

# Alkaline sizing (AKD) with GCC filler: Our experience

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## ABSTRACT

To sustain in the competitive market, it is inevitable to up-date the quality of product on a continual basis. We have made an attempt to switch over from neutral size to synthetic or cellulose-reactive sizing agents such as AKD (Alkyl Ketene Dimer) with the use of GCC filler. In this regard, we have carried out laboratory studies on alkaline sizing with the use of AKD from three different suppliers along with their retention aid and fixing agent. AKD samples were evaluated in laboratory with soapstone and GCC. With varying dosage of AKD (1.0%, 1.2%, 1.5% as such basis), laboratory handsheets were made and tested for Cobb value. Based upon laboratory studies, the most effective AKD was selected for the plant trial. A full-scale mill trial was conducted on the Fourdrinier paper machine of 120m/min speed manufacturing superior grade of paper i.e. Royal Executive Bond to validate laboratory study. Alkaline sized paper could be manufactured, however, the optimization of these chemical to reduce sizing cost could not be made due to limitation in the process. This paper deals with the mill experiences of AKD sizing, using GCC filler.

## INTRODUCTION

Sizing is an application of a chemical to paper which reduces its free surface energy. Basically internal sizing can be categorized based on the pH of the sizing operation [figure 1].

Reduction of paper's free surface energy increases the hydrophobicity (water hating, repellency) of paper. Sizing is done either to limit the pick up at the size press and coaters or to render the final product water, ink and other aqueous liquids resistant. The sizing agents control the penetration of liquid. The Liquid can penetrate paper in two ways. The inter fiber penetration is fluids penetration through the pore or spaces between the paper fibers and intra fiber penetration is fluid penetration through the fibers themselves. In order to effect in this function, the molecules of the sizing agent must be well distributed throughout the paper structure and firmly anchored to the fiber structure. Also the sizing process must be controllable.

## Basic Sizing Mechanism

The general requirements of good internal sizing agents are as follows.

**Distribution:** Distribution of size in high shear areas of paper making furnish.

- Dilution water is good for wet end size.

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- High shear addition points preferred such as post stock pump.

**Attachment:** Attachment of size chemicals to the fiber (all size attach in the same manner, that is cationised portion attaches to fiber leaving hydrophobic end of size molecule facing away).

**Retention:** Retention of size in sheet to maximize sizing efficiency.

**Spreading:** Heat during drying melts the size particles, causing them to "spread" over the fibers. Even distribution at the wet end ensures coverage throughout the sheet.

## AKD Sizing

AKD (Alkyl Ketene Dimer) is a neutral charged molecule (wax) that is synthetically derived from animal or vegetable fatty acids. AKD required categorization prior to use cationising agent such as starch or polymer, therefore AKD is self-retaining.

## EXPERIMENTAL APPROACH

A laboratory scale study was conducted on bleached chemical pulp (Hardwood + Bamboo) using AKD with the following fillers

- Soap Stone powder
- GCC (Ground Calcium Carbonate)

The final bleached pulp was collected from bleached decker after centricleaner. The pulp has the furnish of 20% Bamboo and 80% Hardwood (Eucalyptus 15% & poplar 65%).

We have studied three different AKD from three different suppliers with their retention aid and fixing aid in the laboratory to select the effective one for process trial.

Bleached pulp was beaten in a valley beater to a freeness level of 28 °SR for all the sizing experiments. AKD and other chemicals like retention aid and fixing aid were added in the

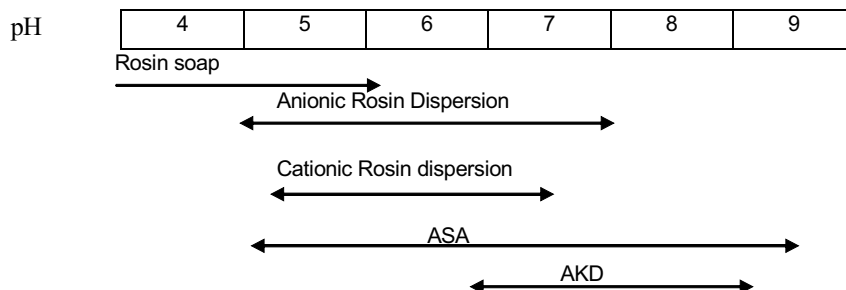


Figure 1. Working pH range with different sizing chemicals

### AKD reaction with cellulose and filler

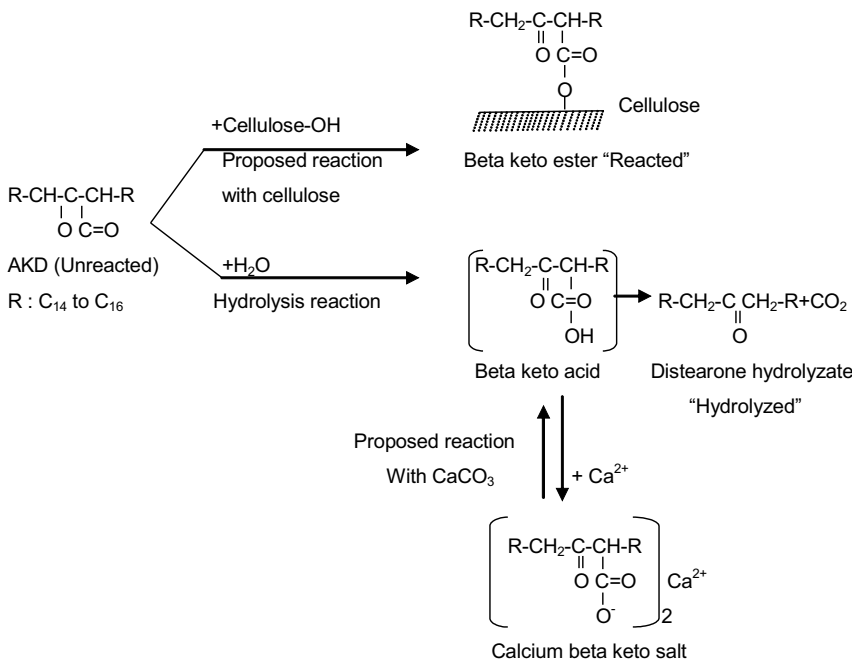


Table 1. Use of Soapstone power

Parameters	AKD-1			AKD-2			AKD-3		
<b>Chemical addition</b>									
Pulp (28 °SR), gm	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Soapstone, %	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
AKD, %	1.0	1.2	1.5	1.0	1.2	1.5	1.0	1.2	1.5
Retention Aid, g/MT	200	200	200	200	200	200	200	200	200
Fixing Aid, g/MT	500	500	500	500	500	500	500	500	500
Cationic Starch, %	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Final pH	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
<b>Hand sheet property</b>									
GSM, g/m <sup>2</sup>	62.5	63.0	62.5	61.8	62.0	60.5	62.1	61.8	62.5
Cobb value, g/m <sup>2</sup> Top	20.0	19.6	18.6	20.6	19.2	19.0	20.2	18.8	15.2
Wire	22.2	20.0	19.4	22.0	20.4	20.2	21.4	19.5	16.7

Table 2. Use of GCC (Ground Calcium Carbonate)

Parameters	AKD-1			AKD-2			AKD-3		
<b>Chemical addition</b>									
Pulp (28 °SR), g	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
GCC, %	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
AKD, %	1.0	1.2	1.5	1.0	1.2	1.5	1.0	1.2	1.5
Retention Aid, g/MT	200	200	200	200	200	200	200	200	200
Fixing Aid, g/MT	500	500	500	500	500	500	500	500	500
Cationic Starch, %	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Final pH	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
<b>Hand sheet property</b>									
GSM, g/m <sup>2</sup>	61.5	62.0	62.0	62.5	61.8	62.2	61.2	61.5	62
Cobb value, g/m <sup>2</sup> Top	24.5	20.7	19.8	23.3	21.3	20.0	22.2	20.2	19.3
Wire	27.0	23.5	22.7	25.0	23.0	22.0	23.9	22.0	20.2

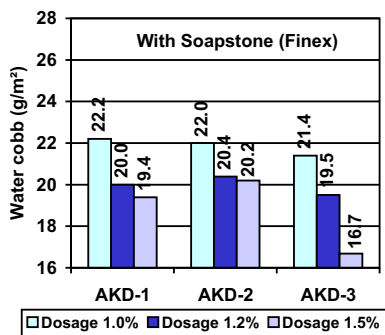


Figure 2. Cobb values with Soapstone

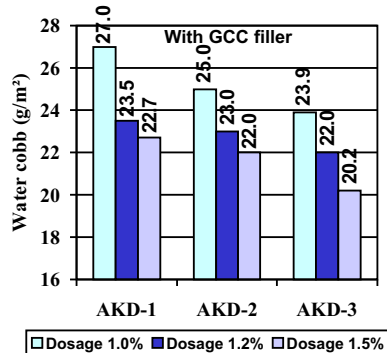


Figure 3. Cobb values with GCC

disintegrator along with filler (Soapstone and GCC separately in different sets of experiments). Different dosage of AKD (1.0 %, 1.2 % & 1.5 % as such on OD basis of pulp) with different suppliers have been used in our laboratory experiments. The handsheets of 60gsm were made on British Handsheet making machine in the alkaline pH range of 7.5-8.0 at different AKD level. The handsheets were pressed air-dried for 15 minutes and finally dried in oven for another 15 minutes. The handsheets were then conditioned in temperature & humidity controlled room (relative humidity 65±2% & temperature 27± 2° C). It was tested for Cobb (60 sec) as per methods (T 441 om-98). Results are tabulated in table 1 & 2. The Cobb values at different AKD dosages level with soapstone and GCC have also been plotted and shown in figure 2 & 3 respectively.

### PLANT TRIAL

Based on laboratory study, AKD-3 was found more effective and thus selected for the process trial. The machine trial was conducted with AKD-3, to validate our laboratory findings. PM -7 (Fourdrinier type, speed 120 m/minute, deckle 2.7 meter) was selected for process trial due to the use of GCC as a filler at this machine. Royal Executive Bond, a superior grade of water marked paper, is produced on this machine using dispersed rosin. Back water pH of 6.9 to 7.1 is maintained. Ash content in paper is maintained in the range of 11-12%.

### Paper Machine Wet End

Pulp is received from the pulp mill in new mixing chest. Chemicals like tinting dye, optical whitening agents etc are added in this chest. It is sent to dump chest. The furnish is then refined in the stock refiner and collected finally in the machine chest. Stock is passed through centricleaner and pressure screen to head box after refining at machine refiner. Filler, GCC is added in the accept line of primary centricleaners. The details are shown in the figure 4.

Before commencement of the trial, data during the normal run (neutral sizing) was collected and tabulated for comparison purpose. During AKD sizing, the dosing points of the various chemicals are as follows.

- AKD : Primary centricleaning accept
- Fixing agent : Machine chest
- Retention aid : Out let of pressure screen

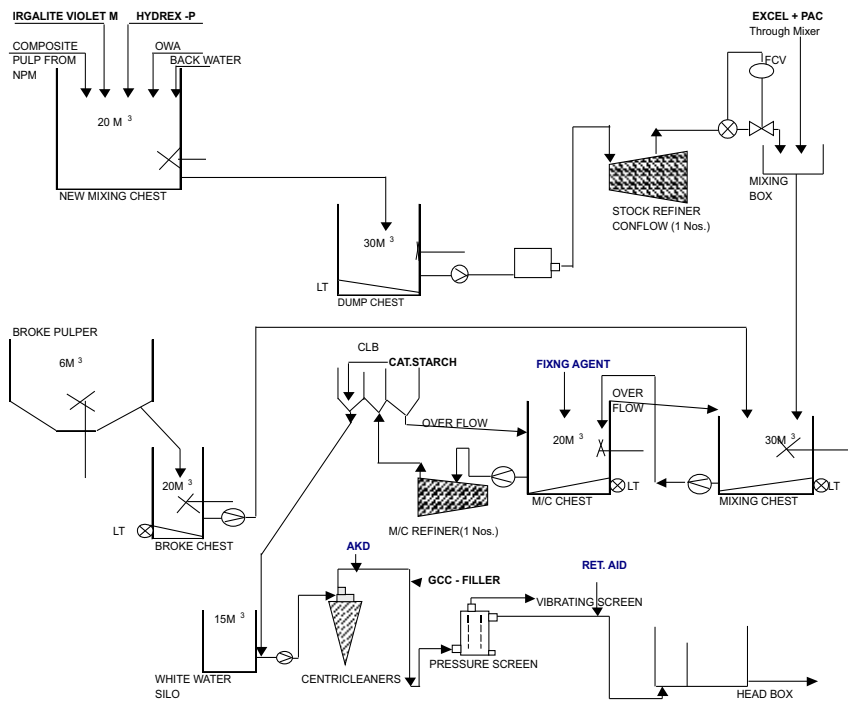


Figure 4. Approach flow system

Table 3. Chemical dosage and Cobb values

Sample	Neutral size kg/MT	PAC kg/MT	*AKD 3 kg/MT	*Ret. Aid g/MT	*Fixing agent g/MT	Cobb value values, g/m <sup>2</sup>			FPR %	FPAR %	
						Before size press	As such	Cured After 24 hr			
Blank	32.5	38.5	-	-	-	30/32	22/24	-	80.3	52.6	
	32.5	38.5	-	-	-	-	19/20	-	83.7	55.5	
	32.5	38.5	-	-	-	27/29	23/25	-	82.9	49.0	
	32.5	38.5	-	-	-	-	24/26	-	84.0	54.2	
	32.5	38.5	-	-	-	29/31	24/26	-	84.2	60.4	
Trial	32.5	38.5	-	-	-	-	25/27	-	82.8	52.7	
	32.5	38.5	8.0	300	50	27/29	26/28	26/27	82.9	48.0	
	28.1	32.8	8.0	300	50	30/31	26/27	23/25	83.0	51.2	
	28.1	32.8	8.0	300	50	-	25/27	22/23	83.0	52.0	
	14.4	19.8	12.0	350	50	48/50	32/34	19/21	81.8	52.9	
	14.4	19.8	12.0	350	50	-	41/43	21/23	83.7	51.3	
	14.4	19.8	12.0	350	50	60/62	43/45	21/23	84.3	52.9	
	0	21.0	18.0	350	50	-	40/44	20/22	84.8	48.4	
	0	21.0	18.0	350	40	85/90	62/66	21/23	83.3	50.0	
	0	21.0	16.0	350	20	-	83/85	21/23	22/24	84.0	51.2
	0	21.0	16.0	350	20	96/99	80/82	21/23	21/24	83.8	52.4
	0	21.0	16.0	350	20	-	96/98	24/26	22/24	84.0	52.4
	0	20.0	16.0	300	20	94/96	98/102	22/24	21/23	81.6	56.9
	0	20.0	16.0	300	20	-	98/100	22/24	21/24	86.3	56.4
	0	20.0	16.0	300	20	109/111	101/102	21/23	22/24	83.6	56.1
0	20.0	18.0	300	20	-	129/132	23/25	22/24	84.8	57.0	
0	20.0	16.0	300	20	80/85	64/67	18/20	20/22	84.5	52.0	
0	20.0	16.0	300	20	52/56	42/44	19/20	19/21	83.8	52.4	
0	20.0	16.0	300	20	96/98	94/97	23/25	21/23	83.3	52.0	

\* AKD- Aqueous dispersion of modified fatty alkyl diketene with medium cationic charge, Ret-Aid -Cationic polyacrylamide base & fixing agent-Polyvinylamine base, Paper was conditioned before testing at 65±2% RH & 27±2 °C temp.

Table 4. Back water pH, Conductivity, Hardness & Alkalinity during the AKD trial

Sample	Back water pH	Conductivity S/cm	Alkalinity as CaCO <sub>3</sub>	Hardness as Ca	Cationic demand meq/l	
					Head box	Back water
1	7.1	1140	210	126	18	23
2	7.3	1150	215	135	18	22
3	7.4	1020	230	152	17	19
4	7.4	1090	220	130	18	21
5	7.3	1100	232	128	11	22
6	7.3	1170	232	170	13	18
7	7.4	1040	215	160	10	17
8	7.4	1140	230	140	26	30

Conductivity : Checked with conductivity indicator controller instrument , Alkalinity : T 553 om.00, Hardness :Book quantitative inorganic analysis, I. Vogel IV 18 EDTA method , Charge : particle Charge analyzer.

Initially AKD was added at a dosage of 8 kg/MT (1:1 Dilution) with the fixing agent 300 g/MT (20 gpl solution) and retention Aid 50 g/MT (1.5 gpl solution). We reduced the dispersed rosin and PAC by 10% after checking the Cobb values and gradually increased the dosage of AKD-3 up to 18 kg/MT, while fixing agent up to 350 g/MT keeping retention aid at the same dosage level. Simultaneously dosage of dispersed rosin and PAC was reduced keeping a watch on Cobb values. Finally the dispersed rosin was stopped and PAC reduced to 20 kg/MT of paper. The optimum dosages were 16-18 kg/MT AKD, 300-350 g/MT fixing agent and 20 g/MT of paper retention aid.

During the trial Royal Executive Bond in 70 gsm was manufactured at fourdrinier paper machine at a speed of 120 m/min. Cobb value of paper at pope reel (each jumbo roll) was monitored. Cobb value measured at pope reel in as such, cured (15 min. at 105±2°C in oven) and after 24 hrs natural curing conditions. Cobb value of before size press was also determined at times. There was wide variation in the Cobb values, ranging from 60 to 110 g/m<sup>2</sup>.

We also determined Alkalinity, Hardness, Conductivity, pH of back water and charge, cationic demand of head box and back water. During trial dryer temperature profile was checked specially whenever high Cobb values were obtained. Paper was also tested for all properties as per standard\* after conditioning in controlled room (RH 65 ±2% & temp 27±2.0°C) as per our normal testing practice.

\*Standards used (Burst factor T 403 om-02, Breaking length T 456 om-03, Brightness T 571 om-03, Opacity T 519 om-02, Gurley porosity T 460 om-02, Cobb value T 441 om-98, Wax pick T459 om-03, Smoothness SACN-P 84: 02).

Chemical dosing and Cobb values were given in table 3, hardness, conductivity and charge in table 4 and dryer cylinder temperature profile in table 5 and all paper properties in table 6.

## RESULTS AND DISCUSSION

### Laboratory Study

With Soapstone at the dose of 1.5% AKD, all the three AKD have

Table 5. Surface temperature profile of dryer cylinders.

Dryer Nos.	Before trial	AKD Trial		
	°C	°C	°C	°C
1	74	70	70	72
2	84	90	88	83
3	84	88	91	87
4	85	90	91	93
5	84	86	87	84
6	82	88	87	90
7	92	92	93	93
8	94	96	93	98
9	93	95	97	92
10	92	103	101	98
11	75	68	79	75
12	80	81	78	84
13	92	90	87	84
14	94	86	88	80
15	103	96	96	83
16	93	94	93	79
Steam pressure kg/cm <sup>2</sup>	1.67	1.94	1.94	1.87
Surface tem. Checked with the infrared thermo meter instrument				

Table 6. Paper properties during the trial and compared with the blank

Properties	Unit	Blank	AKD Trial
Substance, ACT	g/m <sup>2</sup>	70.1	70.0
Bulk	cc/g	1.42	1.42
Burst Factor		25.6	25.5
Breaking length, MD/CD	Meter	6100/3200	6150/32100
Cobb value, as such T/W	g/m <sup>2</sup>	22/24	40-80/45-100
Cured cob T/W		-	19-23/23-25
Smoothness, T	ml/min	100-250	100-250
(Bendtsen) W		200-320	180-320
Stiffness, taber MD/CD		2.0/1.0	2.1/1.0
<b>Brightness, ISO</b>	%	<b>94.5</b>	<b>94.9</b>
Opacity, ISO	%	85.0	85.1
CIE-Whiteness	%	150	150
Formation		150-160	150-160

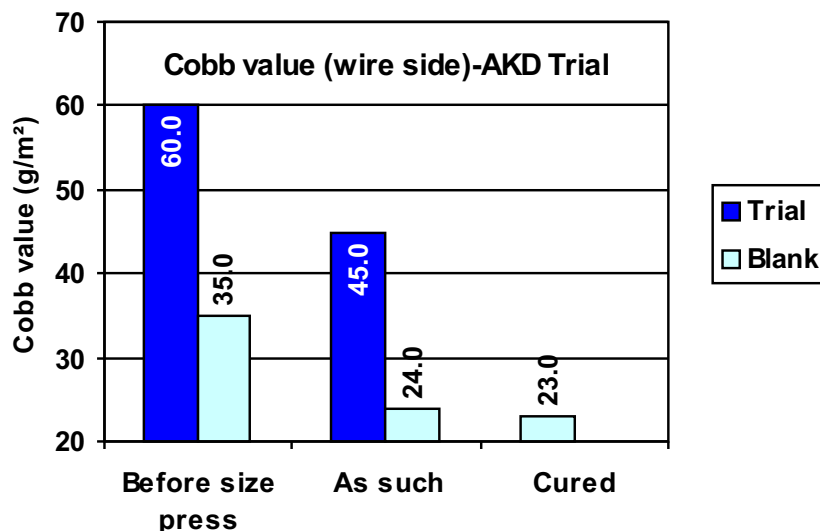


Figure 5. Cobb value with trial and blank

performed well. However, with AKD-3, Cobb value was minimum i.e. 16.7 g/m<sup>2</sup> as compared to 20-22 g/m<sup>2</sup> with AKD-1 & 2. It indicates that performance of AKD-3 is better than AKD 1 & 2.

With GCC filler at the dose of 1.5 % AKD, Cobb value was 22.7 g/m<sup>2</sup>, 22.0 g/m<sup>2</sup> & 20.2 g/m<sup>2</sup> with AKD-1, AKD-2 & AKD-3 respectively. This also indicates that AKD-3 performed better as compared to AKD 1 & 2.

AKD consumption with GCC was more as compared to the Soapstone by approximately 3.0 kg/MT of pulp.

### Plant Trial

Plant trial was conducted with AKD-3 with the GCC filter. Our observations are as follows.

- There was wide variation in Cobb values at pope reel. It varied from 40-100 g/m<sup>2</sup>. But the cured Cobb values remained in the range of 19-25 g/m<sup>2</sup>. Higher AKD dosage did not result in lower Cobb value.
- Whenever, Cobb increased up to 90 g/m<sup>2</sup>, there was problem of paper feeding through size press roll at the time of paper break. Machine runnability was poor and some times breaks were observed after size press roll in the third dryer group due to high Cobb before size press. Paper used to become slack in the 3<sup>rd</sup> dryer group.
- Some sticky material at size press roll was observed in the initial stage of the trial due to lower dosage of fixing agent. Once the dosage of fixing agent was optimized, no sticking was observed on the roll surface.
- Hardness, alkalinity and conductivity of backwater were in the desired range.
- Back water pH was in the range of 7.1 to 7.4. It was on the lower side. We could not reduce PAC due to high Cobb value before size press.
- Surface temp. of dryer cylinders before size press was in the range of 70 to 103° C, which affected the curing rate of AKD. The Cobb values before size press were in the range of 60-110 g/m<sup>2</sup>.

- Steam pressure variations were observed in the range of 1.67 to 2.0 kg/cm<sup>2</sup>. This has also resulted in variation in dryer temperature and finally Cobb values at pope reel. Steam pressure should be around 2.5-3.0 kg/cm<sup>2</sup> to get the desired dryer surface temperature and the sheet temp. for AKD sizing development.
- Defoamer consumption was more (1.5-1.6 kg/MT) which retarded internal sizing.
- During trial, the charge study was also carried out. Head box charge was in the range of 110 to 190 mv and corresponding cationic demand was in the range of 10 to 26 meq/l.
- All paper properties during AKD trial were comparable with the normal (dispersed rosin sizing).
- There was increase in final paper Brightness ISO by about 0.4 point i.e. from 94.5 to 94.9% at the same dosage of optical dye.

## CONCLUSIONS

- Lower dryer temperature, due to low steam pressure, resulted in higher Cobb values before size press and finally at pope reel. Desired curing could not be achieved due to low dryer surface temperatures.
- The desired Cobb value before size press should be around 50-60 g/m<sup>2</sup> for better machine runnability.
- The desired Cobb values of 20-25 g/m<sup>2</sup> after curing could be achieved even at high as such Cobb value at pope reel.
- PM-7 has drying limitation as regards to AKD sizing of paper.

## Recommendation /Future plan

- Due to drying limitation, the optimization of AKD could not be done.
- AKD consumption was more and finally there was marginal reduction in sizing cost i.e. Rs. 55.0 / MT against our normal neutral sizing.
- Further trial will be conducted after steam pressure is increased to

a level of 2.5 - 3.0 kg/cm<sup>2</sup> for faster curing and saving in AKD so that cost effectiveness is obtained.

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