

Two-Stage O₂ Delignification System Cuts Mill's Chemical Use, Boosts Pulp Quality

Arauco mill in Chile has significantly reduced chlorine, chlorine dioxide, and soda consumption in standard and ECF pulps, as well as reducing effluent discharges.

— BY MANUEL ALEJANDRO GONZALEZ SALDIVIA

Kappa number is normally decreased in modern mills by including an oxygen delignification stage before bleaching, using oxygen and oxidized white liquor. However, the kappa number can be further decreased by applying extended delignification in two stages. This results in longer residence times and operating conditions that produce a higher degree of delignification than is possible with conventional systems.

Celulosa Arauco's mill in Arauco, Chile, spent almost two years investigating and researching new technologies that could ensure actual decreases in the kappa number at the bleaching infeed—with the consequent reduced consumption of chemicals—and concluded that extended oxygen delignification in two stages was the right answer.

The application of extended delignification in two stages by means of the OxyTrac system has benefited the Arauco mill in two ways. On one hand, it has increased kappa number at the digester outfeed, with the consequent effect on pulp quality and yield, while on the other hand it has enabled the mill to significantly reduce specific amounts of chemicals used in the bleach plant, due to the higher degree of delignification.

This article examines results achieved at the Arauco mill when the OxyTrac oxygen delignification system in two stages (supplied by Metso) was installed in production line No. 2.

Oxygen Delignification

Removal of lignin present in pulp after the cooking process may be achieved with a higher alkali charge during the cooking process itself, with the consequent effect on yield, due to decreased selectivity with increased alkali charge. However, increased delignification can instead be achieved by adding an oxygen stage, which under the appropriate conditions of pressure, temperature, and alkali charge, results in higher delignification without any significant effect on pulp yield.

Figure 1 shows that oxygen delignification has a behavior very similar to the theoretical delignification curve (good selectivity), greatly reducing the yield loss compared with that carried out with pulping, while simultaneously improving kappa number at the bleaching inlet.

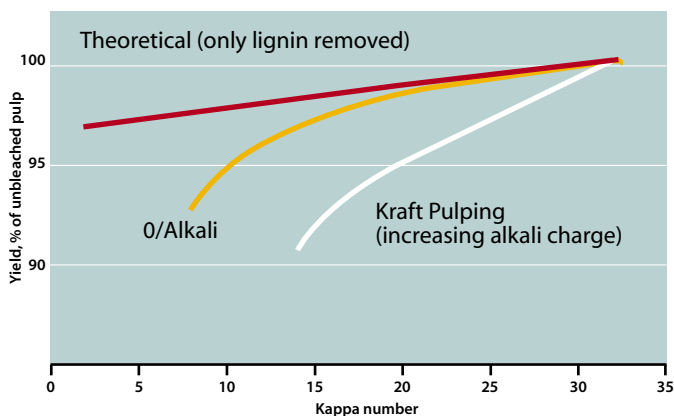


Figure 1. Effect of oxygen delignification.

Due to the high selectivity of oxygen to remove lignin, this element is normally used to delignify pulp before bleaching. At this stage, the kappa number of pulp for bleaching can be reduced, making it possible to produce higher brightness and reduce chemical consumption in the bleach plant. On the other hand, a lower kappa number at the bleaching stage makes the improvement of cir-

cuit close-ups possible, helps the implementation of new recirculations, and simultaneously reduces liquid effluent volume discharged from the bleach plant to the sewer.

Oxygen delignification in two stages

Oxygen delignification in two stages exploits delignification reaction kinetics and allows maximum delignification of the pulp.

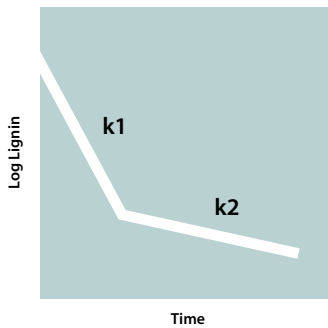


Fig. 2. Kinetics of the oxygen delignification reaction.

Figure 2 depicts the behavior of oxygen delignification reaction kinetics. The occurrence of two reaction stages can be clearly seen—the first with a higher speed and shorter time and the second with a slower speed and longer time.

Delignification systems in two stages are currently designed in such a way that the first phase of the reaction occurs in the first reactor, which has a short residence time. The second stage has a longer residence time to allow the second phase of the delignification reaction (60 min) to be carried out. Furthermore, both stages have different conditions of pressure, temperature, and alkali charge, which together contribute to maximizing the delignification reaction selectivity.

Currently, there are a number of set-ups that meet the conditions of delignification reaction kinetics. All of them seek to provide the best conditions in order to maximize the delignification speed, at both the initial and final stages. One of these set-ups is the Metso OxyTrac system.

OxyTrac is an extended delignification system divided into two stages to achieve higher delignification of the pulp and improved selectivity. The first stage takes place in a rather small reactor with a residence time of 40 min, which operates at high pressure (8 bars at the top) and low temperature (80o C).

All of the oxygen and alkali are added at this first stage. This provides the right elements for a higher selec-

tive breakdown of lignin present in the pulp. The higher pressure and lower temperature help to dissolve oxygen in the liquor, resulting in a higher oxygen concentration for the reaction.

The second stage occurs in a larger reactor (residence time of 60 min), where the pressure is lower (3 bars) and the temperature is higher (90o-100o C). This provides the right elements to carry out the slower delignification stage. The longer residence time gives the proper volume to complete the slower stage of the delignification reaction, while the higher temperature makes it possible to remove the lignin most strongly bound to the pulp, thus improving the lignin diffusion coefficient.

Figure 3 shows a typical OxyTrac system layout. Chemicals are added at the first reactor inlet to provide good conditions for a faster reaction. Medium pressure steam is injected at the second reactor inlet to raise the temperature to 90o-100o C.

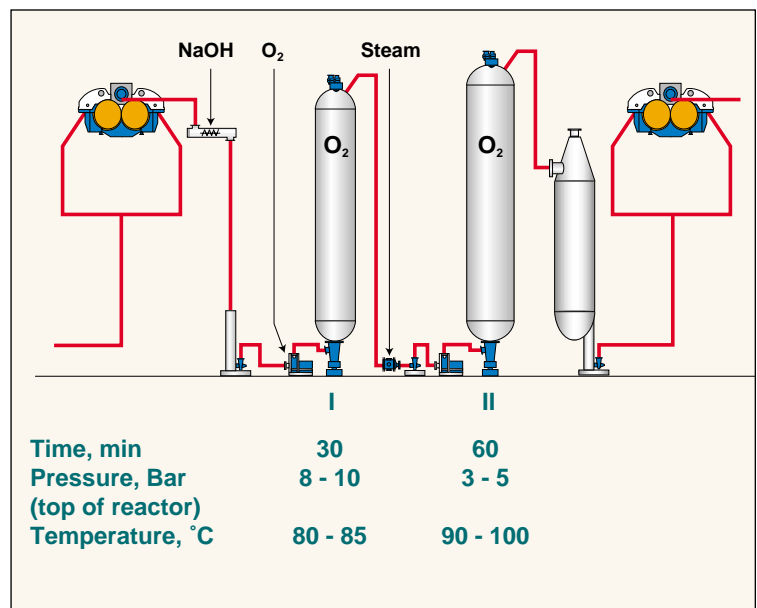


Figure 3. Typical OxyTrac system set-up.

Original Arauco mill configuration

The Arauco mill had previously operated with a conventional delignification system, consisting of an MC pump, a Komax pulp heater, an oxygen mixer, and an oxygen reactor.

This one-stage delignification system was originally designed for a residence time of 60 min. After sustained production increases and consistency adjustment problems, however, the residence time was gradually reduced to values around 40 min, which meant that no more than 38% delignification was achievable. This required low kappa number levels at the digester outlet (with the consequent effect on pulp quality) in order to achieve lower kappa numbers at the bleaching inlet to get the required brightness of bleached pulp.

The delignification system had a lot of problems in the pulp blowing area after the oxygen reactor, due to the lack of stability of the pulp flow fed to the post-oxygen press. This low stability caused large consistency variations, which led to continuous shutdowns of the post-oxygen press. The low feeding consistency at the stage and an inadequate oxygen injection rate were also factors contributing to these big variations in the pulp flow. Variations in the oxygen flow led to drastic changes in the stability of the kappa number at the bleaching inlet.

OxyTrac System at the Arauco Mill

The OxyTrac system proposed for the Arauco mill consisted mainly of Metso-supplied equipment, in addition to some equipment provided by Arauco. The Metso equipment included an oxygen reactor, an MC pump, a pulp heater, an agitator for the blow tank, and a liquid cooler.

Additionally, the mill had to make some modifications to provide conditions required for the system. These included a new white liquor oxidation system, a new oxygen compressor, and modifications or changes to pumps that had too low capacity. Also, several modifications had to be made in the causticizing area of Line No. 1, which were intended to improve white liquor production, hence reducing transference from Line 2.

The OxyTrac system startup required certain operating conditions to be changed. These involved modification of pressure and temperature variables in the delignification area, as well as changes in chemical dosing.

Table 1 shows conditions before and after installation of the OxyTrac process in the delignification area

Operating Conditions	Single Stage	OxyTrac
Production Rate (adt/day)	1550	1550
Inlet Kappa Number	24 – 29	28
Outlet Kappa Number	16 - 17	14
1st Reactor Pressure (Bars)	3.8 – 4.0	8.0
1st Reactor Temperature (oC)	94	82
2nd Reactor Pressure (Bars)	--	4.0
2nd Reactor Temperature (oC)	--	90
Inlet Consistency (%)	9.5 – 10.0	>10.5
Oxidized White Liquor		
Consumption (kg NaOH/adt)	10	23
O2 Consumption (kg O2/adt)	10	25

Table 1. Operating conditions of single-stage and OxyTrac system for oxygen delignification

Additionally, a new delignification supervisory control system was adopted. By optimizing the chemical addition, this system improves outlet pulp quality and reduces any deviation in the kappa number at the bleaching inlet.

Project Results

After implementation of the new oxygen reactor, a notable reduction in kappa number at the bleaching inlet was observed. The kappa number decreased from average values of 16-17 to a level lower than 11.5, even though the kappa number at the digester outlet increased around 3 points, reaching values close to 29. Figure 4 shows the development of kappa number at the bleaching inlet related to kappa number at the digester outlet, before and after startup of the OxyTrac system.

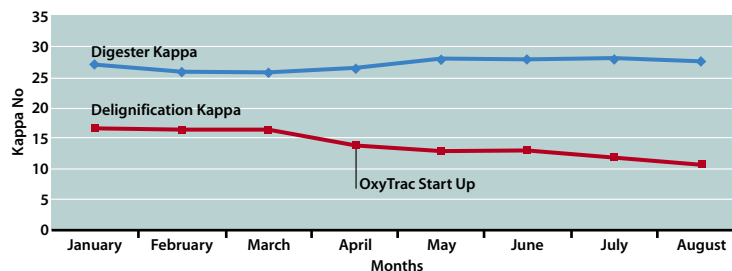


Figure 4. Development of kappa number.

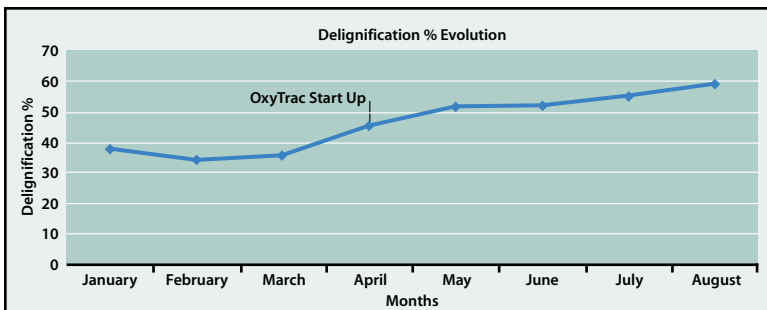


Figure 5: Development of delignification degree.

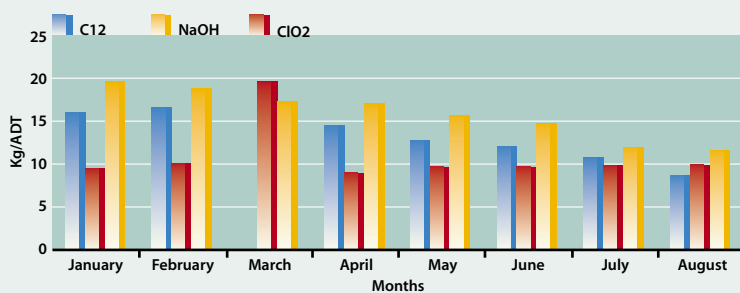


Figure 6. Chemical consumption for bleaching of standard pulp production.

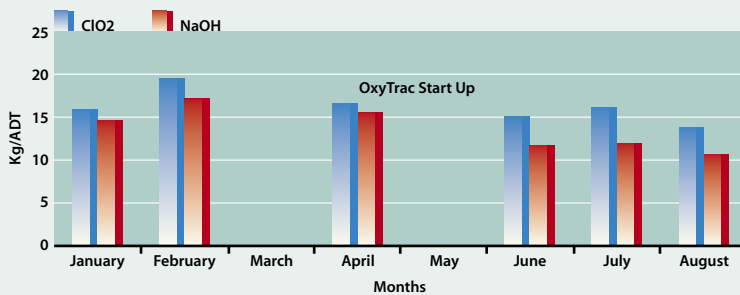


Figure 7. Evolution of chemical consumption for ECF pulp

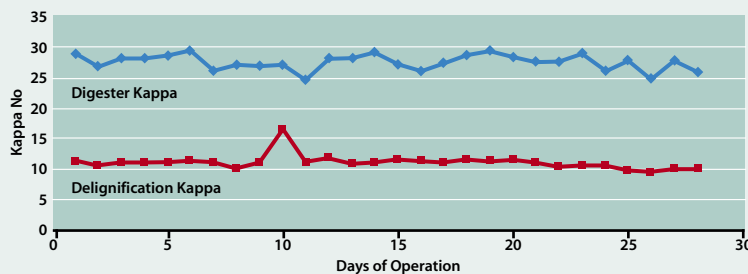


Figure 8 the effect of the new supervisory control system

This development of kappa number has meant an increase in the degree of pulp delignification, from values around 38% to values above 55%. Depending on the alkali and oxygen addition and temperature, it has even been possible to achieve values above 60% delignification. Figure 5 shows the degree of delignification before and after startup of the new system

The major benefit related to adoption of the two-stage delignification system is the reduction of chemicals consumption in the bleaching area. Startup of an extended delignification system has significantly reduced the specific consumption of soda, chlorine dioxide, and chlorine. This has lowered plant operating costs while enabling the production of a better quality product.

Figure 6 show the evolution of specific chemical consumption before and after startup of the OxyTrac system, in the production of standard pulp. The significant reduction in chlorine and soda consumption for standard pulp is particularly notable. After startup of the two-stage system reactor, consumption of chlorine and soda were reduced by about 40% and 45%, respectively.

In the case of ECF pulp production, the trend experienced was similar to that of standard pulp. The reduction observed for both chlorine dioxide and soda reached values of 31% and 38%, respectively. Figure 7 shows the evolution of specific consumption of ClO2 and NaOH for ECF pulp production.

An important consideration in the adoption of the two-stage oxygen system is replacement of the existing supervisory control in the delignification area. Accordingly, the Arauco mill ordered a new supervisory control system along with OxyTrac. The system is based on reaction kinetics and, equipped with a proper

control strategy, enables improvement of final pulp quality, eliminating the effect that kappa number variations at the digester outlet had on kappa number at the bleaching inlet.

Figure 8 shows the effect of the new supervisory control system with variations of kappa number at the digester outlet. The graph shows the high stability of bleaching inlet kappa number, even in the presence of significant variations in digester outlet kappa number. This high stability has made it possible to optimize chemical consumption in the bleaching area on one hand, while enabling an improvement in pulp quality at the bleaching inlet (more stable) on the other hand, which obviously improves final pulp quality.

The intrinsic viscosity has improved for both standard pulp and ECF pulp production, although the kappa number at the bleaching inlet has been reduced from 17 to 11.5 on average. For standard pulp, the intrinsic viscosity increased from 840 cm³/g to 850 cm³/g, and for ECF pulp it increased from 859 cm³/g to 877 cm³/g.

This higher stability and pulp quality improvement is the result of both higher selectivity in the oxygen delignification process and a more stable chemical addition in the delignification area (optimization of the corresponding chemical loads).

Conclusions

Adoption of the two-stage oxygen delignification system has resulted in a notable increase in the degree of pulp delignification for the Arauco mill, from 39% to values

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above 60%, with no adverse effect on pulp quality. This higher delignification capability has made it possible to raise the kappa number at the digester outlet, improving pulp quality.

The new system has also reduced the specific consumption of chemicals in the bleaching area,

reaching values far lower than those originally planned for the project. For the Arauco mill, this has resulted in highly attractive financial gains in the production of standard pulp as well as ECF pulp.

Startup of the new supervisory control system has resulted in a definite reduction of kappa number stability problems at the bleaching inlet, by optimizing chemical loads in the delignification area. This new control has contributed to the proper addition of alkali and oxygen, improving pulp quality and oxygen overdosing problems, with the consequent effect on feeding stability for the post-oxygen press.

Additionally, the higher stability and better quality of pulp fed to the bleaching stage has produced cleaner filtrates, which helps in the adoption of a new recirculation. This new recirculation that feeds filtrate from the EOP stage to the second shower of the C/D washer has allowed a reduction of soda consumption in the EOP stage, as well as a decrease in effluent flow from the bleach plant, currently down to 5,040 m³/day.

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