

Polymeric Sizing to Reduce Wet End Sizing Chemicals and To Improve Printability of Paper

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ABSTRACT

Surface sizing allows reduction or removal of chemicals from the white water which helps in improving environmental performance. Synthetic surface sizing agent (Polymeric sizing) was introduced to reduce the sizing chemicals and chemical load at wet end. In this regard, a laboratory study on polymeric sizing was carried out. Two polymers from different suppliers were evaluated to select the most effective polymer. Raw maize starch was enzymatically converted into starch solution. Polymeric sizing agent was added in starch solution at different dosage levels to keep it at 1.0kg/T, 1.5kg/T & 2.0kg/T on paper basis. Handsheets at three different Cobb values (50g/m², 40g/m² & 30g/m²) were made by varying the dosage of dispersed rosin. These handsheets were coated. Uncoated and coated handsheets were tested for Cobb (60 sec). Based upon laboratory studies, the most effective polymeric sizing agent was selected for the plant trial. A full scale plant trial was conducted on the Fourdrinier paper machine running at 340 m/min speed manufacturing superior grade of writing / printing paper. At a dosage of 1.0kg/T of paper polymeric sizing agent, dispersed rosin and Poly Aluminum Chloride (PAC) were reduced by 33% and 14% respectively. Total sizing cost was reduced by Rs. 50/T of paper. This has also reduced variation in wax pick of paper i.e. from 12-14 to 13-14.

Key words: Maize starch, Enzyme, K-coater, Dispersed rosin, PAC

INTRODUCTION

Paper making fibres have a strong natural tendency to interact with water. The fibre web produced without use of additives consists of hydrophilic fibres that make up capillary system with cavities of different size and shapes between fibres. Due to both capillarity and the hydrophilic nature of the fibre web, the sheet of paper is very absorbent. There are basically two different procedures to impart resistance to water penetration in paper: internal and surface sizing.

Internal sizing is carried out in the wet end of the paper machine, where size is added to the fibre suspension before sheet formation takes place. This brings about sizing of the cross-section of the paper sheet.

Surface sizing is carried out by means of an application unit (size press) in the drying section of the paper machine. Here the already formed and dried paper sheet is treated at size press, with a formulation composed of hydrophobizing substance (size) and starch generating not only hydrophobicity but also surface strength due to polymeric structure of starch and sizing agents. The sizing is generally limited to the surface region of paper, which acts as a protective

layer preventing penetration of water into the hydrophobic interior of the sheet.

It is also possible to combine these two techniques in order to control the wetting and absorption of the paper sheet. Surface sizing provides close to maximum retention of added chemicals. This improved retention also reduces the problem of wet end deposits and increases life of machine clothing. Size press operations must be carefully controlled to assure that the sheet absorbs the desired amount of chemical uniformly across the machine.

Polymeric sizing

Polymer sizing agents, that are now used in surface sizing, undergo strong bonding with the cellulose. Polymeric surface sizing agents are generally applied together with starch solution so that the internal and surface strength of the paper increases. The yield of the surface sizing agent is almost 100%. It is possible to control the degree of sizing over a wide range during surface sizing, whereby the sizing costs fall at higher basis weight. Suitable surface sizing agents are available for almost all paper qualities.

The polymeric sizing agents can be classified according to their charge

characteristics i.e. cationic, anionic and amphoteric. During this study, anionic acrylonitrile-acrylic dispersion was used.

Application benefits of polymeric sizing agents are;

- I. Control of wetting and absorption of paper web
 - Reduce sizing chemicals at wet-end
 - Improve printability.
- II. Improve paper strength
 - Internal bond
 - Tensile strength
 - Surface strength
- III. Environmental improvement
 - Reduce or remove chemicals from white water
 - Reduce the problems of wet deposit.
 - Increase the life of machine clothing

EXPERIMENTAL APPROACH

A laboratory scale study was conducted on bleached chemical pulp (Hardwood + Bamboo) using polymeric surface sizing agent. Two different synthetic surface sizing agents from two different suppliers were collected for this study and to select the effective one for plant trial.

The final bleached pulp was collected

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Table-1. Lab handsheets properties

Parameters	Set-1	Set-2	Set-3
Chemical addition			
Pulp (28 °SR), g	15.0	15.0	15.0
Soapstone, %	25.0	25.0	25.0
Rosin size, %	1.5	1.8	2.0
PAC, %	1.5	1.8	2.0
Cationic starch, %	0.5	0.5	0.5
Final pH	6.5-6.8	6.5-6.8	6.5-6.8
Handsheet properties			
GSM, g/m ^{1/2}	61.0	60.5	61.5
Burst factor	42.3	41.0	41.2
Tear factor	67.2	68.0	68.5
Breaking length, m	6550	6580	6610
Wax pick, no	8	8	9
Gurley porosity, sec./100ml	21.0	22.2	23.5
Cobb value, g/m^{1/2}Top	44.5	35.0	25.0
Wire	50.0	40.0	30.0

dried for 15 minutes and finally dried in oven for another 15 minutes. Handsheets were tested for all properties as per standard* after conditioning in temperature & humidity in controlled room (RH 65 ±2% & temp. 27±2.0°C) as per our normal testing practice. Results are given in Table-1.

Maize starch solution was prepared by enzymatically converted in lab. Solid and viscosity of solution were maintained 10% and 16-18 cps respectively, similar to the plant. Different dosage of synthetic surface sizing agent was added in surface size solution which works out to be 1.0kg/T, 1.5kg/T & 2.0kg/T on paper basis. Evaluation of maize starch and properties of surface size solution are given in Table-2. Handsheets of different Cobb (60 sec.) values were coated with the prepared surface size solution by the application of Lab K-coater while maintaining coat weight of approx. 3.0g/m² on both sides. Coated handsheets were air dried and tested for the Cobb values. Results of coated handsheets are given in Table-3, 4 & 5. Bar charts of Cobb values are shown in Fig. 1, 2 & 3.

Table-2. Evaluation of maize starch and properties of surface size solution

Parameters	Results
Maize starch	
Moisture, %	11.3
Brightness, %	90
Viscosity, 5% paste at 60°C, cps	1200
Preparation of starch solution (enzymatically converted)-Total vol. 400ml	
Starch, g	40
Enzyme dose g/T of starch	10
Cooking temperature, °C	90
Viscosity at 60°C, cps	16
Solid, %	9.8

PLANT TRIAL

Based on laboratory study, synthetic surface sizing agent-1 was found more effective and thus selected for the process trial. PM-4 (Fourdrinier type, speed 340 m/minute, deckle 3.2 meter) was selected for process trial due to the high consumption of dispersed rosin and PAC at wet-end at this machine. It is mainly due to the use of coated broke to an extent of 10%. Bilt Classic and Sunshine Super printing papers (superior grade of writing / printing paper) are mainly produced on this machine using dispersed rosin. Back water pH of 6.6-6.8 is maintained. During the trial, Bilt Classic in 70 GSM paper was manufactured at the paper machine at a speed of 340 m/min.

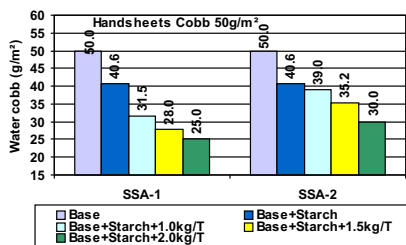


Fig. 1. Cobb values of coated handsheets (Cobb 50 g/m²)

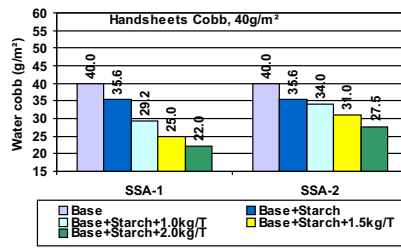


Fig. 2. Cobb values of coated handsheets (Cobb 40 g/m²)

from bleached decker after centricleaner. The pulp has the furnish of 20% Bamboo and 80% Hardwood (Eucalyptus 40% & poplar 40%). Bleached pulp was beaten in a valley beater to a freeness level of 28 °SR for all the sizing experiments. Handsheets at three different Cobb values (50g/m², 40g/m² & 30g/m²) were made by

varying the dosage of dispersed rosin size(1.5%, 1.8% & 2.0%) and PAC (1.5 %, 1.8 % & 2.0%). Soapstone was used as filler and cationic starch was added at a dosage of 0.5% on pulp basis in all the experiments. The handsheets of 60gsm were made on British Handsheet making machine at a pH range of 6.6-6.8. The handsheets were pressed, air-

Preparation of starch solution

Initially approx. 2.0 m³ of fresh water is taken in the cooker and 400 kg raw maize starch and 4.0g enzyme are added under agitation. Steam was injected to raise the temperature up to 70 °C and hold for 20 minutes at this temperature. The temperature is further raised to 90°C and again held for 15 minutes. Then the volume is made to 4.0 m³ by adding fresh water. Finally

Table-3. Properties of coated handsheets: Set-1, Cobb (60 sec.) 50g/m²

Parameters	Hand sheet (Base)	Coated with only Starch	Coated with starch +Synthetic surface sizing agent-1(SSA)			Coated with starch +Synthetic surface sizing agent-2(SSA)		
			1.0	1.5	2.0	1.0	1.5	2.0
Synthetic surface sizing agent, kg/T	-	-	1.0	1.5	2.0	1.0	1.5	2.0
Coat weight, g/m ²	-	3.0	3.0	3.1	3.1	2.9	3.1	3.0
Handsheet properties								
GSM, g/m ²	61.0	64.0	64.0	64.1	64.1	63.9	64.1	64.0
Burst factor	42.3	44.5	44.4	44.8	44.8	44.2	44.6	44.7
Tear factor	67.2	69.5	69.4	70.1	70.0	69.6	69.4	69.8
Breaking length, m	6550	7150	7180	7200	7210	7150	7180	7190
Wax pick, no	8	11	11	11	12	11	11	11
Porosity, sec./100ml	21.0	29.5	30.5	31.5	32.8	30.2	31.5	32.0
Cobb value, g/m²Top	44.5	35.5	28.0	25.0	22.0	33.5	30.0	27.0
Wire	50.0	40.6	31.5	28.0	25.0	39.0	35.2	30.0

Table-4. Properties of coated handsheets : Set-2, Cobb (60 sec.) 40g/m²

Parameters	Hand sheet (Base)	Coated with only Starch	Coated with starch +Synthetic surface sizing agent-1(SSA)			Coated with starch +Synthetic surface sizing agent-2(SSA)		
			1.0	1.5	2.0	1.0	1.5	2.0
Synthetic surface sizing agent, kg/T	-	-	1.0	1.5	2.0	1.0	1.5	2.0
Coat weight, g/m ²	-	3.0	3.0	3.1	3.1	2.9	3.1	3.0
Handsheet properties								
GSM, g/m ²	60.5	63.5	63.5	63.6	63.6	63.4	63.6	63.6
Burst factor	41.0	44.2	44.5	44.8	45.0	44.2	44.5	44.4
Tear factor	68.0	70.0	70.2	70.5	71.0	70.4	70.5	70.5
Breaking length, m	6580	7190	7200	7220	7240	7190	7190	7200
Wax pick, no	8	11	11	12	12	11	11	11
Porosity, sec./100ml	22.2	30.1	31.0	32.5	32.8	31.0	31.5	32.0
Cobb value, g/m²Top	35.0	30.5	26.0	23.0	20.0	30.5	28.0	24.0
Wire	40.0	35.6	29.2	25.0	22.0	34.0	31.0	27.5

Table-5. Properties of coated handsheets: Set-3, Cobb (60 sec.) 30g/m²

Parameters	Hand sheet (Base)	Coated with only Starch	Coated with starch +Synthetic surface sizing agent-1(SSA)			Coated with starch +Synthetic surface sizing agent-2(SSA)		
			1.0	1.5	2.0	1.0	1.5	2.0
Synthetic surface sizing agent, kg/T	-	-	1.0	1.5	2.0	1.0	1.5	2.0
Coat weight, g/m ²	-	3.1	3.0	2.9	3.0	2.9	3.0	3.1
Handsheet properties								
GSM, g/m ²	61.5	64.6	64.5	64.4	64.5	64.4	64.5	64.6
Burst factor	41.2	44.5	44.8	45.0	45.2	44.8	44.9	44.1
Tear factor	68.5	70.8	70.8	71.2	71.5	70.9	71.0	71.2
Breaking length, m	6610	7200	7240	7260	7280	7210	7120	7130
Wax pick, no	9	11	12	12	12	11	11	12
Porosity, sec./100ml	23.5	30.5	30.5	30.1	31.0	30.2	30.2	31.1
Cobb value, g/m²Top	25.0	22.0	20.0	18.0	15.5	22.0	22.0	18.0
Wire	30.0	25.0	23.0	20.0	17.6	26.0	24.0	20.0

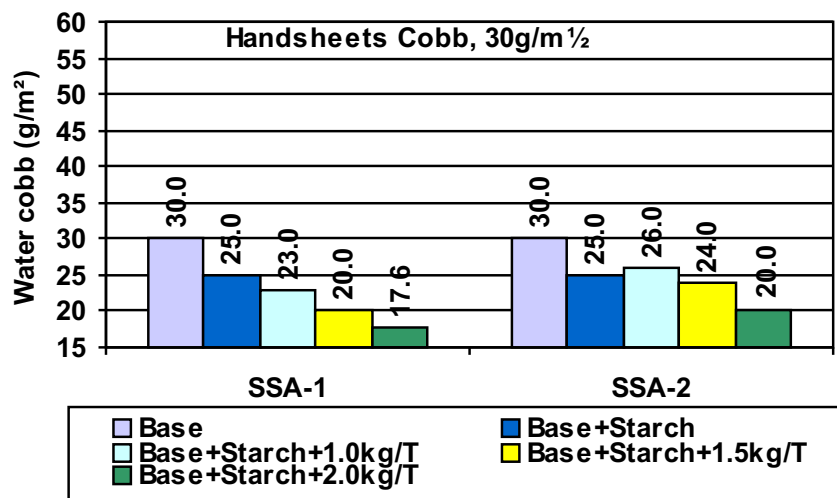


Fig. 3. Cobb values of coated handsheets (Cobb 30 g/m²)

synthetic surface sizing agent is added at around 65°C. Flow chart of starch preparation is shown in Fig. 4.

Paper Machine Wet End

Pulp was received from the pulp mill at the consistency of 3.0-3.5%. Pulp was first taken on the thickener and then stored in the buffer chest. Pulp was refined in DDR and collected in refined chest followed by measuring tank. Coated broke was added in the measuring tank. Chemicals like tinting dye, optical whitening agents etc were added in mixing chest. Dispersed rosin, PAC and filler are added in the machine chest. Stock is passed through centricleaner and pressure screen to head box after refining at machine refiner. Approach flow system is shown in Fig. 5.

Before commencement of the trial, data during the normal run was collected and tabulated for comparison purpose. During normal run, dispersed rosin size and PAC are added at a dosage of 15kg/T and 28kg/T respectively. Cobb values before size press was in the range of 30-34g/m². During polymeric sizing, synthetic surface sizing agent was added in the cooker at 65°C. Initially synthetic surface sizing agent was added at a dosage of 1.5kg/T of paper with the normal dosages of dispersed rosin and PAC. Dispersed rosin and synthetic surface sizing agent were reduced in phased manner by regular checking of Cobb values.

The dosage of dispersed rosin was finally reduced from 15kg/T to 10kg/T and PAC from 28kg/T to 24kg/T. Cobb values at pope reel were maintained 24-25g/m² with backwater pH of 6.6-6.8. Similarly, synthetic surface sizing agent optimized at a dosage of 1.0kg/T of paper. Foam generation was less. Defoamer dosage was reduced from 250g/T to 200g/T. A continuous run of one week was taken. Cobb value of before size press was in the range of 40-45g/m² against 30-34g/m² in normal run. Chemical dosages and Cobb values are given in Table-6.

Paper was also tested for all properties as per standard* after conditioning in temperature and humidity controlled room (RH 65 ±2% & temp. 27±2.0°C) as per our normal testing practice. Test results are given in Table-7. *Standards used (Burst factor T 403 om-02, Breaking length T 456 om-03, Brightness T 571 om-03, Gurley

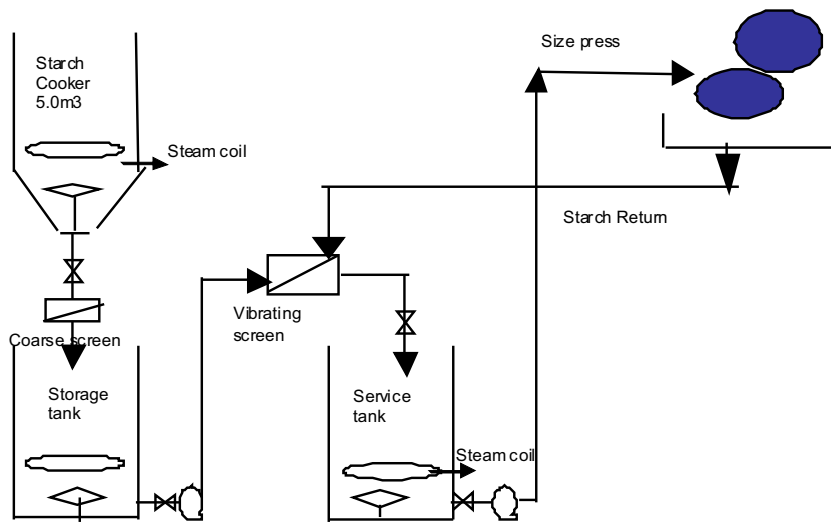


Fig. 4. Preparation of starch solution

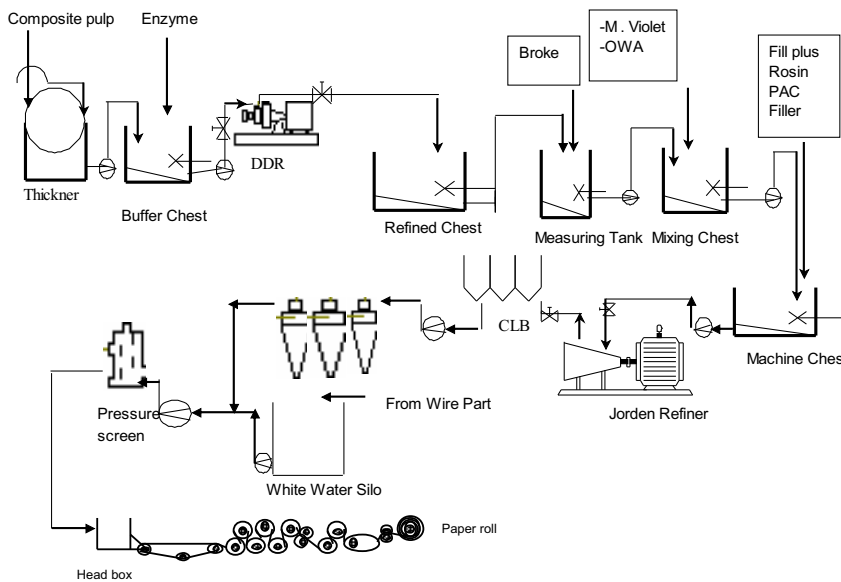


Fig. 5. Approach flow system

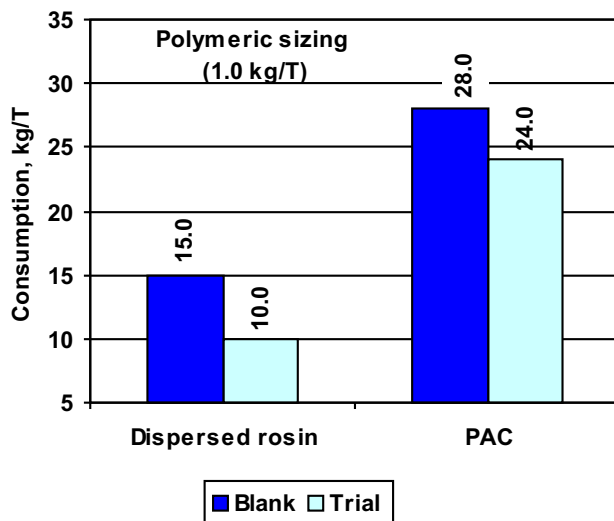


Fig. 6. Consumption of sizing chemicals

porosity T460 om-02, Cobb value T441 om-98, Wax pick T459 om-03, Smoothness SACN-P 84: 02).

Evaluation of paper sample from outside

Samples of normal and trial run were evaluated for printability test from outside agency. Toner adhesion is more in the trial samples i.e. 97.4% against 93.2% in blank run (sizing only with dispersed rosin and PAC). The details are given in **Table-8**.

RESULTS AND DISCUSSION

Laboratory Study

- Performance of synthetic surface sizing agent-1 is better as compared to synthetic surface sizing agent-2 in regards to reduction in Cobb values of handsheets after surface sizing.
- Cobb values of handsheets reduced with increased dosage of synthetic surface sizing agent.
- With the use of synthetic surface sizing-1 in maize starch solution is performing well at the dosages of 1.5kg/T of paper.
- Handsheets of 40g/m² Cobb coated with starch+ synthetic surface sizing agent (1.5kg/T), Cobb value of handsheets was reduced from 50g/m² to 28g/m².
- Lower Cobb value of handsheets (30g/m²) further reduced the final Cobb after surface sizing which is Cobb of 20g/m².
- Wax pick was improved by one point with synthetic surface sizing agent-1, from 11 to 12.

Plant Trial

Plant trial was conducted with synthetic surface sizing agent-1. It was added in starch solution at size press application. Cobb value was 25g/m² in normal run. It was reduced from 25g/m² to 18g/m² with the addition of 1.5kg/T of synthetic surface sizing agent-1 at size press solution and normal dosage of dispersed rosin & PAC. Dispersed rosin was reduced gradually for maintaining normal Cobb value of 23/25 g/m² at pope reel. Synthetic surface sizing agent-1 was optimized at the dosage of 1.0 kg/T of paper.

- Dispersed rosin at wet end was reduced by 33%, from 15kg/T to 10kg/T of paper and PAC by 14% from 28kg/T to 24kg/T of paper

Table-6. Chemical dosing and Cobb values

Sample	Dispersed rosin kg/T	PAC kg/T	*SSA-1 kg/T	Back water pH	Starch solution		Wax pick no.	Cobb values, g/m ²	
					Solid,%	Viscosity at 60°C, cps		Before size press	At pope reel
Blank (Normal run)	15.0	28.0	-	6.6	9.5	16.0	12	28/32	22/24
	15.0	28.0	-	6.8	9.6	16.0	13	30/32	22/24
	15.0	28.0	-	6.7	9.4	18.0	14	28/33	23/25
	15.0	28.0	-	6.8	9.8	18.0	14	32/34	21/24
	15.0	28.0	-	6.6	9.4	16.0	13	30/32	22/25
	15.0	28.0	-	6.7	9.4	16.0	12	28/30	22/24
	15.0	28.0	-	6.8	9.5	16.0	13	29/31	23/25
	15.0	28.0	-	6.6	9.6	14.0	14	30/32	22/24
	15.0	28.0	-	6.6	9.4	16.0	13	30/32	21/23
	15.0	28.0	-	6.6	9.6	16.0	13	31/34	16/18
Trial	15.0	28.0	1.5	6.8	9.6	16.0	13	31/34	16/18
	15.0	28.0	1.5	6.8	9.5	18.0	14	32/35	17/18
	15.0	28.0	1.5	6.7	9.8	18.0	13	28/32	17/18
	15.0	28.0	1.5	6.6	9.5	20.0	14	32/35	16/18
	15.0	28.0	1.5	6.8	9.6	16.0	14	30/34	16/17
	13.5	28.0	1.5	6.6	9.5	16.0	14	32/35	18/20
	13.5	28.0	1.5	6.8	9.6	16.0	14	33/36	18/21
	13.5	28.0	1.5	6.6	9.6	16.0	14	34/36	17/19
	13.5	28.0	1.5	6.6	9.6	16.0	14	34/36	20/22
	12.0	26.0	1.3	6.8	9.5	16.0	14	37/38	22/24
	12.0	26.0	1.3	6.7	9.4	18.0	13	36/40	22/24
	12.0	26.0	1.3	6.6	9.8	18.0	13	38/40	21/23
	12.0	25.0	1.3	6.6	9.5	20.0	14	36/38	22/24
	10.0	26.0	1.3	6.8	9.5	16.0	13	40/42	21/23
	10.0	25.0	1.3	6.8	9.5	16.0	13	43/45	22/24
	10.0	25.0	1.3	6.7	9.6	18.0	14	40/42	21/23
	10.0	24.0	1.3	6.6	9.5	16.0	14	38/42	22/24
	10.0	24.0	1.0	6.7	9.5	18.0	13	42/44	23/25
	10.0	23.0	1.0	6.6	9.4	16.0	14	42/45	22/24
	10.0	24.0	1.0	6.7	9.6	16.0	14	42/44	24/26
10.0	24.0	1.0	6.8	9.6	18.0	14	40/44	23/25	
10.0	24.0	1.0	6.7	9.5	18.0	14	41/44	23/25	
10.0	23.0	1.0	6.8	9.4	16.0	14	42/44	21/24	
10.0	23.0	1.0	6.8	9.5	20.0	13	42/45	23/26	
10.0	24.0	1.0	6.7	9.4	18.0	14	41/44	22/24	

* SSA- Synthetic: surface sizing agent (anionic acrylic dispersions)
Paper was conditioned before testing at 65±2% RH & 27±2 °C temp. and tested as per standard.

Table-7. Paper properties during the trial and its comparison with the blank (normal run).

Properties	Unit	Blank (Normal run)	Trial
GSM, Act	g/m ²	70.1	70.0
Bulk	cc/g	1.35	1.36
Burst Factor		25.0	24.8
Tear Factor		58/60	58/61
Breaking length, MD/CD	meter	6150/3160	6140/3200
Cobb, before size press TW	g/m ²	32/35	40/45
Cobb, at pope reel TW	g/m ²	22/24	22/24
Brightness, ISO	%	88.5	88.6
Smoothness, T (Bendtsen) W	ml/min	100-150	100-150
Wax pick	no.	12-14	13-14
Gurley porosity	sec/100ml	18.5	18.6

Table-8. Printability test results of samples

Properties	Unit	Blank (Normal run)	Trial
Cobb (60 sec)	g/m ²	21	21
Ink swim time	second	956	963
Toner adhesion	%	93.2	97.4
Wax pick	no.	13	14

with backwater pH of 6.8-6.8. Bar chart is shown in Fig. 6.

- There was marginal improvement in wax pick no. of paper from 12-14 to 13-14.
- Toner adhesion improved from 93.2% to 97.4%.
- All physical strength properties and optical properties are

comparable.

- Total sizing cost was reduced by Rs.50/T (from Rs. 550/T to Rs. 500/T) of paper.

After completion of one month commercial trial, it is now in regular use at PM-4.

CONCLUSION

- Dispersed rosin at wet end was reduced by 33% and PAC by 14%.
- Wax pick of paper improved.
- Total saving in sizing cost of Rs. 50/T of paper.
- Defoamer consumption reduced by 20% from 250g/T to 200g/T.
- Successfully commercialized.

Recommendation /Future plan

- Polymeric sizing implemented at all machines.
- Planning of ASA trial with GCC/PCC filler.

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