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PULP LINE TECHNOLOGY AND OVERCAPACITY EFFECTS ON THE BLEACHING CHEMICALS CONSUMPTION - CASE STUDIES

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ABSTRACT

A survey was conducted on mills that produce the same product and quality, to understand their pulp lines behavior. This strategy enabled to study the evolution of the continuous digesters represented by four pulp lines established in the last 30 years to produce eucalyptus pulp. The aim was to understand the cooking effect, the washing and carryover effect, and the bleach plant effect on the chemicals consumption. There are patterns due to technology evolution and due to mill management that indicate how bleaching chemicals consumption may vary.

INTRODUCTION

The evolution of cooking and bleaching technologies over the recent decades have enabled substantial process optimization with respect to chemicals consumption (1-2). It is easy to find mill cases discussing the latest technologies updates in distinct aspects of the kraft cooking and bleaching technologies (3-4). However, there is scarce public information on the evolutionary effects that these technologies bring to the mills management, and how the mills manage the potential production capacity released by technology updates.

Mills of distinct technology vintages have been in operation all over the world (5). All of them manage process technology aiming at the balance of product quality, production ouput and profit. This paper examines a sample of the eucalyptus market pulp lines. The aim is to understand the cooking effect, the washing and carryover effects, and the bleach plant technology effect on the bleaching chemicals consumption.

OBJECTIVES

As a broad objective, to establish the effect of the evolutionary technology updates on the chemicals consumption in the bleaching plant, based on case studies. This objective includes the discussion of the possible causes that interfere in the achievement of optimum results in each case studied.

As a specific objective, to quantify the potential of technology updates in the digester room, brownstock washing room and bleach plant, based on the extreme cases observed.

EXPERIMENTAL

Four pulp lines were surveyed. The main selection criteria was the kraft cooking technology of the sampled pulp line. The selected digesters represent a 30-year evolution of continuous digester technology to produce eucalyptus pulp. They are identified in the Table 1.

Table 1. Continuous cooking digester identification in crescent chronological order of installation, and related kraft cooking technology.

pulp Line	installation period	cooking technology
# 1	early-seventies	co-current+counter-current (C+CC)
# 2	late-eighties	modified counter-current (MCC)
# 3	early-nineties	modified counter-current (MCC)
# 4	mid-nineties	isothermal (ITC)

All pulp lines studied have installed oxygen delignification plants. The pulp lines # 1, # 2 and # 3 were operating at the peak capacity deemed achievable by the mill management at the time of the survey. Pulp line # 4 was operating by the end of its startup learning curve, near its nominal capacity. These pulp lines represent a sample of continuous cooking evolution, from the seventies (# 1), to the state-of-the-art (# 4).

Each surveyed pulp production manager filled up a form about design and operational conditions of his production line. There was also a personal interview with these managers to clear up specific strategies and peculiarities of the operation. This was a co-operative program among the involved mills. Kvaerner Pulping - Brazil co-operated in the analysis of the design and operational data collected, with its proprietary cooking simulator, the Crossim 2, version 1.31 (6-7). It must be stressed that this work was evaluating the interaction of technology evolution with the operational strategies of each surveyed case, as they are practiced. It is not the objective of this work to judge the technological choices and/or operational methods in current practice.

Another portion of the work included sampling. All mills supplied screened eucalyptus wood chips and pulp samples. A sample from the last washer in the digester room represented the washed and screened digester sample. A sample of the last washer from the oxygen delignification represents the pulp that is ready to be bleached. These samples were examined for conventional parameters to determine the pulp quality and washing efficiency of each line. The ready-to-bleach samples were lab-bleached according to the fixed sequence (D70C30)EDED with various charges of active chlorine to establish bleaching curves. The results were interpolated for the consumption of active chlorine to achieve brightness 90.5 % ISO. Such lab evaluation informs the charge of chemicals necessary to fully bleach the pulps with the carry-over substances.

The pulp and pulp filtrates analysis of kappa number, brightness, viscosity, COD were determined according to specific ISO methods.

RESULTS

From preliminary work in the lab, there is no evidence that wood origin and chipping operations affect significantly the overall bleaching chemicals consumption. This evidence comes from the lab-produced pulps from eucalyptus wood chips, under standard lab pulping and bleaching conditions (data not shown).

Table 2. Pulp quality produced by each continuous cooking digester

pulp line	intrinsic viscosity v	kappa average k	kappa range	v/k ratio
	cm^3/g	-	-	v/k
# 1	1100	15.5	± 3	71
# 2	1150	15.5	± 2	74
# 3	1200	15.0	± 1	80
# 4	1350	17.0	± 1	79

The evaluation of the pulps quality from the digesters (Table 2) indicates that each mill is practicing a target kappa number around 15-16. The exception is the digester # 4, which is intentionally practicing kappa number 17. There is a direct indication that the pulping selectivity (expressed by viscosity figures or the ratio viscosity/kappa) has improved with the digester technology. Hence, this selectivity enhancement comes together with a decrease in the digester kappa number range. This kappa range is the statistical variation around the average observed on a daily operating basis of these digesters. These figures indicate that the evolving cooking technology and fine-tuned controls (e.g. automatic analyzers, digital controls) have been diminishing the heterogeneity of the continuous kraft cook, especially in the last decade, as indicated by digesters # 3 and #4.

Table 3. Pulp quality after oxygen delignification

pulp line	intrinsic viscosity v_1	kappa average k_1	kappa reduction	v/k ratio
	cm^3/g	-	%	v_1/k_1
# 1	950	10.5	- 32	90
# 2	1050	10.5	- 32	100
# 3	950	9.0	- 40	105
# 4	900	9.5	- 44	95

The same evaluation performed to the pulps quality after the oxygen delignification and washing (Table 3) indicate that this step allows a "smoothing" effect to the pulp quality. It is common operational practice to control kappa variations of the incoming pulp. This practice results in an evened ouput profile, limited by viscosity targets. From the data shown in Table 3, it is possible to learn that if selectivity is not so evident, delignification efficiency is better in new pulp lines.

Table 4. Pulp washing performance after digester and after oxygen delignification, based on COD load in the pulp filtrates.

	COD in pulp filtrates			
pulp line	after digester washing		after oxygen delignification washing	
	kg /ADMT	mg/L	kg /ADMT	mg/L
# 1	54	11	19	3
# 2	69	15	20	9
# 3	34	9	17	2
# 4	30	7	7	3

The COD load in the pulp filtrates after the digester washing and after the oxygen delignification (Table 4) demonstrate a general decreasing profile from the older to the newer lines. The line # 2 operates characteristic washing equipments that explain its deviation from the trend described above. The lines # 1-3 were running at their characteristic capacities. Only line # 4 was running at the design rates. The typical overcapacity drawback is a higher COD load in the filtrates to the bleach plant. Mill testing of washing strategies in line # 1 has demonstrated that the range of 12-18 kg COD/ADMT load introduces an extra demand of 3-6 kg act. Cl/ADMT to the bleaching plant. This comparison was between clean water and foul condensate washing.

Table 5. Pulp bleaching performance in the standardized lab sequence (D70C30)EDED. Data interpolated to achieve 90.5 % ISO. Kappa factor to DC stage = 1.9

pulp line	kg act. Cl / ADMT per kappa unit input to the bleaching plant	reduction %
# 1	4.3	reference
# 2	4.0	- 8
# 3	3.1	- 28
# 4	3.0	- 30

Not always, a COD overloaded system introduces extra consumption of chemicals to the pulp to be bleached. As can be seen in Table 5, the line # 3 does not produce a pulp that consumes much more chemicals, compared to the line # 4. In the line # 3, it seems that the washing system is releasing oxydized dissolved solids to the bleach plant. The mill states that the condensate is clean. The Table 5 informs the optimized amount of active chlorine due to fibres bleaching plus the consumption by the carryover from the unbleached portion of the mill. The mixing and internal carryover problems of each industrial bleaching plant evaluated were isolated by this lab strategy. The evaluation of the specific chemicals consumption on a unit kappa number basis permits to state that there are more effects involved than the unbleached pulp carryover overload. A comparison of worst to best case (# 1 versus # 4 lines) provides a 1.3 difference. The line # 1 can only attribute a maximum of 0.6 unit to the washing overload towards the bleaching line. The remaining consumption must be attributed to the intrinsic quality of the kraft unbleached pulp of that line.

DISCUSSION

Digester design and operation

This paper intends to discuss the evolutionary technology effects on the chemicals consumption. From the data collected it is evident that the digester technology updating provides benefits that can be indirectly infered, as this work made possible.

Table 6. Design criteria for the studied digesters

pulp line	production per screen open area (AD kg/m^2.min)				production per digester traverse area*
circulation loop screen tag****	trim **C6**	extr **extr**	cook **C66**	wash **C8**	**ADMT/m^2.day**
# 1	-	210	292	269	49.5
# 2	350	92	72	164	41.5
# 3	196	92	83	116	39.9
# 4	123	79	79	151	26.7

* Digester traverse area @ washing zone

** Circulation name and screen tags are according to Kvaerner Pulping nomenclature to designate the function of each circulation loop.

Table 6 summarizes aspect of design criteria of the digesters studied. The evolving technology of continuous digestion has provided the adequate circulation of liquors and improved loading of the vessel. The pulp throughput per traverse area of the vessel has changed. The mass, and consequently the volumetric loads to the circulation screens were initially high (line # 1). Along the years, these loads to the screens have been trimmed according to the novel pulping strategies proposed (1,5).

One important point of discussion is the role of the trimming circulation (C6), close to the top of the digester. A set of graphs depicted in Figure 1 informs the vertical kappa number profile in each of the studied digesters. These graphs were provided by the Crossim Pulping Simulator (6-7). These graphs confirm that uneven cooking occur inside the digesters # 1 and # 2. The origin is the heterogeneous bulk phase caused by insufficient mixing of liquor and heat. The model is able to explain the digester output variability observed in the mills survey data.

The uniformity of a digester top portion, by means of the C6 circulation design and control, play a role in the bleachability of the pulp. The isothermal profile and adequate specific flows in the digesters # 4 and #3 (not shown) determine an adequate alkali and temperature distribution during the bulk phase of the cook. In the case of uneven distribution, the abnormalities produced during this phase can not be overcome anymore. These are the cases of digesters # 1 and # 2. Digester # 1 does not even have this circulation. Digester # 2 seems to have this circulation overloaded, as compared to newer designs (# 3 and # 4 digesters). This circulation must distribute alkali and heat without blocking the chips column, that is moving downwards. A high volumetric flow per screen open area, may mean high fluids velocity around the screen plates. This disturbed region impedes the chips column to move downwards. The intentional flow decrease to sub-optimal rates can release the chips column, but disturbs the cooking kinetics and the radial profiles of heat and alkali. A common symptom from such digesters operation is the severity of the column blockages it experiences. Every blockage and recovery of the operating parameters converts into a cycle of shifting digester quality.

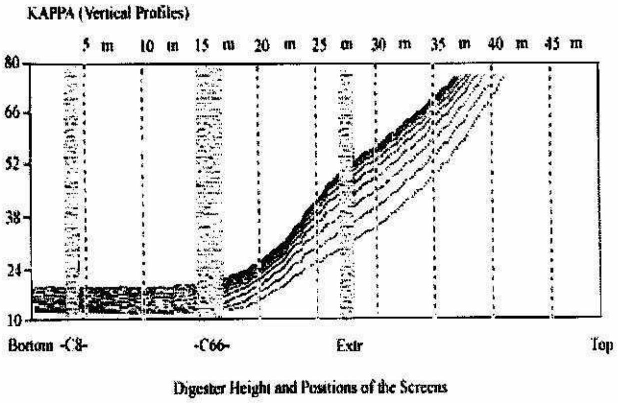
Factors that potentially affect pulp bleaching

The ability to bleach a pulp can be affected by the factors discussed in this work, with variable intensity, according to each case. A calculation of the maximum potential economy in bleaching chemicals, due to technology and process constraints of the whole pulp line can be estimated from this work. It is a case to case comparison, summarized in Table 7.

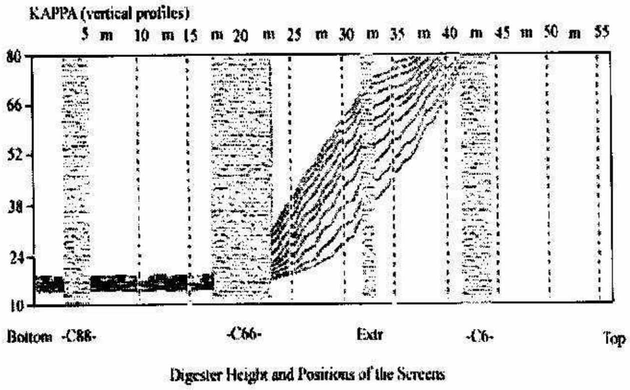
Table 7. Stepwise balance of bleaching chemicals consumption. The relative data refer to existing pulp line figures in comparison to a benchmark pulp line.

relative consumption of bleaching chemicals			
	factors	balance of factors	
pulp line consumption reference case studied	100%		
pulp line consumption with clean washing	90%		
		10%	foul condensates
pulp consumption lab bleached pulp	73%		
		17%	bleach plant overload (balance estimate)
pulp line consumption benchmark case studied	60%		
		13%	digestion technology update
potential reduction of chemicals		**40%**	

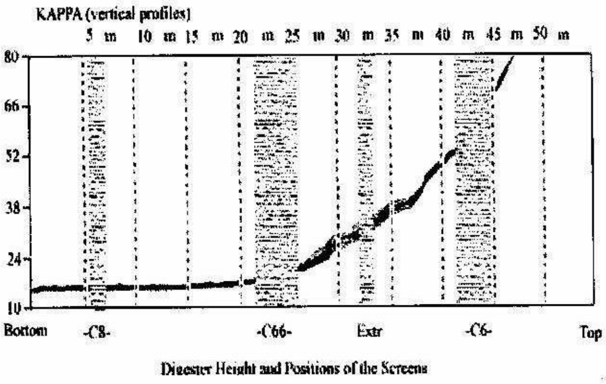
There is a great potential economy overseen in this balance. The amount due to technology update of the digester is relevant. Foul condensates problems refer to optimization of the evaporation plant. The kraft digestion technology update competes equally with the washing debottlenecking that is normal practice in mill optimization projects.



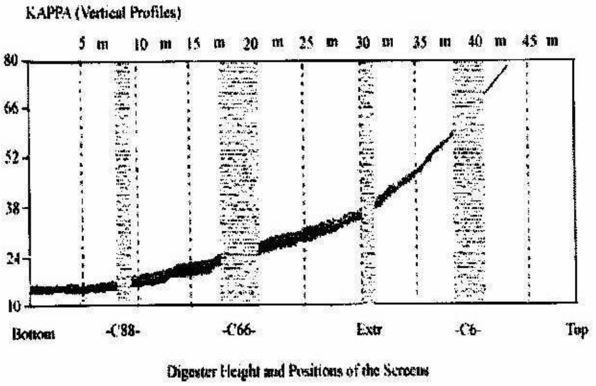
Pulp line # 1 – The digester does not have a trimming circulation. The dispersion of vertical kappa profile is in the beginning of the cook. At 40 m height, the center-to-shell temperature profile varies 7 °C (not shown).



Pulp line # 2 – The digester is MCC design. The dispersion of vertical kappa profile is in the beginning of the cook. At 40 m height, the center-to-shell temperature varies 10 °C (not shown). The digester runs non-optimized circulation flows. The vertical temperature profiles are uneven (not shown).



Pulp line # 3 – The digester is MCC design. There is little dispersion of vertical kappa profile through the cook. The center-to-shell temperature profile is negligible. The digester runs even temperature profiles and the kappa variation is minimum.



Pulp line # 4 – The digester is ITC design. There is litlle dispersion of vertical kappa profile through the cook. The center-to-shell temperature profile is negligible. The digester runs vertical temperature profile of 150 °C and the kappa variation is minimum. Lowest alkali consumption is reported.

Figure 1. Vertical kappa number profiles and predicted kappa output range at steady conditions of the surveyed digesters. Modeling was performed by the Crossim 2 simulator. The names of the screens are according to circulation loop: C6 (trimming), Extr (extraction), C66 (cooking), C8 (washing), C88 (ITC).

CONCLUSIONS

It is the objective of this work to demonstrate the opportunities that a mill has, when it is seeking production scale-up and plant optimization. The relationship between the cooking technology and the bleaching chemicals consumption is a difficult-to-prove task in existing mills. The methodology followed by this work allows the partition of the bleaching chemicals consumption, based on actual cases.

A thorough break-up of an evaluation and the proof for indirect gains is important to establish the return of investment in mill optimization projects.

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REFERENCES

1. Dallhöf, H.: State-of-the-art and recent developments in technologies for cooking, washing and bleaching. 1997 Kvaerner Symposium, Oct. 10, 1997. Foz do Iguaçu, paper 1, 11pp.

2. Dillner, B., Larsson, L-O, Tibbling, P.: Non-chlorine bleaching of MCC-pulp. 1989 TAPPI Pulping Conference, October 22-25, Seattle. Book 1. pp.213-221.

3. Donato, E. M.: Cenibra ITC continuous cooking. 1997 International Emerging Technologies Conference, March 9-13, 1997. Orlando, paper 2-3. 15pp.

4. McDonald, S., Uusitalo, P., Hiljanen, S.: Performance of mill-scale superbatch displacement batch cooking systems. 1993 TAPPI Pulping Conference, November 1-3, 1993, Atlanta. Book 2, pp 415-421.

5. MacLeod, J.M., Kingsland, K.A., O'Hagan, T.J., Thomas, B.C., McPhee, F.J., Tristram, R.W., Kowalska, R.E.: Pulp strength delivery along kraft mill fiber lines. 1994 TAPPI Pulping Conference, November 6-10, 1994, San Diego, Book 1, pp 183-191.

6. Olson, T.: Continuous cooking simulation in computers. 1993 Kvaerner Symposium. August 19-20, 1993. Curitiba. Oral presentation.

7. Antbacka, S. : ITC cooking . 1993 Kvaerner Symposium. August 19-20, 1993. Curitiba, paper 2, 30 pp

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