizing values with improved optical and physical properties were obtained with alkaline sizing with Bagasse firnish. Improved Visual appeal and better print room performance is appreciated by the domestic as well as overseas customers. Shade variation almost negligible and shade stability improved. Reduction in fluff and retention of strength properties of paper after ageing are the added advantages. High cost and deposits are the limiting factors for binary sizing. Individual mill has to work out the techno-economic feasibility as per their operating conditions to choose the right sizing method.

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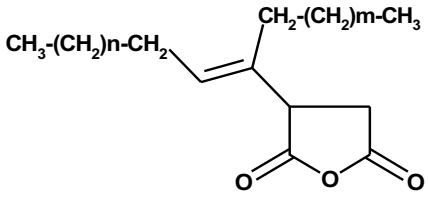
Binary Sizing(AKD + ASA)



alkenyl **s**uccinic **a**nhydride
(n = 10, 11, 12, ..
m = 0, 1, 2..)