Improving Digester Performance through the Use of Surfactants and AQ

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The effects of adding AQ and surfactants individually and in combination in Kraft pulping of mixture of hardwoods and bamboo were studied in the lab and process scale studies were also conducted. With addition of combination of surfactant DA-1 and AQ, the AA charge to maintain the constant kappa number reduced by 7.6%, pulping rejects reduced by 30% and the DCM extractives reduced by 20%. The yield increase was 1.5% over the control. The combination program resulted in higher kappa reductions (3.4 points) (cooking at the same chemical charge) when compared to use of either surfactant or AQ alone. Pulps produced with pulping additives showed higher unbleached and bleached viscosity and better bleaching response as compared to the reference pulps. The reduction in AA and increase in yield reduced both the organic and inorganic solids loading in recovery per tonne of pulp production. In process scale trial, about 8.2% reduction in AA was obtained besides 23% reduction in knotter rejects.

INTRODUCTION

During the past few decades, a lot of efforts have been made to investigate the use of different digester additives to enhance the pulping (1-6). The digester additives can be broadly divided into two categories viz., AQ-based and surfactant-based additives. AQ acts as a catalyst and promotes both lignin degradation and yield improvement. The use of AQ with the soda or the Kraft processes has been studied extensively in the laboratory and in the field (1,2). Laboratory experiments and mill trial result show that AQ leads to higher production rates and more environment friendly operations (2,7). The use of AQ in the Kraft process is gaining popularity, largely because of the recent cost reductions and the industry's desire to extend production without any capital expenditure. Industry is pleased with the potential benefits from the AQ program (2). AQ is extensively used in Japan and has been accepted in North America since 1990. Currently AQ pulping technology is successfully applied for both bleachable and linerboard grades.

The next emerging technology is based on the surfactants that reduce the strong cohesive forces found on and between molecular surfaces (1,3-6, 8,9,). The addition of surfactants-based additives can reduce the surface tension between the liquor and chips, allowing for more thorough wetting of the chip surface and facilitating rapid penetration of liquor into the inner matrix of the chip (9). Better penetration of the cooking liquor into the wood chips can result in faster defibering of chips, improved deresination, reduction in kappa number and rejects and overall improvements in pulp quality (9,10). Although several authors have studied the effect of AQ and surfactants individually during Kraft pulping, very little information is available on the use of AQ plus surfactant combination program in Kraft pulping. Manji (11) has reported Kraft pulping of software using combination of AQ and surfactants. However, no information is available on Kraft pulping of hardwoods and bamboo with combination of AQ and surfactants. The work presented in this paper was intended to identify the potential of AQ and surfactants both individually and in combination for kraft pulping of mixture of hardwoods and bamboo. The main objective was to study the effectiveness of pulping additives in reducing the AA requirement, pulping rejects and extractives and increasing the pulp yield. The results of mill scale trial with AQ and surfactants performed in Kraft pulping mill processing mixture of hardwoods and bamboo to high grade pulp are also presented.

Experimental

Studies were conducted with a mixture of hardwood and bamboo pulp. The pulp was obtained from a large integrated pulp and paper mill. It was produced from 40% bamboo (Maharashtra bamboo, 65%; M.P. bamboo, 35%) and 60% hardwood (Subabul with bark 34%, eucalyptus debarked 54%, mixed firewood 12%).

Experiments were carried out in Lab Autoclave digester consisting of six bombs, each of 2.5 litre capacity rotating in an electrically heated polyethylene glycol bath. Chemical doses were selected so as to get kappa number in the medium range (20-22), which represents the current practices of Indian Paper mills. Pulping studies were performed at constant H factor with a charge of 300 g of wood chips (dry basis) in each autoclave. A control experiment was also run simultaneously in each set. After charging the bombs with wood chip and liquor, they were sealed and placed in the oil bath. The initial temperature of oil was 50°C. The temperature was then ramped up and held according to the desired H factor of the cook. During the cook, the bombs rotated end-over-end to facilitate mixing and uniform heat transfer. At the end of the cooking, the bombs were removed and quenched in the water tank to depressurize. The digested wood chips were dispersed with pulp disintegrator and washed with hot water to remove the black liquor and dissolved substances. After thorough washing, the unscreened pulp yield was determined and the pulp was screened in laboratory screen of 0.25 mm slot width. Pulps were evaluated for kappa no., brightness, yield, rejects and DCM extractives etc. Black liquor was characterized for solids, free alkali, TTA, orgânics, inorganics, silica, sulphate, NaCl, R_2CO_3 and viscosity at different solids concentrations.

The surfactants were tested at a charge of 0.2-0.5 kg/tonne of raw material chips (dry basis). The AQ dosage reported in reference 2 as the industry standard is 0.4-0.5 kg/TRM. The dosage used in the laboratory experiments was 0.2-0.5 kg/TRM. The surfactants DA-1 and DA-2 are available commercially from M/s Anmol Group of Companies, Delhi, India under the trade name Anmopulp MIBR and Anmopulp MICR respectively and DA-3, DA-4 and DA-5 are available commercially from M/s Hercules, M/s Nalco and M/s Value Addition Papers Private Ltd., Delhi, India under the trade name DA-2600, PP10-3036, Dyanamix-3000 respectively.

The surfactant solution an AQ were added in the Kraft cooking liquor and thoroughly mixed before transferring into the bombs. The cooking conditions used for pulping are detailed in various tables .

Analytical Procedures

Kappa number, a measure of lignin content was determined by reaction of pulp samples with acidified potassium permanganate solution according to Tappi test Method T 236 cm-85. Brightness of the pulp hand sheets was determined with a Technibrite instrument (Model TB 1c) according to Tappi Test Method T 525 om-02. Yield was calculated as pulp (oven dry weight basis) produced per 100 g wood chip after determining the moisture content of the pulp as per Tappi Test Method T 210 cm-86. Rejects, the uncooked materials, were determined by drying in an oven at 105°C. Dichloromethane (DCM) extractives, a measure of wood components that are soluble in neutral organic solvents, were determined according to Tappi Test Method T 204 om-88.

Total solids in the black liquor were measured gravimetrically after removal of water and other non-aqueous volatile materials according to Tappi Test Method T 650 om-99. Viscosity at different solids content was determined using Brookfield

Table 1: Pulping conditions used for Kraft pulping of mixture of hardwoods and bamboo to kappa~22

Raw material in each bomb, g (dry basis)	300
Alkali charge, %	19.7
Sulfidity, %	23
Bath ratio	1:3
Cooking temperature. °C	160
Time to temperature 131°C, min	60
Time at temperature 131°C, min	60
Time to cooking temperature, min	30
Time at cooking temperature, min	185

Table 2a: Kraft pulping of mixture of hardwoods and bamboo with Surfactant DA-1

Cooking at reduced alkali charge

Parameter	Control	Surfactant DA-1		
		0.25 kg/TRM	0.50 kg/TRM	1.0 kg/TRM
Active alkali, %	19.7	18.5	18.5	18.5
Kappa number	22.3	22.2	22.1	22.1
Brightness, % ISO	20.2	21.1	21.3	21.2
Yield, %	46.3	47.1	47.3	47.2
Residual alkali as Na_2O, g/l	8.54	8.17	8.03	8.20
Rejects (%)	0.94	0.71	0.70	0.70
Black liquor solids, T/TP	1.65	1.54	1.54	1.54
DCM extractives, %	0.162	0.130	0.130	0.130

Cooking conditions	
Raw material in each bomb, g (dry basis)	300
Bath ratio	1:3
Cooking temperature. °C	160
Time to temperature 131°C, min	60
Time at temperature 131°C, min	60
Time to cooking temperature, min	30
Time at cooking temperature, min	185

Table 2b: Kraft pulping of mixture of hardwood and bamboo with Surfactant DA-1

Cooking at same alkali charge

Parameter	Control	Surfactant DA-1		
		0.25 kg/TRM	0.50 kg/TRM	1.0 kg/TRM
Active alkali, %	19.7	19.7	19.7	19.7
Kappa number	22.3	20.2	20.2	19.9
Brightness, % ISO	20.2	22.3	22.5	22.7
Yield, %	46.3	46.9	46.8	46.8
Residual alkali as Na_2O, g/l	8.54	10.10	10.20	10.80
Rejects (%)	0.94	0.52	0.52	0.49

digital viscometer according to the method of Venkatesh and Nguyen (12). Other black liquor parameters were determined as per Tappi Test Method T 625 cm-85.

All the experiments were performed in duplicate and repeated once more to confirm the results/ observations of the earlier set. The average values are reported herewith.

RESULTS AND DISCUSSION

Conventional Kraft cooking of mixture of hardwoods and bamboo to Kappa number of ~22 requires 19.7% active alkali charge as shown in Table 1. The unbleached yield at this kappa number was ~46%.

Use of all the pulping additives resulted in reduction in AA requirement and rejects generation and improvement in pulp yield. DCM extractives also reduced in case of surfactants. However, in case of AQ, no reduced in DCM extractives was observed. The AA charge to maintain the constant

Table 3a: Kraft pulping of mixture of hardwoods and bamboo with Surfactant DA-2

Cooking at reduced alkali charge

Parameter	Control	Surfactant DA-2		
		0.25 kg/TRM	0.50 kg/TRM	1.0 kg/TRM
Active alkali, %	19.7	18.7	18.7	18.7
Kappa number	22.3	22.1	22.1	22.1
Brightness, % ISO	20.2	21.2	21.1	21.9
Yield, %	46.3	47.0	46.9	46.9
Residual alkali as Na_2O, g/l	8.54	8.10	8.20	8.20
Rejects (%)	0.94	0.80	0.79	0.79

Cooking conditions	
Raw material in each bomb, g (dry basis)	300
Bath ratio	1:3
Cooking temperature. °C	160
Time to temperature 131°C, min	60
Time at temperature 131°C, min	60
Time to cooking temperature, min	30
Time at cooking temperature, min	185

Table 3b: Kraft pulping of mixture of hardwoods and bamboo with Surfactant DA-2

Cooking at same alkali charge

Parameter	Control	Surfactant DA-2		
		0.25 kg/TRM	0.50 kg/TRM	1.0 kg/TRM
Active alkali, %	19.7	19.7	19.7	19.7
Kappa number	22.3	20.5	20.5	20.4
Brightness, % ISO	20.2	22.1	22.0	22.0
Yield, %	46.3	46.5	46.5	46.5
Residual alkali as Na2O, g/l	8.54	7.2	7.1	7.1
Rejects (%)	0.94	0.71	0.70	0.70

kappa number by 6%, pulping rejects reduced by 25% and the DCM extractives reduced by 20% with addition of 0.25 kg DA-1/TRM of (Anmopulp MIBR) (Table 2a). Solids in black liquor reduced from 1.65 to 1.54 tonne/tonne of pulp (Table 2a). The yield increase was 0.08% over the control (no surfactant) (Table 2a). When cooking was done at the same chemical charge, the kappa number reduced by 2.1 points (Table 2b). Using higher dose of surfactant DA-1 -0.50 kg/TRM and 1.0 kg/TRM, the saving in AA and reduction in kappa number were the same as with 0.25 kg DA-1/TRM (Table 2a). Lack of concentration effect could be because the DA-1 concentrations were above the critical micelle concentration (CMC) of the surfactant. Above the CMC, surfactant solution surface tension has a constant value. Benefits were found to be lower with surfactant DA-2 (Anmopulp MICR), surfactant DA-3 (2600), surfactant DA-4 (PP10-3036) (Tables 3-5) and comparable with surfactant DA-5 (Dynamix-3000) which showed maximum benefits at a dose level of 0.4 kg/TRM (Table 6).

Use of 0.50 kg AQ/TRM, reduced the AA charge by 5.1%, pulping rejects by 23% and black liquor

Table 4a: Kraft pulping of mixture of hardwoods and bamboo with Surfactant DA-3

Cooking at reduced alkali charge

Parameter	Control	Surfactant DA-3		
		0.25 kg/TRM	0.50 kg/TRM	1.0 kg/TRM
Active alkali, %	19.7	18.7	18.7	18.7
Kappa number	22.3	22.2	22.1	22.0
Brightness, % ISO	20.2	21.5	21.5	21.2
Yield, %	46.3	47.0	46.9	46.9
Residual alkali as Na_2O, g/l	8.54	7.51	7.52	7.63
Rejects (%)	0.94	0.72	0.70	0.70

Cooking conditions	
Raw material in each bomb, g (dry basis)	300
Bath ratio	1:3
Cooking temperature. °C	160
Time to temperature 131°C, min	60
Time at temperature 131°C, min	60
Time to cooking temperature, min	30
Time at cooking temperature, min	185

Table 4b: Kraft pulping of mixture of hardwoods and bamboo with Surfactant DA-3

Cooking at same alkali charge

Parameter	Control	Surfactant DA-3		
		0.25 kg/TRM	0.50 kg/TRM	1.0 kg/TRM
Active alkali, %	19.7	19.7	19.7	19.7
Kappa number	22.3	20.4	20.5	20.4
Brightness, % ISO	20.2	22.0	22.1	22.0
Yield, %	46.3	46.5	46.7	46.6
Residual alkali as Na2O, g/l	8.54	8.1	8.2	8.1
Rejects (%)	0.94	0.75	0.76	0.75

solids from 1.65 T/TP to 1.55 T/TP (Table 7a). A net yield increase of 1.0% was obtained over the control and no reduction in DCM extractives was observed. The kappa number redced by 2.3 points when cooking was done at the same alkali charge (Table 7b). Use of 0.25 kg DA-1/TRM, in combination with 0.50 kg AQ/TRM, resulted in more reduction in AA requirement, pulping rejects and black liquor solids and more improvement in pulp yield. The AA charge reduced by 7.6%, the pulping rejects reduced by 30% and the yield increased by 1.5% over control (Table 8a). The combination program resulted in higher kappa reductions (3.36 points) (cooking at the same chemical charge) when compared to use of either surfactant or AQ alone (Table 8b). It did not result in additional removal of DCM extractives, as the reduction in DCM extractives was same (25%) was when 0.25 kg DA-1/TRM by 30% and 40% from the standard dose (0.50 kg/TRM) and supplemented with 0.25 kg DA-1/TRM (Tables 8a-8b).

Pulps produced with pulping additives showed higher unbleached and bleached viscosity and better bleaching response as compared to the reference

Table 5a: Kraft pulping of mixture of hardwoods and bamboo with Surfactant DA-4

Cooking at reduced alkali charge

Parameter	Control	Surfactant DA-4		
		0.20 kg/TRM	0.40 kg/TRM	0.5 kg/TRM
Active alkali, %	19.7	18.8	18.8	18.8
Kappa number	22.3	22.1	22.2	22.2
Brightness, % ISO	20.2	21.5	21.5	21.2
Yield, %	46.3	46.5	46.5	46.5
Residual alkali as Na_2O, g/l	8.54	9.12	9.20	9.19
Rejects (%)	0.94	0.72	0.75	0.70

Cooking conditions	
Raw material in each bomb, g (dry basis)	300
Bath ratio	1:3
Cooking temperature. °C	160
Time to temperature 131°C, min	60
Time at temperature 131°C, min	60
Time to cooking temperature, min	30
Time at cooking temperature, min	185

Table 5b: Kraft pulping of mixture of hardwoods and bamboo with Surfactant DA-4

Cooking at same alkali charge

Parameter	Control	Surfactant DA-4		
		0.20 kg/TRM	0.40 kg/TRM	0.50 kg/TRM
Active alkali, %	19.7	19.7	19.7	19.7
Kappa number	22.3	20.1	20.1	20.0
Brightness, % ISO	20.2	21.2	21.5	21.5
Yield, %	46.3	46.7	46.7	46.8
Residual alkali as Na2O, g/l	8.54	9.10	9.25	9.22
Rejects (%)	0.94	0.63	0.65	0.63

pulps (Table 9). The Eop kappa number reduced by 7.9% and final brightness and whiteness increased by 0.5 point and 2.0 points respectively in case of cook with AQ and surfactants (Table 9).

The black liquor characteristics with and without combination of surfactants and AQ are presented in Table 10. The reduction in active alkali requirement and increase in yield reduced both the organics and inorganic solids loading in recovery per tonne of pulp production. The black liquor solids were 1.65 T/TP and 1.53 T/TP in case of control cook and cook with combination of AQ 7 surfactants respectively. The organics reduced from 52.0 to 50.0% and inorganics increased from 48.0 to 49.9% in case of cook with combination of AQ and surfactants. The swelling volume ratio was better and the data on silica, sulphite, chloride, mixed oxides and viscosity were comparable in case of cook with combination of AQ and surfactants.

Commercial mill trial results

Trial was conducted in a Kraft pulping mill processing mixture of hardwoods and bamboo to a high-grade paper pulp. As the white liquor availability was a limiting factor in the mill, the main objective of the trial was to determine the

Table 6a: Kraft pulping of mixture of hardwoods and bamboo with Surfactant DA-5

Cooking at reduced alkali charge

Parameter	Control	Surfactant DA-5		
		0.40 kg/TRM	0.50 kg/TRM	1.0 kg/TRM
Active alkali, %	19.7	18.5	18.5	18.5
Kappa number	22.3	22.0	22.1	22.1
Brightness, % ISO	20.2	21.1	21.3	21.2
Yield, %	46.3	46.9	46.9	47.0
Residual alkali as Na_2O, g/l	8.54	9.18	9.23	9.15
Rejects (%)	0.94	0.75	0.76	0.76
Black liquor solids, T/TP	1.65	1.54	1.54	1.54

Cooking conditions	
Raw material in each bomb, g (dry basis)	300
Bath ratio	1:3
Cooking temperature. °C	160
Time to temperature 131°C, min	60
Time at temperature 131°C, min	60
Time to cooking temperature, min	30
Time at cooking temperature, min	185

Table 6b: Kraft pulping of mixture of hardwoods and bamboo with Surfactant DA-5

Cooking at same alkali charge

Parameter	Control	Surfactant DA-5		
		0.40 kg/TRM	0.50 kg/TRM	1.0 kg/TRM
Active alkali, %	19.7	19.7	19.7	19.7
Kappa number	22.3	20.0	20.1	20.1
Brightness, % ISO	20.2	21.9	21.9	22.0
Yield, %	46.3	46.8	46.8	46.9
Residual alkali as Na_2O, g/l	8.54	8.25	8.32	8.57
Rejects (%)	0.94	0.61	0.62	0.61

effectiveness of AQ and surfactant combination in reducing the AA charge at the comparable kappa number. The trial was performed for one week. Dose of surfactant DA-1 and AQ during the plant trial were 0.459 kg/T and 0.408 kg/T of pulp respectively. At the same Kappa number, about 8.2% reduction in active alkali was obtained over control (no surfactant, no AQ) besides 23% reduction in knotter rejects (Table 11). This reduction in active alkali would result in increased pulping capacity by producing 2 additional cooks per day or about 20 tonnes unbleached pulp for the same kappa number. The DCM extractives reduced by 25%. The improvement in yield could not be established due to back calculation method of unbleached pulp production from paper but there was a positive indication (from black liquor data). Solids in black liquor before and after the trial were found to be 1.67 toone and 1.52 tonne respectively.

Discussion

The study clearly shows that surfactants greatly

Table 7a: Kraft pulping of mixture of hardwoods and bamboo with AQ

Cooking at reduced alkali charge

Parameter	Control	AQ 0.50 kg/TRM
Active alkali, %	19.7	18.70
Kappa number	22.3	22.2
Brightness, % ISO	20.2	20.3
Yield, %	46.3	47.3
Residual alkali as Na_2O, g/l	8.54	8.9
Rejects (%)	0.94	0.73
Black liquor solids, T/TP	1.65	1.55

Cooking conditions	
Raw material in each bomb, g (dry basis)	300
Bath ratio	1:3
Cooking temperature. °C	160
Time to temperature 131°C, min	60
Time at temperature 131°C, min	60
Time to cooking temperature, min	30
Time at cooking temperature, min	185

Table 7b: Kraft pulping of mixture of hardwoods and bamboo with AQ

Cooking at same alkali charge

Parameter	Control	AQ 0.50 kg/TRM
Active alkali, %	19.7	19.7
Kappa number	22.3	20.0
Brightness, % ISO	20.2	20.8
Yield, %	46.3	46.9
Residual alkali as Na_2O, g/l	8.54	9.20
Rejects (%)	0.94	0.62

increase the rate of penetration and diffusion of the cooking liquor into and out of the internal wood structure. This achieved much uniform pulping as reflected by the lower kappa number, lower percent rejects and lower pulp resin content. Surfactants improve cooking liquor penetration by a variety of mechanisms. it is generally believed that surfactants enhance penetration and diffusion by wetting, emulsifying, mobilizing and dispersing resins and fatty acids occupying wood chip flow channels. The extractives, when liberated during processing of the wood chips to pulp and paper products, can cause problems as contributors to the effluent toxicity, as undesirable components of papermaking furnishes and as troublesome deposits (pitch) on all mill equipment.

The data presented in this paper indicate that bleached Kraft mills can utilize the combination of AQ and surfactants for reductions in the following area; white liquor, kappa variations, kappa number,

Table 8a: Kraft pulping of mixture of hardwoods and bamboo with combination of Surfactant DA-1 and AQ

Cooking at reduced alkali charge

Parameter	Control	0.25 kg SURF DA-1+0.5 kg AQ/TRM	0.25 kg SURF DA-1+0.4 kgAQ/TRM	0.25 kg SURF DA-1+0.3 kgAQ/TRM	0.25 kg SURF DA-1+0.2 kgAQ/TRM
Active alkali, %	19.7	18.2	18.2	18.2	18.2
Kappa number	22.3	22.1	22.8	22.3	23.2
Brightness, % ISO	20.2	21.1	22.2	21.5	20.0
Yield, %	46.3	47.8	47.8	47.8	47.2
Residual alkali as Na_2O, g/l	8.54	8.9	8.92	9.2	8.35
Rejects (%)	0.94	0.66	0.66	0.67	0.75
Black liquor solids, T/TP	1.65	1.53	1.53	1.53	n.d.
DCM extractives %	0.162	0.130	0.130	0.130	n.d.

Cooking conditions	
Raw material in each bomb, g (dry basis)	300
Bath ratio	1:3
Cooking temperature. °C	160
Time to temperature 131°C, min	60
Time at temperature 131°C, min	60
Time to cooking temperature, min	30
Time at cooking temperature, min	185

Table 8b: Kraft pulping of mixture of hardwoods and bamboo with combination of Surfactant DA-1 and AQ

Cooking at reduced alkali charge

Parameter	Control	0.25 kg SURF DA-1+0.5 kg AQ/TRM	0.25 kg SURF DA-1+0.4 kgAQ/TRM	0.25 kg SURF DA-1+0.3 kgAQ/TRM	0.25 kg SURF DA-1+0.2 kgAQ/TRM
Active alkali, %	19.7	19.7	19.7	19.7	19.7
Kappa number	22.3	18.9	18.9	18.9	19.2
Brightness, % ISO	20.2	22.1	22.3	22.5	22.0
Yield, %	46.3	47.3	47.3	47.2	47.0
Residual alkali as Na_2O, g/l	8.54	8.52	8.50	8.50	8.52
Rejects (%)	0.94	0.51	0.51	0.50	0.62

pulping rejects and pulp resin content. the Study indicates that mills can reduce alkali and pulping rejects while maintaining the same kappa number. High kappa pulping without surfactant would certainly increase screen rejects. To avoid excessive rejects and keep much of the yield gains from high kappa pulping, it is highly desirable to use surfactant-based digester additives. Surfactants would ensure uniform penetration of cooking chemicals, allowing homogenous pulping of chips and thereby reducing knots and screen rejects when pulping to high kappa number. Use of AQ and surfactant combination resulted in more reduction in AA requirement, pulping rejects and black liquor solids and more improvement in pulp yield. The AQ/ surfactant program actually enhances the lignin removal by maximizing the efficiency and effectiveness of cooking chemicals and AQ during

Table 9: Bleaching of pulps produced with pulping additives in CDEop HD sequence

Bleached pulp properties

Parameter	1	2	3	4
Brightness, % ISO	89.0	89.1	89.2	89.5
Whiteness, % ISO	75.1	77.0	77.2	77.5
Viscosity, cp	10.7	11.3	11.9	12.1
	(18.8)*	(19.5)*	(19.2)*	(19.3)*

Unbleached viscosity

1. Pulp produced without pulping additives and then bleached in $C_{90}D_{10}E_{op}HD$ (Control)
2. Pulp produced with pulping additive - 0.25 kg SURF DA-1/TRM and then bleached in $C_{90}D_{10}EopHD$.
3. Pulp produced with pulping additive - 0.5 kg AQ/TRM and then bleached in $C_{90}D_{10}E_{op}HD$ sequence.
4. Pulp produced with pulping additive - 0.25 kg SURF DA-1/TRM + 0.3 AQ/TRM - 100/TRM and then bleached in $C_{90}D_{10}E_{op}HD$.

Table 10: Characterization of black liquor

Parameter	Control	0.25 kg SURF DA-1/TRM + 0.3 kg AQ/TRM
Active alkali as Na_2O in pulping, %	19.7	18.3
Unbleached pulp yield, %	46.3	47.8
Kappa number	22.3	22.1
Total Solids in black liquor, T/TP	1.65	1.53
pH of black liquor	12.2	12.1
TTA as Na_2O, g/l	58.3	54.6
Residual alkali as Na_2O, g/l	8.6	7.2
Organics, %	53.9	49.5
Inorganics, %	46.1	50.5
Silica, g/l	2.08	1.92
Sulphate, g/l	15.5	15.9
NaCl, g/l	1.86	1.62
R_2O_3, g/l	0.72	0.70
Swelling volume ration, ml/g	62.3	67.9
Viscosity, cp* at different solid	2.4 (22.1)	2.3 (21.8)
concentrations (given in parenthesis)	5.7 (34.5)	6.0 (35.1)
	8.7 (41.2)	16.3 (46.5)
	15.7 (46.9)	44.7 (53.5)
	25.2 (50.8)	116.0 (56.7)
	61.0 (54.3)	156.0 (58.7)
	121.0 (57.1)	280.0 (60.7)
	277.0 (60.3)	375.0 (62.6)

Table 11: Commercial mill trial results

Parameter	Control	Trial
Surfactant DA-1, kg/T of pulp	nil	0.459
Anthraquinone, kg/T of pulp	nil	0.408
Active alkali consumption on BD raw material, %	16.86	15.47
Reduction in active alkali, %	-	8.2
DCM extractives in unbleached pulp, %	0.181	0.135
kappa number of unbleached pulp	19.6	19.3
Knotter screen rejects, number of trolleys/d)	195	150

different phases of the cook cycle. An interesting association exists between the AQ and the surfactants. Being insoluble and hydrophobic, AQ would definitely benefit from an agent to keep it in solution. It is believed that the surfactant micelle species might act as emulsifier for the extremely hydrophobic AQ, and thus disperse and transport them is solution. This would facilitate the rapid tranportation of AQ molecules more selectively to the reaction sites at the early stages of the cook. The data also show that at any given kappa number, AQ-surfactant treated samples could maintain higher pulp yields than control samples. The yield improvement could be due to the selective dissociation of lignin with no concurrent attack on the carbohydrates.

CONCLUSION

Through the application of pulping aids, mills can improve the efficiency and selectivity of their pulping operations. Use of dual pulping aid approach is expected to result in significant economic benefits in terms of reduced alkali requirement, reduced recovery loading and higher pulp yield.

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