# Neutral Sizing Of Bagasse Furnish - A Laboratory Study

Paul S.K., Jayasayee V., Balasubramanian S., Kasi Viswanathan K.S., Gopalaratnam N.

ABSTRACT

*Conventionally paper is sized with rosin and alum. Alum reacts with rosin to form a complex hydrophobic compound, aluminium resinate, which is precipitated on the paper fiber rendering it water repellent. This method of sizing is most effective below a pH of 5. While sizing in the acidic medium has many advantages, it has some inherent disadvantages like corrosion of wet end parts of machine, increased dissolved solids in back water and creating a favourable environment for slime growth. This can be avoided by switching over to neutral sizing with rosin. The economics of neutral sizing and its effectiveness depends on how well the sheet retains filler, starch and rosin. Retention of these can be considerably improved by using a synthetic polymer retention aid.*

*Several studies have been made on neutral sizing on softwood and hardwood pulp. Some Indian mills have adopted neutral sizing on softwood and hardwood pulp mixture. But not much study, however, has been made with bagasse furnish. Laboratory study on neutral sizing of bagasse furnish was made in Seshasayee Paper and Boards. This article describes the results of such studies.*

## INTRODUCTION

The sizing of paper pulp with rosin and alum is a colloid-chemical process, by which the fibers are covered with a more or less continuous film of water-repellent precipitated rosin. The action of rosin sizing depends upon physico-chemical laws of surface tensions, among which the adhesion tension is the predominant factor. The rosin sizing of a paper becomes fully effective, when the adhesion tension can be reduced practically to zero, which is the case when water is brought in contact with sized paper.

The degree of sizing increases with the amount of aluminium adsorbed then it remains almost constant even with further increase of the adsorbed aluminium. Better sizing results can be obtained with pulps containing adsorbed salts of aluminium hydroxide, probably because of the lower degree of dispersion of the later (1).

In rosin-alum sizing, alum fulfills three critical functions when used with soluble rosin soap size:

(i) it provides the acid condition for aluminium ions to precipitate the size,

(ii) it gives the precipitate a positive charge that attracts it to the negatively charged fiber surface, and

(iii) during drying, the aluminium anchors the hydrophobic portion of the size on to the outer surface of the fiber.

**Seshasayee Paper and Boards Ltd,**
**ERODE- 638 007 (T.N.)**

## ACID SIZING

Acid fixation of rosin size (at pH 4-4.5) is common paper mill practice; however, the excess alum destroys the sizing affect. In acid sizing, the degree of sizing is achieved mainly by adjustment of the level of rosin added and the pH at wet end by proper addition of alum.

Though, acid sizing has some advantages like easy handling and use of low cost alum, it brings with it following disadvantages:

- it functions at narow pH range for sizing
- corrosion of wet end parts of paper machine
- formation of weaker final sheet
- yellowing tendency of paper on ageing
- concentration of sulphate ion in the system acts as breeding ground for corrosive bacteria and slime.
- increases suspended solids in the white water system.

## NEUTRAL SIZING

In neutral environment, the concentration of hydrogen ion will reduce and the tendency to neutralise the fiber will also be less, resulting in a more anionic fiber which will have greater attractive force towards the cationic size precipitate, and hence the efficiency of size precipitation and size fixing into a sheet of paper improves. Moreover, the neutrality of the size will also promote the durability of paper, reduce machine-wire wear and will be less corrosive. An effective rosin sizing at neutral pH has two components: a dispersed rosin/fortified dispersed rosin that is stable and chemically reactive at about pH 7.0 and an aluminium source with sufficient cationic charge for bonding the fortified dispersed rosin to the fiber (2). Neutral rosin sizing requires the help of a polynuclear retention aid which promote reaction between aluminium and dispersed rosin size and which also helps in better retention of size, fillers and fines.

The dispersed rosin contains about 90% unsaponified rosin dispersed in small amount of rosin soap and is stabilized by the addition of about 2% casein on the weight of rosin. A finished rosin dispersion of about 45% solids is obtained with an average particle size of about 1 micron. This type of rosin is manufactured from paste rosin size that contains 12-20 percent free rosin, which is subsequently converted to a size of 75-100% free rosin content by the addition of acidic materials (3). The particle size of this rosin depends largely on the temperature used in preparing the size.

The fortified dispersed rosin is manufactured from the gum rosin first by fortifying it with maleic/fumeric acids and subsequently by dispersing it. These types of rosin can be used in a wide pH range of 4.0 to 7.0. Owing to the large particle size than rosin soap, they have low degree of ionisation and much smaller surface area. This results in less consumption of alum and better retention. It has several advantages like, less corrosion if used at high pH, easy handling and reverse sizing is possible with it. It has one disadvantage that it is sensitive to temperature and hard water.

Poly Aluminium Chloride (PAC) has emerged as the primary polynuclear chemical for neutral sizing. Poly aluminium chloride used as neutral size bonding agent and as drainage and retention aid (4). It is amber coloured, clear to-slightly turbid aqueous solution. Hydroxylic groups of poly aluminium chloride give rise to polynuclear complexes by means of co-ordinating bonds with aluminium atoms. On hydrolysis, PAC produces high molecular weight and a large number of positive electric charge which is able to interact with the cellulose fibers and size, optimising sizing and retention of fibers.

The presence of preformed chains, part of them already hydrolysed, makes floc formation easier (5). Other benefits can be obtained by using PAC in the wet end are:

(i) It can be used at neutral or at slightly alkaline pH, because it maintains its high cationic charge into the alkaline pH range and does not form insoluble aluminium hydroxide as quickly as alum at low pH.

(ii) Since PAC is prehydrolysed, it does not withdraw hydroxyl ions from the paper making system and therefore does not depress system pH to the same degree as alum.

Poly Aluminium Chloride has the general formula:

$$(Al)_n (OH)_m (Cl)_{3n-m}$$

Where 'm' is determined by the degree of neutralisation when hydroxyl ions are substituted for some of the chloride ions. The degree of polymerisation depends on several variables, mainly hydroxyl ion concentration. For this reason, PAC is characterised by either the ratio of Al to Cl or by percent basicity (degree of neutralisation).

## EXPERIMENTAL

Laboratory studies were carried out at different phases on neutral sizing, to optimise the dosages of fortified dispersed rosin and polyaluminium chloride in the bagasse furnish for obtaining target cobb value of 24+/-1 gsm. At the same time, various paper qualities and the cost aspects of neutral sizing over acid sizing were studied.

For all phases of study, a blend fiber furnish of 80% bleached bagasse and 20% bleached hardwood pulp was used. Refined bleached hardwood pulp (36' SR) and unrefined bleached bagasse pulp (30' SR) were collected separately from the stock preparation end. Both the pulps were blended in the laboratory. To the blended pulp for each set of experiment, constant quantities of filler, dyes optical brightening agent and amphoteric starch, in that order., were added. After addition of all chemicals dispersed or fortified dispersed rosin was added and the stock was throughly mixed. pH of final stock was maintained as per requirements either by addition of dilute polyaluminium chloride or alum solution. For each set of experiment, after addition of all chemicals and maintaining required pH, 60 gsm handsheets were made, air dried, cured at 103 +/- 2~C for 5 minutes and tested for cobb and other strength properties.

## PHASE-I

In this phase of study, combination of dispersed rosin and Poly Aluminium Chloride was used for all trials. Experiments were carried out by varying the percentage of rosin at 1.8%, 2.0% 2.2% and PAC at 1.2%, 1.4%, and at different pH level of 6.0, 6.5 and 7.0 in order to obtain target cobb of 25 +/-1 gsm. Test results are tabulated in **Table-1.**

After dosing of rosin and PAC at optimised pH level, experiments were conducted at those optimum doses to confirm the results for cobb and strength properties. The results obtained by conventional acid sizing (rosin-1.1% and alum 3.2%) was also taken for comparision purpose.

Test results of this set of experiments are presented in **Table-2.**

Sizing experiments were also carried out in combination of dispersed rosin and iron free alum at 4.5 and 6.0 pH at the rosin dosage of 2.2%. The results are tabulated in **Table-3.**

## OBSERVATIONS

- The target cobb value of 25+/-1 gsm could not be achieved at pH level of 6.0 and 7.0 at all dosages of dispersed rosin and PAC.
- However, cobb value of 26-27 gsm could be achieved at a pH of 6.5 at a dosage of rosin of 2.2% and PAC of 1.2% (Table-1)
- Repeatability in cobb value was achieved in neutral sizing at a pH level of 6.5 with 2.2% of dispersed rosin and 1.2% of PAC (Table-2).
- Target cobb value could not be obtained by combining dispersed rosin and papermaker's alum even at 4.5 pH may be due to the insufficient amount of aluminium molecule (Table-3).
- Ash content of handsheet increased by about 1.0% in neutral sizing compared to acid sizing (Table-2).Though, ash percentage in netural sized paper increased by 1.0%, the strength properties of both type sized paper are well comparable.
- Opacity of neutral sized paper is about one unit higher than the acid sized paper may be due to high retention of ash, fines and filler.

**Table-1**

**Results of cobb at different percentages of PAC and dispersed rosin at different pH levels At 6.0 pH**

| Particulars | Units | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| Dispersed rosin | % | 1.8 | 1.8 | 2.0 | 2.0 | 2.2 | 2.2 |
| PAC | % | 1.2 | 1.4 | 1.2 | 1.4 | 1.2 | 1.4 |
| Cobb | gsm | 47 | 31 | 33 | 33 | 31 | 33 |

**At 6.5 pH**

| Particulars | Units | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| Dispersed rosin | % | 1.8 | 1.8 | 2.0 | 2.0 | 2.2 | 2.2 |
| PAC | % | 1.2 | 1.4 | 1.2 | 1.4 | 1.2 | 1.4 |
| Cobb | gsm | 54 | 33 | 35 | 34 | 26 | 27 |

**At 7.0 pH**

| Particulars | Units | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| Dispersed rosin | % | 1.8 | 1.8 | 2.0 | 2.0 | 2.2 | 2.2 |
| PAC | % | 1.2 | 1.4 | 1.2 | 1.4 | 1.2 | 1.4 |
| Cobb | gsm | 65 | 36 | 39 | 35 | 30 | 30 |

**Table-2**

**Test results of trials with PAC & dispersed rosin at 6.5 pH**

| Particulars | Units | Control | Trial-1 | Trial-2 | Trial-3 |
|---|---|---|---|---|---|
| Dispersed rosin | % | NIL | 2.2 | 2.2 | 2.2 |
| PAC | % | NIL | 1.2 | 1.2 | 1.2 |
| Cobb | gsm | 26 | 25 | 25 | 26 |
| Brightness in Technibrite (TB) | % | 77.2 | 77.2 | 77 | 77 |
| Opacity | % | 88 | 89 | 89 | 89 |
| Post color number | - | 4.57 | 4.34 | 4.26 | 4.37 |
| Burst factor | - | 26 | 27 | 27 | 26 |
| Tear factor | - | 47 | 48 | 46 | 48 |
| Breaking length | m | 4100 | 4100 | 3900 | 4000 |
| Ash content | % | 10.1 | 11.1 | 11.3 | 11.1 |

**Table-3**

**Test results with dispersed rosin and alum**

| Particulars | Units | Control | Dispersed rosin+Alum AT pH 4.5 | Dispersed rosin+Alum AT pH 6.5 |
|---|---|---|---|---|
| Cobb (F/B) | gsm | 25/26 | 36/40 | 56/60 |
| Brightness in Technibrite | (TB) % | 74.3 | 74.2 | 74.1 |
| Opacity | % | 87 | 89 | 88 |
| Ash content | % | 8.8 | 9.6 | 9.3 |

## COST ANALYSIS

**Basis: Cost of chemicals** **Cost/t**

(a) Dispersed rosin Rs. 39,000

(b) PAC Rs. 12,000/-

(c) Starch (amphotoric) Rs. 28,000/-

(d) Alum Rs. 4,440/-

(e) Fortified rosin Rs. 29,000/-

### (I) NEUTRAL SIZING:

| | | **Per ton of paper** |
|---|---|---|
| Cost of dispersed rosin (dose :2.2% on O.D. paper) | : | Rs. 858/- |
| Cost of PAC (dose :1.2% on O.D. paper) | : | Rs. 144/- |
| Cost of Starch (dose: 0.5% on O.D. paper) | : | Rs. 130/- |
| Total | : | Rs. 1132/- |

### (II) ACID SIZING:

| | | **Per ton of paper** |
|---|---|---|
| Cost of fortified rosin (dose : 1.1% on paper) | : | Rs. 319/- |
| Cost of alum (dose : 3.2% on paper) | : | Rs. 142/- |
| Total | : | Rs. 461/- |

Additional cost for neutral sizing over acid sizing : Rs. (1132-461)
= Rs. 671/- per ton of paper

## PHASE-II

In this phase, the neutral sizing experiments were carried out in combination of fortified dispersed rosin (FDR) with PAC and fortified dispersed rosin with iron free alum. In this phase of study, retention aid was also added at a dose of 300 ppm in addition to other chemicals as per the recommendation of rosin supplier. First, the experiments were carried out to achieve the target cobb value of 25+/- 1 gsm by varying the dosage of fortified dispersed rosin at the levels of 1.8%, 2.0% and 2.2%. PAC and alum were dosed to maintain the target pH of pulp slurry at the levels of 6.0, 6.5 and 7.0.

The results are presented in **Table 4 and 5** for PAC and alum separately. Though the target cobb value could be obtained at the PAC dose of 0.7% and alum dose of 1.04% at pH of 6.5 and at rosin dose of 2.2%, further set of experiments were carried out with the combination of dispersed fortified rosin and alum in order to reduce the cost.

Attempts were also made, to avoid the use of amphotoric starch to see how strength properties of paper were affected. The results are tabulated in **Table-6.** As no difference in strength properties were noticed by avoiding the use of starch, further experiments were carried out without starch addition. At the optimum dose of alum and rosin as

**Table-4**

**Results of cobb at different percentages of fortified dispersed rosin & PAC at various pH levels**

| Particulars | Units | At 6.0 PH | | | At 6.5 pH | | | At 7.0 pH | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| Fortified dispersed rosin | % | 1.8 | 2.0 | 2.2 | 1.8 | 2.0 | 2.2 | 1.8 | 2.0 | 2.2 |
| PAC | % | 1.14 | 1.12 | 1.1 | 0.75 | 0.72 | 0.70 | 0.46 | 0.43 | 0.38 |
| Cobb | gsm | 44 | 36 | 26 | 48 | 35 | 25 | 54 | 42 | 33 |

**Table-5**

**Results of cobb at different percentages of fortified dispersed rosin & alum at various pH levels**

| Particulars | Units | At 6.0 PH | | | At 6.5 pH | | | At 7.0 pH | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| Fortified dispersed rosin | % | 1.8 | 2.0 | 2.2 | 1.8 | 2.0 | 2.2 | 1.8 | 2.0 | 2.2 |
| Alum | % | 1.15 | 1.1 | 1.04 | 0.78 | 0.74 | 0.68 | 0.54 | 0.50 | 0.48 |
| Cobb | gsm | 41 | 36 | 25 | 43 | 34 | 27 | 65 | 45 | 36 |

**Table-6**

**Test results on effectiveness of starch (with FDR & alum at 6.0 pH)**

| Particulars | Units | Control | with starch | without starch |
|---|---|---|---|---|
| Fortified dispersed rosin | % | NIL | 2.2 | 2.2 |
| Alum | % | 3.2 | 1.04 | 1.04 |
| Cobb | gsm | 25 | 25 | 26 |
| Brightness in Technibrite (TB) | % | 74.0 | 74.2 | 74.7 |
| Opacity | % | 91 | 93 | 92 |
| Post color number | - | 4.6 | 4.4 | 4.3 |
| Burst factor | - | 25 | 27 | 26 |
| Tear factor | - | 47 | 45 | 46 |
| Breaking length | m | 4200 | 4300 | 4300 |
| Ash content | % | 11.9 | 13.0 | 12.6 |

| Table-7 | | | | | |
|---|---|---|---|---|---|
| **Test results of trials with alum & fortified dispersed rosin at 6.0 pH** | | | | | |
| **Particulars** | **Units.** | **Control** | **Trial-1** | **Trial-2** | **Trial-3** |
| Fortified dispersed rosin | % | NIL | 2.2 | 2.2 | 2.2 |
| Alum | % | 3.2 | 1.04 | 1.04 | 1.04 |
| Cobb | gsm | 26 | 25 | 25 | 26 |
| Brightness in Technibrite (TB) | % | 74.0 | 74.7 | 74.3 | 74.5 |
| Opacity | % | 91 | 92 | 93 | 92 |
| Post color number | - | 4.6 | 4.3 | 4.4 | 4.3 |
| Burst factor | - | 25 | 26 | 27 | 26 |
| Tear factor | - | 47 | 46 | 46 | 45 |
| Breaking length | m | 4200 | 4300 | 4100 | 4000 |
| Ash content | % | 11.9 | 13.0 | 12.9 | 13.0 |

mentioned above, further experiments were done for determining cobb and strength properties of handsheets. Test results of the same including conventional acid sizing are tabulated in **Table-7.**

## OBSERVATIONS:

The target cobb value of 25+/-1 gsm could be achieved in both the combination of FDR and PAC at 6.5 pH and FDR and alum at 6.0 pH and at the rosin dose of 2.2%. The optimum dose of PAC and alum are 0.7% and 1.04% respectively. The optimised dose of rosin and alum was confirmed by obtaining similar cobb value in several set of experiments.

As in phase-I study, in this phase study also the ash content of paper is increased by about 1% compared to control. Even with the increase of ash content in paper, the strength properties of neutral sized paper is well comparable with that of acid sized paper (Table-6).

From **Table-7**, it can be seen that, addition of starch can be avoided by adding retention aid in neutral sizing process without sacrificing strength properties of sheet.

**Cost analysis:**

| **Basis : Cost of chemicals** | **Cost/t** |
|---|---|
| (a) Fortified dispersed rosin | Rs. 29,000/- |
| (b) PAC | Rs. 12,000 |
| (c) Retention aid | Rs. 220/- (per kg) |
| (d) Alum | Rs. 4,440/- |
| (e) Fortified rosin | Rs. 29,000/- |

**(I) Neutral sizing:**

| | **Per ton of paper With PAC** | **With alum** |
|---|---|---|
| - Cost of fortified dispersed rosin (dose : 2.2% on O.D. paper) | : Rs. 638/- | Rs. 638/- |
| - Cost of PAC (0.7% dose on O.D. paper) | : Rs. 84/- | |
| - Cost of alum (1.04% dose on O.D paper) | : Rs. | 47/- |
| - Cost of retnetion aid (300 g/t dose) | Rs. 66/- | 66/- |
| Total | : Rs. 788/- | Rs.751/- |

**(II) Acid sizing:**

| | Per ton of paper |
|---|---|
| - Cost of fortified rosin (dose : 1.1% on paper) | : Rs. 319/- |
| - Cost of alum (dose: 3.2% on paper) | : Rs. 142/- |
| Total | = Rs. 461/- |

Additional cost for neutral sizing over acid sizing : Rs. (751-461)

: Rs. 290/-

**CONCLUSIONS:**

- Response of neutral sizing for bagasse furnish is positive.

- In the bagasse furnish the optimum dosages of neutral sizing chemicals as per the studies are as below:

| | Dispersed rosin with PAC (%) | Fortified dispersed rosin with PAC (%) | Fortified dispersed rosin with alum (%) |
|---|---|---|---|
| Rosin: | 2.2 | 2.2 | 2.2 |
| PAC/alum | 1.2 | 0.7 | 1.04 |

- From economic point of view, combination of fortified dispersed rosin and iron-free alum is the best combination for neutral sizing of bagasse furnish.

- By switching over to neutral sizing from conventional acid sizing about 1.0% of fiber can be saved by better retention of ash in paper.

- Neutral sizing increases the cost of sizing by nearly Rs. 290/- per ton of paper over acid sizing.

**REFERENCES**


1. "Generalised rosin soap sizing with co-ordinating elements" by Subramangyam, & Biermann, C.J. TAPPI 75(3): 223 (1992).
2. "Neutral sizing system allows fast, easy conversion for acid machines" by Brian Herner, Pulp & Paper, January 1990.
3. "Pulp and Paper Chemistry & Chemical Technology" by Casey J.P., Vol. III.
4. "Bonding with Polyaluminium chloride makes neutral rosin sizing possible" by Barbara Wortley Pulp & Paper, November 1990.
5. "Recent trends in the use of chemicals and additives in stock preparation" by Subhash Maheshwari & etal., IPPTA Vol.6, No.4, December 1994.