Chemical Additives in Paper Manufacturing : Selection of Sizing Chemicals and Process Optimisation

B. Barman and A. K. Ghosh

Hindustan Paper Corpn., Nagaon Paper Mill, Kagajnagar-782413, Dist. Marigaon, Assam.

To attain market leadership, sustainability of product quality and productivity, the asking demand today is to adopt innovation in process design and to explore suitably effective chemical additives for continual improvement in product quality and process control. Use of environment friendly chemicals and recycling of waste fibre/water to reduce effluent load has become mandatory to abide by the Government regulations as well as to maintain public relation and environmental protection. This paper deals with chemical additives used in Nagaon Paper Mill, with particular focus on chemicals used in paper machine. In the recent past, The Mill has undertaken trial of a few new generation chemical additives and process technologies.

INTRODUCTION

Papermaking is a process where multifarious inputs are required to be used to produce the single product" Paper", the matrix of civilization. Varieties of fibrous raw materials collected from Plant Kingdom of the Nature comes out as paper through stages of mechanical & chemical treatments where chemicals play the major role. In the present scenario or global competition with respect to product quality, productivity and environmental consciousness, up gradation of process technology and cost effective environment friendly additives has become a concentrated concern for paper makers. To keep pace with the changing paper market and to meet the Government guidelines for environmental protection, all concern involved in paper manufacturing are putting their head together to develop ecofriendly alternative chemical additives.

To keep pace with changed circumstances, Nagaon Paper Mill, has also taken up various schemes to adopt such new generation chemical additives. Plant scale trial of bio-enzyme prebleaching, alkaline sizing, and retention aids and micro biocide programmes has been carried out with many acclaimed chemical additives procured from different suppliers. Retention aids and alkaline sizing trials were carried out in August, 2002 under the supervision and monitoring of the respective suppliers. Though marginal-variation in performance results were observed with respect to suppliers, in totality, the trials were successful with encouraging outcomes. Micro Biocide programme was taken up for trial in January- February, 2002 and bio count trend was prospective. However, for optimization of dosing and stabilization of the system, further study and trial for longer period was suggested by the suppliers. NPM management is scrutinizing its schemes for commercial use and carrying out further study on economic viability, system suitability and assimilation to other activities in other areas of the whole paper manufacturing process. Another series or trial programmes on retention aids and alkaline sizing will start shortly. We will try to discuss the behavior of some of the chemicals used in paper machine with some information on observations attained from the trial runs.

PAPER SIZING

Paper sizing with conventional gum rosin and paper maker's alum supplemented with wax emulsion was adopted at the very inception of production in Nagaon Paper' Mill and switched over to fortified rosin sizing after convincing trial run by different suppliers. Though rosin consumption during plant scale trial by the suppliers under their supervision and close monitoring was established in the range of 10 to 12 Kg/ MT of paper, it could not be maintained consistently throughout. They interpreted the high consumption due to lower pH of chlorine dioxide bleached pulp (4.5 to 5,0). Of course, alter increasing the pH to 5.5 to 6.5, rosin consumption could be reduced marginally. But, still it is not consistent through out the year.

To get optimum benefit of the chemicals, trials were taken at varied concentration of the solution with change in addition point. Out or different dilution levels, 10 to 12 gpl concentration found to give best result and out of different addition point (including reverse sizing) , rosin addition in machine chest and alum partly in machine chest and rest in fan pump gave the best result.

The consumption pattern ranges from 10 kg/MT of paper to 14 kg/MT of paper. It is observed that the

consumption in summer season is higher than in winter season. Higher rosin consumption in the months from May to August assumed to be due to increase in hardness of mill water and high ambient temperature. Fig-l shows the variation in consumption month wise in the year.

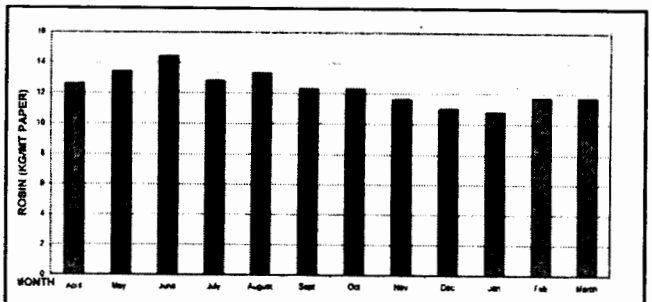

Fig. 1 Variation in rosin consumption in the year 2003-04

In view of maintaining eco friendly environment and improving quality to enter the value added paper market. Nagaon Paper Mill has taken up intensive programmes to go for alkaline sizing and plant scale trial has already been completed.

Alkaline sizing

Alkaline sizes are cellulose reactive sizes. They form co-valent bond with cellulose, which is extremely resistant to hydrolysis resulting in a hydrophobic structure, They are made compatible with paper making fibre by emulsifying with stabilizer and dispersants. Utilization of cationic stabilizer gives the emulsified particles a net positive charge, which provides an electrostatic retention mechanism similar to that of rosin size precipitate. In alkaline sizing every step must occur sequentially from retention in wet end to distribution during pressing, initial drying and final reaction during drying. The reaction of synthetic sizing agent with fibre is 'chemical' in nature and can be relatively slow compared to the essentially instantaneous ionic and polar interaction between rosin, alum and fibre. This leads to curing time, which may range from minutes to days. Though retention under proper condition is excellent, it requires some experimentation to select the optimum polymer and dosage level.[2] The optimal alkaline size addition point differs with each machine and is ultimately based on machine runnability consideration and quality improvement. In general, addition should be in the region of low shear[3].

A comparative performance report of product quality in acid sizing and alkaline sizing is given in table no- 1.

Opacity of paper increased by 2 to 4 %

$Cobb_{60}$ of alkaline sizing paper tested after preheating the sample at 105°C for 15 min.

RETENTION AID PROGRAMME

The present trend in paper making being towards lowers basis weight, higher filler level, faster machine speed and increasing trend of twin wire formers-, the filtration efficiency is getting reduced which results in lower retention on forming fabrics.[4] The two main purposes of using retention aid are:

1. To improve retention of fibre, fines, inorganic fillers and other small particles within the sheet and thereby saving costly fibre-s.

2. To improve liquid water removal or drainage during paper making operation saving energy.

Even though most of the water drained from the wire is recirculated to the wire, optimum operating standards require the "First Pass Retention" to be as high as possible.[5]

The retention aid chemical additives work in two mechanisms

i) Neutralising negative charges on fibres, fillers and other small, particles to increase the effective size of the particles in fines fraction- coagulation.

ii) Forming polymer bridges between neutralized particles and long fibre or other filler particles forming agglomerates and hold them on the sheet- Floculation.

The furnishes used for making paper develop an anionic surface charge in water as a result of dissociation of carboxylic group and sulphonic group. These raw materials include fibre, fillers and fines as well as most of the dissolved and colloidal materials liberated during pulping and bleaching process. Cations may be attached by electrostatic and absorptive forces to these surfaces. The anionic charges on the surface are partially neutralized by these cations causing the net potential energy of the system to drop rapidly in this region. Beyond the layer of firmly attached cat ions exists a second layer which contains a high concentration of cat ions attached by the zeta potential. Zeta potential is determined by the magnitude of the anionic surface charge minus the magnitude of the cationic charge in this layer of attached counter ions, These cat ions, however, are not attached to the particles. The addition of a coagulant uniformly neutralizes the charges reducing the zeta potential and coagulation occurs when zeta potential is reducing almost to zero.[4]

High molecular weight (HMW) polymeric flocculent are added to the furnish after coagulation to bridge the neutralized particles with long fibre or other filler particles. As per the suitability of the process different

Table 1. Comparative Paper Test Properties With Acid & Alkaline Sizing

Parameters	Unit	Cream Wove-54		Cream Wove-58		Cream Wove-60	
Sizing	-	Acid	Alkaline	Acid	Alkaline	Acid	Alkaline
Bulk	Cc/gm	1.28	1.28	1.39	1.25	1.28	1.27
Ash	%	14.9	14.9	14.3	16.8	16.1	14.8
Brightness	%	79.8	81.4	81.2	81.8	80.3	81.7
Opacity	%	83.2	87.4	84.5	89.0	87.0	89.4
Smoothness (Bendtsen)	Ml/min	201	239/115	237	171/129	176	222/142
No Wax Pick up No.	-	8A-9A	8A-9A	7A-9A	8A-10A	8A-10A	8A-9A
Breaking MD	Met	3087	3159	2942	2892	3063	3108
Length CD		1768	2134	1946	1972	2019	2136
Burst factor	-	13	14	15	13	13	14
Double folds	No	8/6	9/12	7/7	11/11	9/7	12/8
Tear factor	-	59/79	58/66	75/71	56/56	69/76	52/66
One Min Cobb	gsm	20.9	18.2	22.2	18.8	21.6	20.3
TS/WS		22.9	20.2	24.5	20.5	23.8	22.4

types retention aids are used.[6]

- Inorganic chemicals like alum, calcium chloride, sodium silicate etc.
- Natural organic polymers such as gums, starch, proteins, rosin acids and salt there of.
- Modified natural organic polymers such as cationic and anionic starch.
- Synthetic organic polymers such as polyacrylamides, acryl amide copolymers, polyethylineamides, polyquaternert ammonium compounds.

Application point of HMW polymer should be carefully selected. Two variables that will affect the activity of the polymers are contact time and shear rate. If HMW polymers are allowed to mix with the stock for long period or subjected to too much shear, compression can

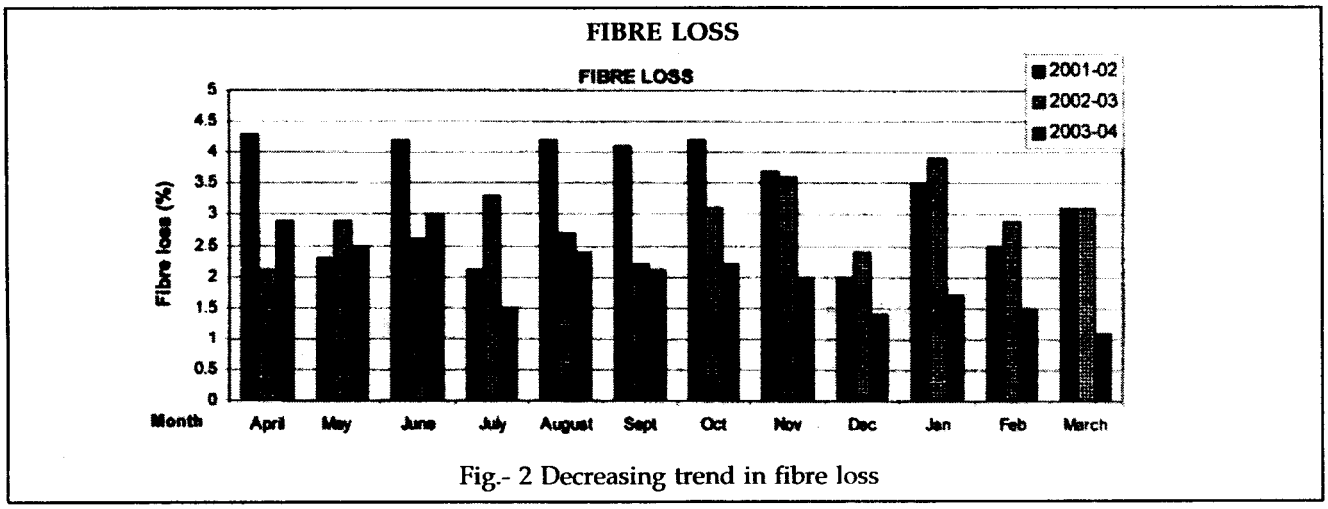

Fig.- 2 Decreasing trend in fibre loss

occur reducing adhesion and bridging with other particles. It should be added after fan pump and just prior to head box (4).

Plant scale trial of retention aid was carried out both in acid & alkaline sizing at NPM and the performance results are given in Table 2.

Before taking a plant scale trial of retention aid, it was evaluated in the laboratory for suitability & optimum dosing. To compare the result in identical condition, Machine speed, grade of paper, sampling point with its interval & other operational parameters were kept at par during the run with & without retention aid.

SLIME & DEPOSIT CONTROL

The manufacturing process with more & more recycling and close-up of process waste, which are highly contaminated with organic materials, provides a very favourable environment for microorganism habitation. Microbial growth is further encouraged by neutral operation of many processes and a chlorine free bleaching process. Formation of biological slime results from the activity of microorganism, which are characterized by their high rate of multiplication. Detachment of bioslime and biofilm deposition inside pipes and machine parts and pass over of the lumps with flowing fluids disturbs the production process and

Table-2 Comparative test results with and without refention aid

Machine speed		Mtr/min	400-550		
Avg. Ash in Paper		%	14-14.5		
Grade of Paper mfd.			CW/52, CW/54, CW/60		
			With out Ret. Aid	With Retention Aid	
				Acid Sizing	Alkaline Sizing
Duration of trial			10 days	10 days	10 days
Doses of retention aid		Gm/MT	-	250	250
Head box : Cy		%	0.66	0.58	0.56
	Ash	%	33.58	27.55	28.91
Back water	Cy	%	0.24	0.175	0.16
	Ash	%	66.25	61.42	61.19
First Pass Ret.		%	63.24	69.73	71.43
Ret. increased		%	-	9.73	12.24
First pass Ash Ret.	%	28.15	32.73	40.43	
Ret. increased		%	-	16.27	40.43
Fibre loss		%	3.30	2.73	2.61

- It has been observed from the trial that retention aid choose was more effective in alkaline sizing compared to acid sizing.
- First pass retention improved by 12% in alkaline sizing and 10%(approx) in acid sizing. Similarly ash retention increased by 40.5 in alkaline sizing as against 16% in acid sizing.
- Fibre loss reduced by 0.6-07 % there by reduces fibrous raw materials demand. Overall reduction of raw material was in between 9-11 %

results quality defects.

The age-old practice to inhabit microbial growth or to destroy microorganism was to use poisonous chemicals such as organic chlorine/bromine compounds, gluter aldehydes. Methylene bithiocyanate etc. These are highly effective, but ecologically very harmful and against legislated regulation of Govt. Considering the requirements of health, safely environmental protection and currently applicable legislation, ecologically compatible products have been developed to inhibit the

Table-3 Pre trial Bio count of paper machine stock and back water system

Trial period	09.01.2002 to 15.02.2002	39 days
Chemical. used	Maxtreat 5303 & Maxtreat	5608
Dosing point	Blending Chest & Save all	
Consumption of chemical	108 gm/MT paper	
Pre trial observation	TBC count/ml	
	First set (20.11.01)	Second set (07.01.02)
Blending chest	-	10^4
Machine chest	10^5	10^4
Broke chest	10^3–10^4	10^5
Save all feed	-	10^4–10^5
Save all filtrate	10^5–10^6	10^4–10^5

Observation during trial period

Sampling point	Date								
	11/01	15/01	18/01	22/01	26/01	01/02	05/02	09/02	11/02
Broke Chest	-	10^3	-	10^2	$< 10^2$	10^3	-	10^2	-
Machine Chest	10^2	-	10^2	-	$<10^2$	-	$<10^2$	-	<10
Back Water Silo	-	10^2	-	10^2	$<10^2$	$<10^2$	-	$<10^2$	$<10^2$
Save all feed	102	-	$<10^2$	-	$<10^2$	-	$<10^2$	-	-

microbial growth and to prevent deposit formation.[7] Green biocide such as hydrogen peroxide, paracetic acid and glutar aldehydes are degraded as it kills the microorganism and the resulting end products are harmless or causes little harm to environment. The biocide free slime control products are based on dispersants, enzymes, paraffin, modified lignin polymers, surfactants (also called bio-dispersant) or combination of these can be safely used by paper industry.[8]

To maintain a safe, clean and environment friendly paper making process, Nagaon Paper Mill has undertaken a bio-audit and carried out trials with biocide chemicals from few suppliers. Observation of one of the trial is given in Table 3.

Caustic boiling was done prior to biocide trial. System observed to be cleaner with no slime deposit on drainage elements and bio count remains almost consistent during the trial period. The suppliers suggested to carry out a trial for minimum 90 days to stabilize the system and to optimize the chemical dose.

PROCESS OPTIMISATION

Process optimization and modification, being part and parcel of paper making process in the present day context, is required to be carried out as per the demand worked out of consistent process monitoring, environmental requirement and above all the quality of the product and productivity. In Nagaon Paper Mill, with more and more close up of system and recycling of waste, there has been consistent improvement in fibre loss and specific retention of lines and fillers on paper. Fig.2, Fig.3 and Fig.4 shows the continual improvement in fibre loss and specific retention. Process optimization has also given results in reducing chemical consumption and quality improvement.

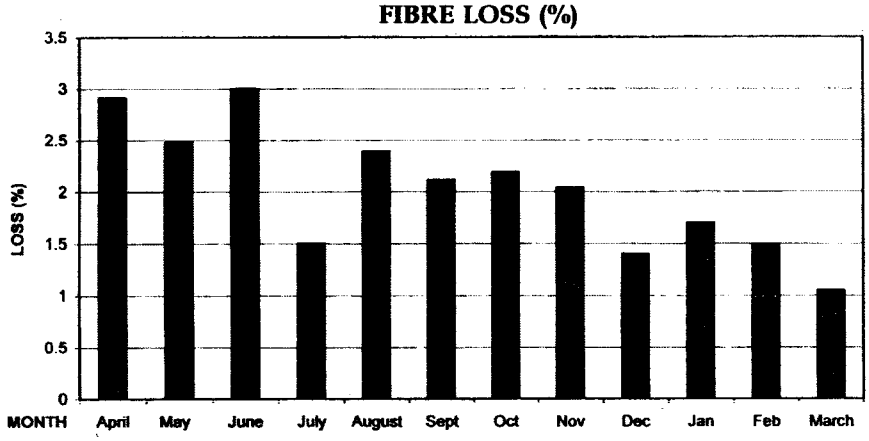

Fig.-3 Decresing trend in fibre loss in the year 2003-04

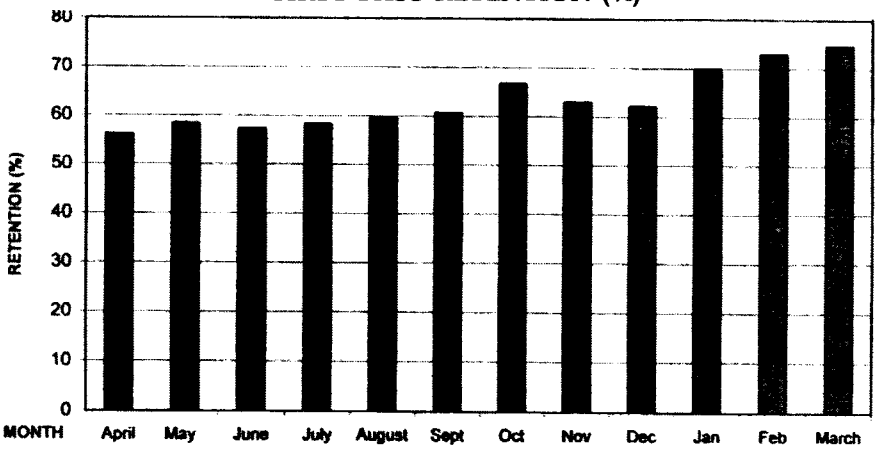

Fig.-4 Increasing trend in First Pass Retention in the year 2003-04.

CONCLUSION

In the context of present market demand and global competitiveness in quality sphere, Government legislation for environmental protection, there will be no option left but to go for new generation chemical additives, more and more recycling or process waste. A concrete joint efforts of suppliers, manufacturer and buyers end co operation of all concern in the field will only make it possible to attain our goal. The trial run carried out in Nagaon Paper Mill was very promising. Improvement in first pass retention. Ash retention and decrease in fibre loss is evident from the trial results. Slime and deposit control programme also showed encouraging results. However, further study on these aspect and optimization and suitability consideration of the system may further enhance the overall performance and improvement in machine runnability and cost control.

ACKNOWLEDGEMENT

The authors are very much grateful to the management of Nagaon Paper Mill for allowing them to present this paper in IPPTA Seminar and publish it in IPPTA journal.

REFERENCES

1. Bharati Rekha and Bharati Shashank-IPPTA J. V. 25, p. 20 (1988) (3).
2. James P Casey Pulp, Vol. III "Internal sizing"
3. Willium J. Andounian Nalco Chemi. Co. "Paper Sizing"
4. Terrence M. Gallagher - Nalco Co., Broucher.
5. Ajoy Ranka IPPTA, J. p.24 (1988)(3).
6. Pandya V. H. IPPTA, J. p.8 (1998) (3). "New chemical additives for pulp and paper industry."
7. Ina Blankenburg and Jahann Schulte IPPTA J. p. 51 (1999) (1). "An ecological Method for slime and deposit control."
8. Mariana Bjorklund, IPPTA J. p.1 (2000)(4). "Alternative to conventional biocides in pulp and paper industry."