SUPERBATCH PULPING OF EUCALYPTUS: THE EFFECT OF PRODUCTION RATE

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ABSTRACT

The objective of this research was to evaluate the effect of changing the production rate in kraft and kraft-anthraquinone SuperBatch cooking of *Eucalyptus grandis*, considering the digester as a bottleneck. Three production rates were considered: at rated capacity, 50% below rated capacity, and 50% above rated capacity. Variations in the production rate were simulated by changing the impregnation and cooking times. The H factor was kept constant by adjusting the temperature and the alkali charge was varied to achieve the targeted kappa number. Anthraquinone was considered as an additive to increase the production capacity. After each cook, yield, kappa number and viscosity were determined. The pulps were bleached using an OD(EPO)D sequence. The bleached pulps were characterized with respect to mechanical properties after refining. The black liquors were analyzed for residual alkali, organic content, and residual anthraquinone. The results showed that the production rate does not affect the yield but for lower production rates the alkali requirement is slightly higher. The addition of anthraquinone leads to a reduction in kappa number with no effect on yield, which suggests that the total alkali charge can be reduced and the yield increased at a given kappa number. The bleaching characteristics of the pulps were not affected by production rate. Pulp viscosity decreased as the production rate was increased. We concluded that SuperBatch pulping of Eucalyptus can be considered very flexible in relation to the production rate. Increasing the production rate does not significantly change specific chemical consumption during pulping and bleaching but there is a slight change in pulp characteristics. The use of anthraquinone should be considered at high production rates.

1. INTRODUCTION

The kraft pulping process was developed by Dahl in 1879 and is still the world's dominant pulping process. Since it was first developed, several modifications of the kraft process have been implemented to improve its yield and pulp characteristics. During the last decade, these have been directed towards increasing extent of delignification without loss of yield or pulp quality, to facilitate the use of ECF and TCF bleaching sequences.

An increase in extent of delignification is usually accompanied by a loss in yield, since the pulping chemicals are not completely specific for lignin removal. Consequently, development of the modified processes required substantive changes. Extended delignification without loss of pulp viscosity ("modified cooking") is achieved through changed concentration profiles of both active cooking chemicals and dissolved lignin. Compared with conventional cooking, the fundamental changes are that a more uniform effective alkali concentration profile is maintained and the final part of the cook is carried out with a minimum concentration of dissolved lignin in the cooking liquor (1). These changes result in better distributions of alkali charge and energy. Such modifications are embodied in several patented process, of which one is the SuperBatch process.

The increase in extent of delignification may be further enhanced by the use of pulping additives that improve the delignification kinetics. The use of additives in conjunction with the modified processes has the potential to be of commercial interest. The best known additive, anthraquinone, has been shown to be very effective in improving both yield and delignification rates. The use of anthraquinone in the kraft process is gaining popularity, largely because of recent price reductions and the industry's desire to increase production without capital expenditure (2).

Production increases are a normal part of a pulp mill's evolution. In the early stages of a new mill's operation, the production rate is usually below rated capacity. As the mill moves up the learning curve, its production increases and eventually reaches a level equal to rated capacity. Further efforts to maximize capital effectiveness result in additional production increases, and bottlenecks begin to appear. If not closely monitored, the higher production levels can lead to process inefficiencies and pulp quality deterioration.

The objective of this research was to determine the effects of changing production levels in kraft and kraft-AQ SuperBatch cooking on the pulping process and on the quality of the pulp produced. Three digester production rate levels were investigated:

- 50% below nominal capacity
- at nominal capacity
- 50% above nominal capacity

2. EXPERIMENTAL

Industrial chips of *Eucalyptus grandis* were kindly supplied by Votorantim Celulose e Papel, Brazil. For the kraft-AQ cooks a commercial grade of anthraquinone powder was used.

The SuperBatch cooks were conducted to a kappa number of 16 ± 1 and the production levels were simulated by altering the time and temperature to keep the H factor constant. The alkali charge was changed to reach the target kappa number.

The pulps with the targeted kappa number were bleached by the OD(EPO)D sequence to reach brightness higher than 88% ISO. The bleached pulps were stored for later analysis.

TAPPI Test methods were used for all pulp evaluations, except where otherwise noted.

3. RESULTS AND DISCUSSION

Information on the basic characteristics of the raw-materials used for pulping is needed to fully understand the behavior of the process, specially when considering different pulping processes and species. Table 4 gives results of determinations the basic characteristics of the *Eucalyptus grandis* used in this study.

Table 1. Raw Material Characteristics

Parameter	Value
Basic density, g/cm^3	0.483
Extractives content, %	4.42
Lignin content, %	23.51
Holocelullose content, %	72.07
Fiber length, mm	1.09
Fiber width, μm	18.60
Lumen diameter, μm	9.80
Wall thickness, μm	4.40
Wall fraction, %	47

The results presented on table 1 show that the material used on this research can be considered representative for the specie *E. grandis* used for pulp production in Brazil.

Figures 1 through 8 summarize the observed values of the parameters evaluated in this research.

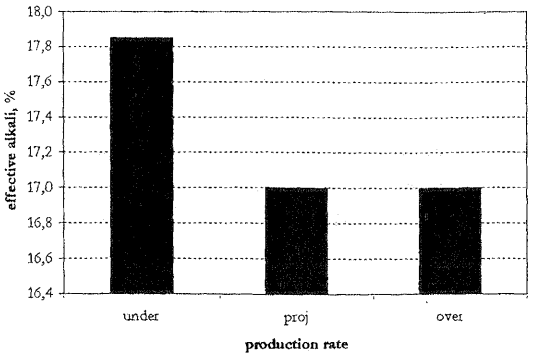

Figure 1. Alkali charge

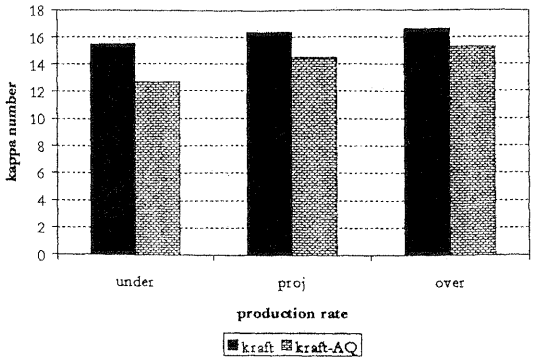

Figure 2. Kappa number

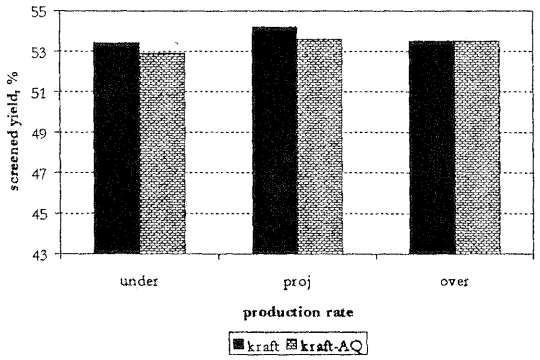

Figure 3. Screened yield

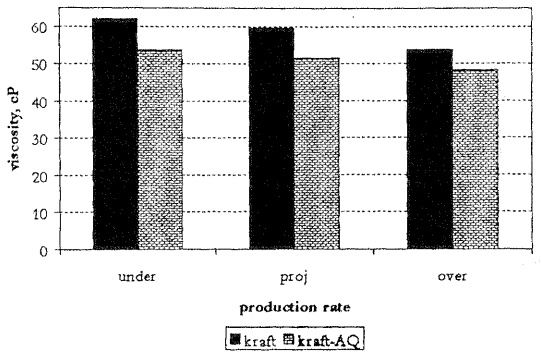

Figure 4. Pulp viscosity

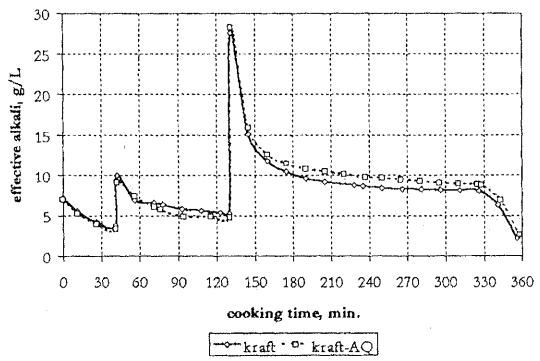

Figure 5. Alkali profile

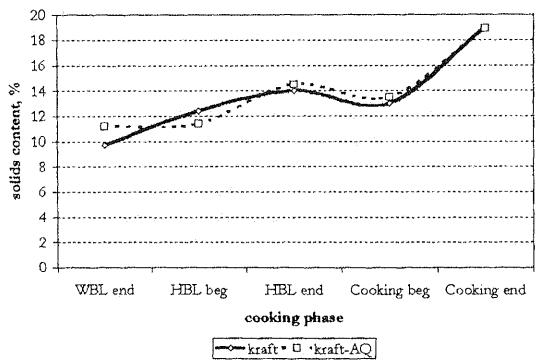

Figure 6. Solids profile

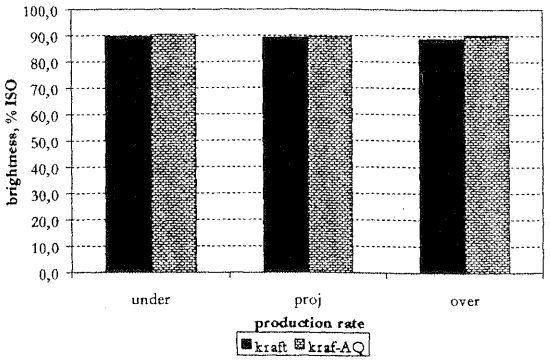

Figure 7. final brightness

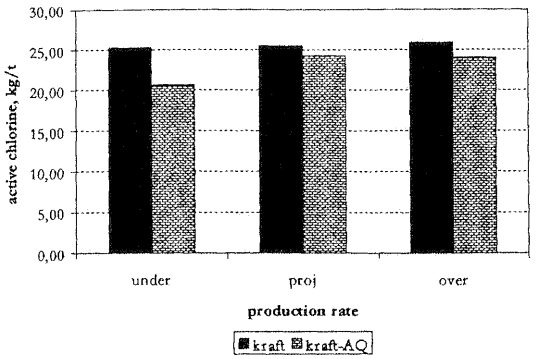

Figure 8. Chlorine charge

The results of Figure 1 show that for low production rates, the alkali charge needed to reach the targeted kappa number is high compared to those for normal or high production rates. A possible explanation is that at low production rates the process time is very long and in order to maintain a constant H-factor, the required maximum temperature is very low. As a consequence, the pulping reaction rates become so low that it is necessary to increase the active alkali concentration to obtain the targeted delignification degree.

The most interesting of the results presented in Figure 2 is the effect of anthraquinone on SuperBatch pulping. It is apparent from the figure that anthraquinone significantly reduces the kappa number at all production rates, especially the lowest one. It follows that, in the presence of added anthraquinone, the alkali charge is greater than needed to achieve the targeted kappa number. In practice it would therefore be possible to reduce the alkali charge and bring about an increase in pulp yield at the targeted kappa number.

Apparent effects on screened yield, as presented in Figure 3, must be viewed in relation to the corresponding kappa numbers, shown in Figure 2. At the nominal (project) production rate, the screened yield was higher than at the other two production levels. At the low rate, the slight yield reduction may be the result of a slightly lower kappa number. At the high rate, the yield reduction is probably due to the known loss of selectivity associated with increased temperature. The apparently greater effect of anthraquinone at higher production rates is due to the correspondingly higher kappa numbers of the anthraquinone cooks at high production rates.

Figure 4 shows that pulp viscosity decreases as a result of the higher cooking temperatures needed to achieve high production rates. The apparently negative effect of anthraquinone would probably disappear if the alkali charge were reduced to adjust the kappa numbers to the same values as were obtained in the corresponding cooks without anthraquinone.

Observation of the alkali and dissolved solids profiles can provide important information about the pulping process and pulp characteristics. Modern extended pulping concepts suggest that both should be kept as low as possible. Figure 5 shows typical alkali profiles for the SuperBatch pulping process. It is characterized by well-defined peaks that result from alkali replacement during the pulping process. Figure 6 shows the corresponding dissolved solids profiles. In the SuperBatch process, the use of black liquor impregnation and two liquor displacements steps limits the increase in solids content during cooking.

Considering that virtually all *E. grandis* kraft pulp is bleached, evaluation of the effect of the production rate on pulp bleachability is important. Figure 7 shows that neither the production rate nor the addition of anthraquinone affect the final brightness when the bleaching chemical application is adjusted for differences in unbleached kappa number. Apparent differences in bleaching chemical requirements (Figure 8) can be ascribed to the differences in unbleached kappa number (Figure 2). Pulps produced under all of the conditions investigated in this study can be bleached to high brightness levels.

4. CONCLUSIONS

We concluded that SuperBatch pulping of *E. grandis* can be considered very flexible in relation to the production rate. Increasing the production rate does not significantly change specific chemical consumption during pulping and bleaching but there is a slight change in pulp viscosity. The use of anthraquinone should be considered at high production rates.

5. ACKNOWLEDGMENTS

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