An Experience with Adaption of Laboratory Results to Optimize AKD Sizing Parameters on a Paper Machine

Kumar P., Gautam S. K., Singh S. P. and Singh I. J.

ABSTRACT

This paper presents the results of a plant study undertaken to convert a rosin-PAC alkaline sizing system to alkyl ketene dimer (AKD) sizing system on a paper machine producing a high-quality offset printing paper. The doses of AKD and other chemicals were first optimized experimentally in the laboratory and later fine-tuned on the paper machine. The results show that at the current prices of various sizing chemicals, the AKD sizing appears to be more economical than the rosin based neutral/alkaline sizing.

INTRODUCTION

The neutral/ alkaline papermaking (pH > 6.5) has several advantages over acid (pH 4 to 5.5) papermaking (1). The paper made under neutral/alkaline conditions has a much longer usage life, and, more importantly, allows use of calcium carbonate as filler. Today, the neutral/alkaline papermaking has significant economic advantage over acid papermaking, particularly for the manufacture of white, pigmented grades of paper.

Neutral/alkaline papermaking, started in early 1970s, has experienced different growth patterns in different parts of the world. In Europe, the growth was driven mainly due to the availability of cheaper and less abrasive natural ground calcium carbonate (GCC) than the locally available clay, but in the USA, the growth began with the availability of precipitated calcium carbonate (PCC) having high brightness and low abrasivity that could be manufactured at the paper mill site (1). In India, the conversion from an acid to neutral/alkaline papermaking picked up only after the turn of the century.

There are two basic approaches in producing paper under neutral/alkaline conditions:

1. Using rosin sizing over a pH range of 6.5-7.5. The usual chemical required to fix and orient the rosin sizing on the fiber surface (mordant) is aluminum sulphate or papermaker's alum, but it works best over the pH range 4-5.5. The favorable pH range can be raised to neutral/weakly alkaline by replacing alum with some other positively charged species. The most common mordant in this category is polyaluminum chloride (PAC) that can act effectively over the pH range 5-7.5 (2-6). The other mordants having favorable pH neutral to weakly alkaline are polyethyleneimine (PEI) (7-9), linear polyamines (10), and cationic amides of low charge density (11). One gets an impression from the current research publications on rosin sizing that the use of rosin is likely to continue as sizing agent in future.

2. Using synthetic sizes alkenyl succinic anhydride (ASA) and alkyl ketene dimer (AKD) that work most efficiently over the pH range 7.5-8.2.

In Indian paper industry, AKD has found greater favor than the ASA. The ASA size reacts rapidly with cellulose while AKD size reacts relatively slowly. The AKD is available to the papermaker in ready-to-use form, while ASA has to be emulsified on site immediately before use. Also, ASA can undergo undesirable hydrolysis reactions, which lower its sizing efficiency and increases tendency to form tacky deposits on papermaking equipment.

Several retention/drainage aid systems are available for a given sizing chemical. In spite of substantial proportion of paper being manufactured under neutral/alkaline conditions and extensive research in this area (12-14), much of the knowledge available is still empirical. Many paper mills have different experiences in converting from acid papermaking to neutral/alkaline paper making (15-20). Some of the common difficulties faced in converting from acidic papermaking to neutral/alkaline papermaking are relatively more web breaks and consequent production loss, deposits on couch roll and press rolls, variation in shade of paper, reduction in sheet brightness, reduced glaze of MG papers, and slipping in finishing and converting sections.

This paper presents our experience in implementing alkaline papermaking using AKD size on a paper machine producing a high quality offset printing paper. We attempted to search for the process conditions where the problems of web breaks and deposits etc. as reported earlier could be minimized.

MATERIALS AND METHODS

Sizing experiments were conducted in the laboratory to determine the optimum pH condition and doses of AKD and other additives. The optimum conditions obtained in the laboratory were fine tuned on a paper machine.

A bleached kraft pulp of mixed hardwoods (85% Poplar, 15% Eucalyptus) prepared in an integrated pulp and paper mill was used for these experiments. The pulp with an unbleached yield of 51% and kappa number 20 was bleached in the mill to a brightness of 85% (Photo volt), using CE_pHH sequence. The bleached pulp was refined in the mill to 30^o SR. The various chemicals used in the laboratory experiments are given in Table-1.

Lab Experiments

Sizing chemicals were added to a bucket containing the refined pulp according to the sequence: ATC + AKD

* *Department of Paper Technology, I.I.T., Roorkee Saharanpur Campus, Saharanpur*

***Star Paper Mills Ltd., Saharanpur-247001*

Table-1 Chemicals used in the sizing experiments

Sizing agent	A commercial AKD emulsion with 15% solids (Ivax 750)
Retention aid	Cationic PEA (Ivax-RTN-100).
Anionic trash catcher (ATC)	Cationic Polyethylene Imine (PEI)-(Ivax Poly TC), or Cationic starch (Bharat Starch Fiber Lock T-25)
pH control chemical	The pH of the bleached pulp was 7.5±0.1. For the experiments at other pH values, ferric alum was added to reduce the pH and dilute NaOH solution was added to increase the pH.
Optical Brightening Agent (OBA)	Lamonite in liquid form (Khyati Chemical)

Table-2 Doses of various chemicals used in lab experiments

Chemicals	Range
AKD dose, on solids basis, kg/t	2.25-3.0
Dose of retention aid, g/t	100-250
Dose of ATC, g/t	500
pH	7.2-8.5

Table-3 Machine parameters prior to AKD sizing trials

Parameters	Range
Grammage, g/m^2	61-90
Machine speed, m/min	180-200
Couch Vacuum, mm Hg	330-400
Back water pH	6-6.2
Freeness of thick stock, °SR	30-33
Temperature range in the dryer, °C	50-120
Sizing chemicals	Dispersed rosin and PAC
Tinting dye	Methyl violet, 30 g/t

Table-4 Doses and dosing points of various chemicals added during plant trials

Chemicals	Dose	Dosing points
AKD (solids basis), kg/t	2.25 – 1.95	Outlet of constant Level box
ATC (as such basis), g/t	500	Machine chest
Retention aid, g/t	250 - 100	Outlet of pressure screen
OBA (as such), kg/t	3	Mixing chest
Dye (Pergasol violet), g/t	100	Mixing chest
Filler (Talc), kg/t	200-250	Mixing chest

Table-5 Economic comparison of AKD sizing with dispersed rosin sizing of the paper

	Dispersed rosin sizing			AKD sizing		
Chemical	Price, Rs/kg	Consumption kg/t	Cost (Rs/t)	Price, Rs/kg	Consumption kg/t	Cost (Rs/t)
Dispersed Rosin	31	20	620			
P.A.C	6	45	270			
Fiber lock T-25	50	2	100			
Methyl violet	130	0.03	3.9			
Antifoaming agent	175	0.1	17.5			
AKD				186	1.95	362.7
Retention aid				250	0.08	20
ATC				50	0.20	10
Bio-sides						22
Pergasol violet				330	0.100	33
Total cost			**1011.4**			**523.5**

+ Retention Aid. The ranges of doses of various chemicals used were as shown in Table-2. Standard handsheets of 60 g/m^2 were made on a British Sheet Former from the pulp mixture prepared as above according to the TAPPI T 205-SP method. The hand sheets were air dried in contact with glaze plates. The dried handsheets were evaluated for $Cobb_{60}$ (SCAN-P12) and brightness. The Cobb values were determined at least 24 hours after sheet making. Alkalinity of the stock was measured in ppm as $CaCO_3$ as per TAPPI T 620cm-83 over a pH range of 7.5-8.2. While making laboratory handsheets, the first pass ash retention (FPAR) was determined in laboratory hand sheets from ratio of ash in the sheet and the amounts of filler (soapstone) added.

Plant Experiments

A plant trial was conducted on a paper machine producing an offset printing paper. The machine parameters maintained during the normal operation (before staring the trials) of the machine are given in Table-3. The various chemicals used, their doses, and dosing points during the trials for AKD sizing are given in Table-4. The backwater pH was maintained at 7.5±0.1, and the temperature in the dyer was raised to 60-120 °C. The other machine conditions were maintained the same.

The paper made on the machine was tested for $Cobb_{60}$, brightness, yellowness, color (L, a, b), and usual strength properties following appropriate TAPPI standard methods. The sample sheets were cured in an oven at 105±2 °C for 5 minutes before testing for $Cobb_{60}$. The first pass retention of total solids (FPR) in the wire part was determined from the measurements of consistencies in the headbox (C_H) and the backwater tray (C_V):

$$FPR\,(\%) = (C_H\ \ C_V / C_H) * 100$$

Since, the possibility of slime growth is greater in alkaline papermaking than in acidic papermaking, a suitable biocide/ slimicide schedule as advised by the sizing chemical supplier was followed during the trials. Adequate slime-control chemical doses were used to maintain a stable bacteria level at less than 10^2 c.f.u. (Colony Forming Units).

RESULTS AND DISCUSSION

Laboratory Results

Fig.1 shows the effect of AKD dose and pH on the $Cobb_{60}$ values of the handsheets prepared in the lab when the doses of retention aid and ATC were

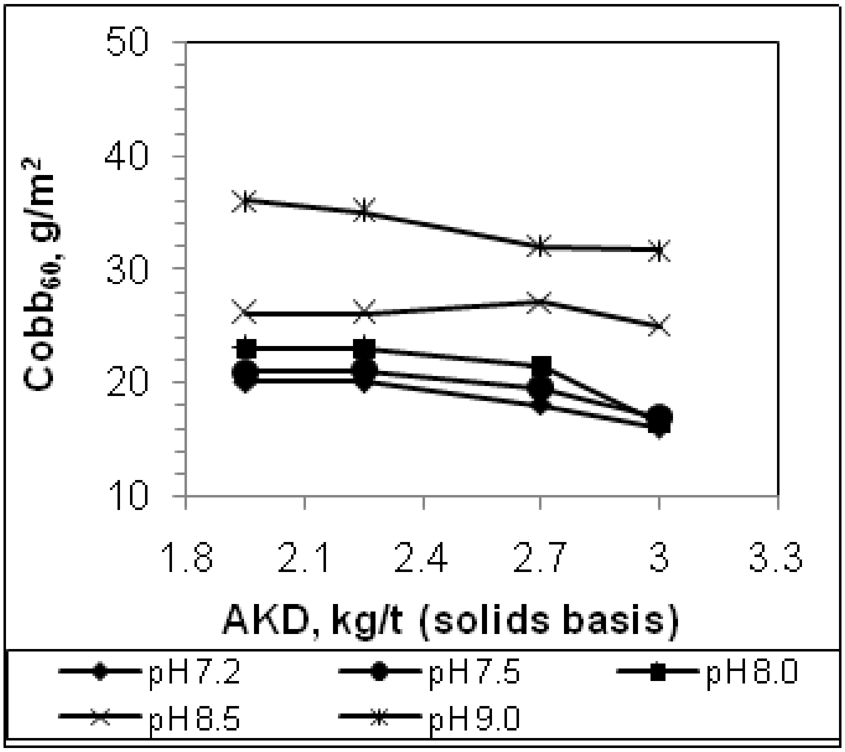

Fig.1: Effect of AKD dose and pH on sizing

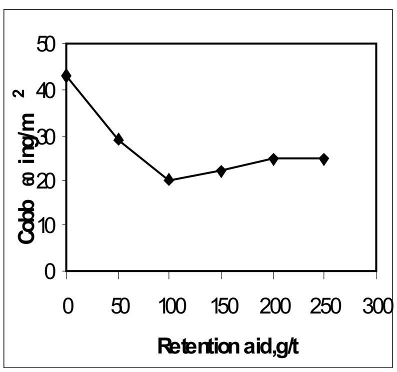

Fig. 2(a)

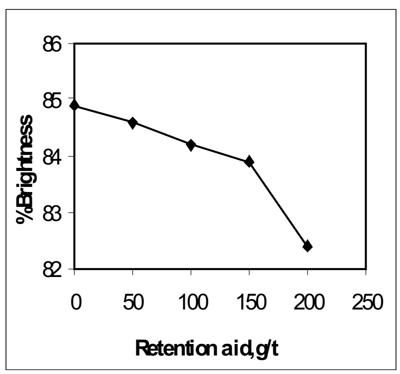

Fig. 2(b)

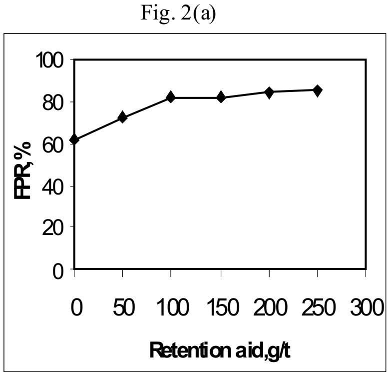

Fig. 2(c)

Fig.2: Effect of retention aid on (a) $Cobb_{60}$, (b) Brightness, (c) FPAR

kept constant at 100 g/t and 500 g/t respectively. A dose of 2.25 kg AKD per tone paper was adequate to obtain a $Cobb_{60}$ value between 21and 25 g/m^2 over a pH range of 7.2 to 8.5. Although a lower pH could be selected, a value of 7.5 was chosen for further experiments on AKD sizing because the pulp available from the bleach plant had a pH of 7.5 and there was no need of adding any chemicals to adjust the pH.

Fig.2 shows the effect of changing the dose of the retention aid on $Cobb_{60}$, brightness, and FPAR value when the dose of AKD and ATC were kept constant at 2.25 kg/t and 500 g/t respectively, and the pH was maintained at 7.5.

The cobb60 value was the lowest for a retention aid dose 0f 100 g/t. However, the Brightness of the sheets was aximum when no retention aid was used and decreased with increasing retention aid dose. The first pass ash retention (FPAR) value increased with increasing dose of the retention aid and attained a steady value of about 82% for retention aid dose of 100 g/t or more.

Fig.3 shows that for a given dose of sizing aid, the cobb60 value increases with increasing alkalinity. The optimum alkalinity range appears to be 150-250 ppm as $CaCO_3$.

Plant Results

In the beginning of the plant run, the doses of AKD, retention aid, and ATC were maintained at the levels optimized through lab experiments and as shown in Table-4. We observed that lower levels of all these chemicals could be used on the paper machine than required in the laboratory sheet former to achieve the acceptable range of $Cobb_{60}$ values. This was possible largely because of partial closure of the backwater on the paper machine, while the backwater was not recycled on the laboratory sheet former.

A $Cobb_{60}$ value of 22 g/m^2 could be achieved with the addition of 1.95 kg/t AKD, 80 g/t retention aid, and 200 g/t ATC. The FPR under these conditions was 83.5%. Alkalinity of backwater was 170 ppm as $CaCO_3$ with soapstone used as filler at the pH range 7.5±0.1. The brightness was 84.7 °PV. When the AKD dose was reduced to 1.8 kg/t, the Cobb value increased to 25 g/m^2.

For retention aid doses that gave FPR value greater than 83.5%, a coating of fine particles on the lump braker roll and the press rolls was observed. This coating caused frequent web-breaks and the consequent loss of production. Fig.4 shows that under the conditions chosen for the AKD sizing, the use of antifoaming agent (Afranil water based

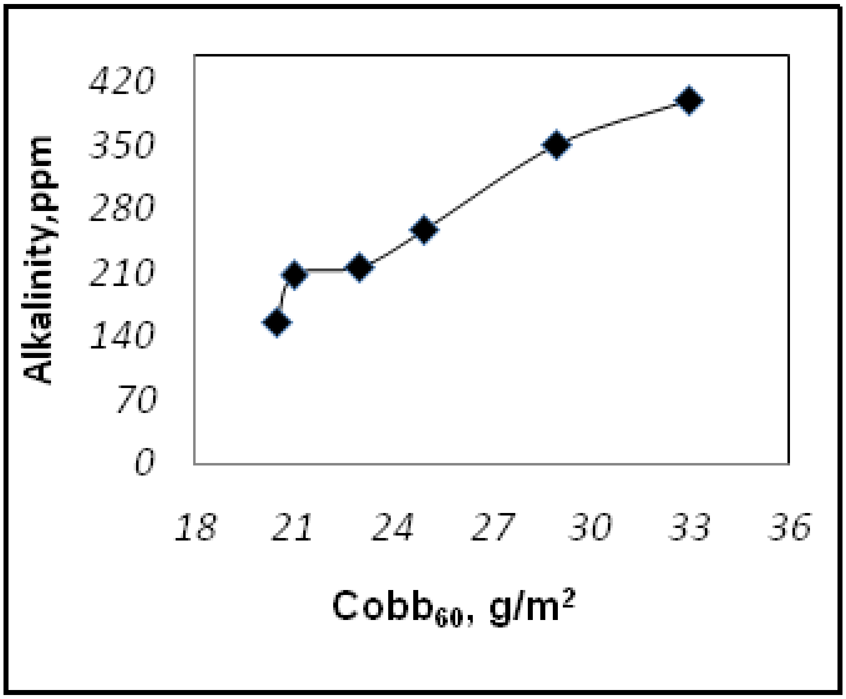

Fig.3: Effect of alkalinity on the $Cobb_{60}$ values of hand sheets.

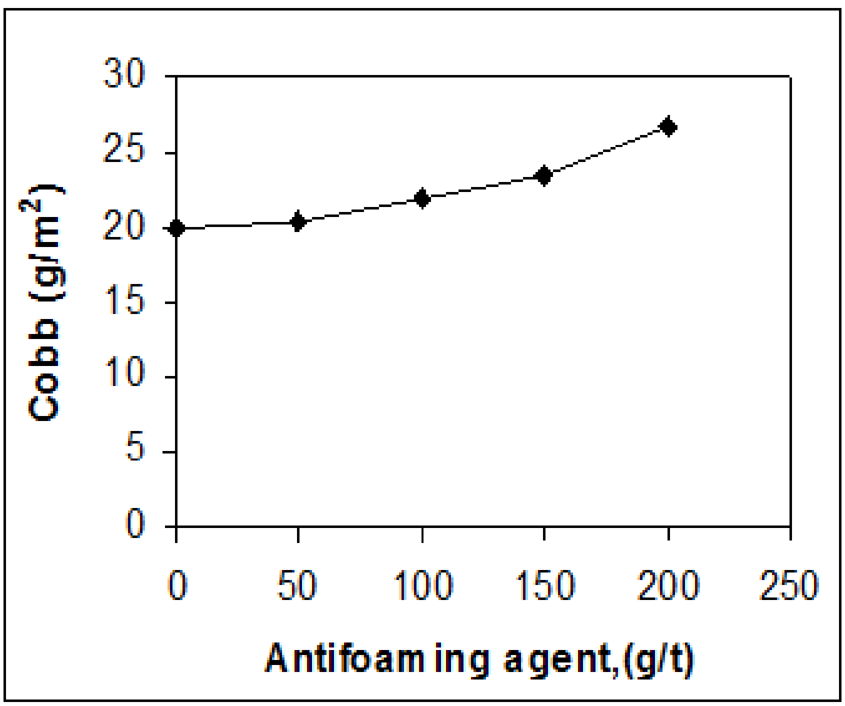

Fig.4: Effect of antifoaming agent on $Cobb_{60}$

from Clarient) could be completely eliminated.

When the plant was operating with dispersed rosin-PAC sizing, the tinting dye used in the offset printing grade was methyl violet. When the same dye was used for tinting during sizing with AKD, there were complaints from the customers that the shade of the paper was not stable with time. An acceptable shade of paper could be obtained by replacing the basic dye - methyl violet by a direct dye - pergasol violet.

Table-5 shows a comparison of the costs of neutral/alkaline sizing using AKD and dispersed rosin as the sizing agents based on the approximate market prices. In addition, the consumption of whitening agent was reduced by 1 kg/t (Rs. 42/t) in the case of AKD sizing for maintaining the same brightness as with dispersed rosin sizing. Clearly, the cost of sizing with AKD is much less than the cost of sizing with dispersed rosin.

CONCLUSIONS

Optimum doses and conditions for AKD based alkaline sizing system for a paper machine producing offset printing paper from bleached kraft mixed hardwood pulp have been determined. Some of the AKD sizing related problems such as excessive web breaks, deposits on the paper machine components, and shade variation could be successfully resolved. At the current prices of various chemicals, the AKD based sizing is more economical than the dispersed rosin-PAC based alkaline sizing.

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