

Mill optimization using Monox-LTM as a replacement for chlorine dioxide

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Chemical costs per ton of pulp were reduced while brightness and viscosity stayed in their target ranges for the Kuusanniemi pulp mill in Finland.

In November 1987, Quantum Technologies conducted its first plant trial using Monox-L bleaching agent at Kymmene Corp.'s Kuusanniemi pulp mill in Kuusankoski, Finland. This trial involved the substitution of Monox-L (M) in the first chlorine dioxide stage (D1) of a (C+D)(E+P)DPD sequence. The results of this trial were presented at the TAPPI 1988 International Pulp Bleaching Conference.¹ A subsequent plant trial was conducted in February 1988. Based on the results of these two plant trials, Kymmene ordered a 20-metric-ton/day Monox-L generator in June 1988. The unit was delivered, set up, and operational by February 1989. The generator startup experience and initial operation and bleaching results are reported elsewhere.²

Since its startup, the Monox-L generator has been in continual operation for more than one year, replacing the D1 stage in the 600-ton/day softwood line. During this operation, there has been continual optimization of the bleaching process, leading to improvements in chemical usage and pulp quality. Laboratory data had suggested that the substitution of Monox-L for chlorine dioxide on approximately a 1.1:1.0 ratio would produce equivalent-quality pulp in terms of brightness, strength, and effluent characteristics. At the plant trials and initial startup, the Monox-L charge levels were higher than this projected ratio. During the continual operation of the unit, chemical charge levels were reduced considerably. The decrease of the chemical charge rates has resulted in increased chemical savings, improved pulp strength, and reduction in levels of chlorinated organic discharge. Under these conditions, both pulp quality and environmental effluent characteristics are comparable to those obtained before the Monox-L substitution. In addition to the cost savings, the use of Monox-L in the softwood line resulted in allowing the corresponding quantity of ClO₂ to be used in the C/D stage of Kymmene's birch line to reduce pulp extractives content and lower AOX emission levels.

I. Conditions of the bleaching performed in Kymmene's laboratory

	Original pulp			
	D1	M1	P2	D2
Consistency, %	10	10	10	10
Temperature, °C	55	55	60	73
Time, h	3	3	1.5	3
ClO ₂ charge, % as ClO ₂				
In DPD	0.84	...	...	0.7
In MPD	...	...	...	1.0
HOCl charge, %	...	0.84	...	...
NaOH charge, %	0.36	0.35	0.5	...
H ₂ O ₂ charge, %	...	...	0.1	...
DPD				
Final pH	3.0	...	10.4	3.5
Residual, %	0.02	...	0.05	0.05
Brightness, % ISO	80.7	...	83.2	90.6
Brightness reversion, % ISO	...	...	...	85.4
Viscosity, dm ³ /kg	870	...	...	810
MPD				
Final pH	...	3.4	10.3	2.9
Residual, %	...	0.08	0.03	0.09
Brightness, % ISO	...	78.9	77.3	90.0
Brightness reversion, % ISO	...	...	...	84.3
Viscosity, dm ³ /kg	...	840	...	780
Original pulp: C(D)P, kappa no. 4.5, viscosity 900 dm ³ /kg, brightness 41.2 ISO.				

Laboratory studies

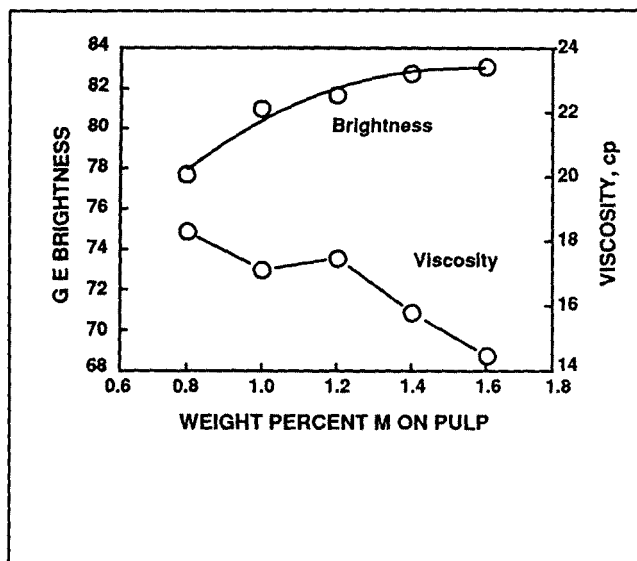
Laboratory studies were performed on the Kuusanniemi pulp before any mill trials were conducted. The purpose of these studies was to evaluate the effects of Monox-L and to give guidelines for the starting point in the mill

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¹Hurst, M. M., Yant, R., Korhonen, R., and Vakeva, K., 1988 International Pulp Bleaching Conference Proceedings, TAPPI PRESS, Atlanta, p. 99.

²Yant, R., Smeds, U., and Hassi, H., 76th Annual Meeting Proceedings, Technical Section CPPA, Montreal, 1990, p. B315.

1. Percent Monox-L vs. brightness and viscosity

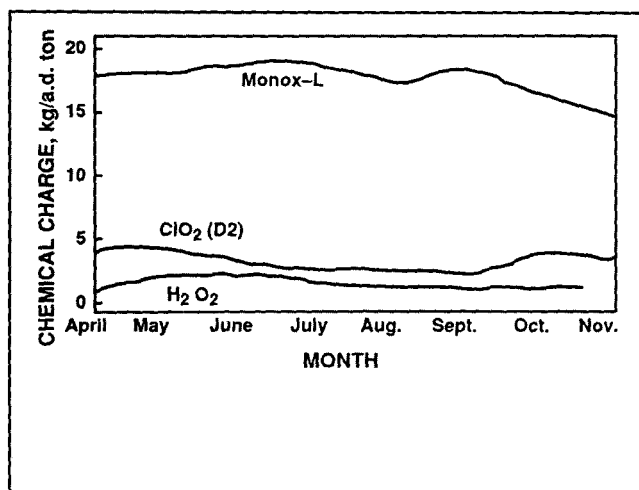


II. Target brightness continued to be achieved even as levels of Monox-L were reduced

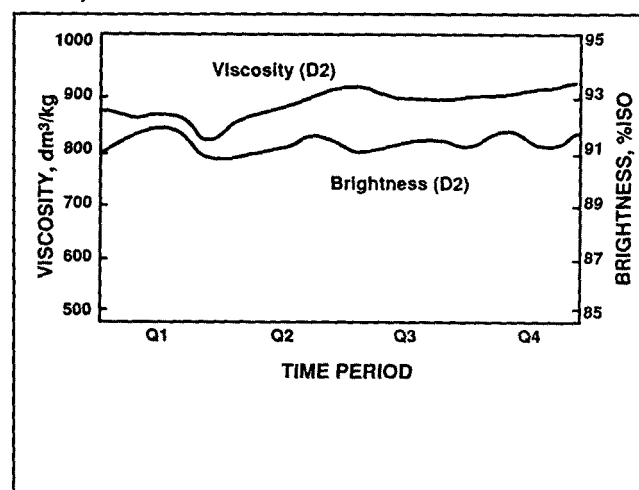
	November 1987		March 1988		April 1988	
	Ref.	M	Ref.	M	Ref.	M
D1 or M1 stage						
% D or % M	1.22	1.70	1.30	1.32	1.30	1.40
Brightness, % ISO	77.9	76.0	75.5	78.5	78.0	72.0
P2 stage						
% P	0.15	0.16	0.13	0.20	0.10	0.11
D2 stage						
%D	0.24	0.41	0.17	0.30	0.25	0.26
Brightness, % ISO	91.7	90.6	91.7	92.1	90-91	90-91
Viscosity, dm ³ /kg	800	790	957	862	900	900

Reference: (C+D)PDPD
M: (C+D)PLPD

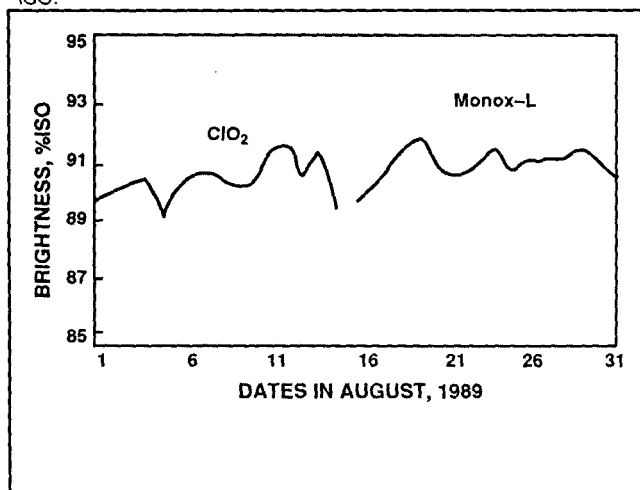
2. Chemical charges of Monox-L were gradually lowered.



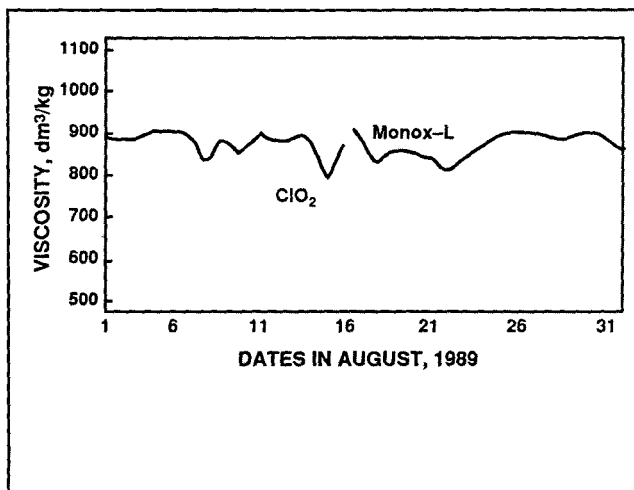
3. As chemical charges were reduced, brightness held steady and viscosity increased.



4. Brightness in the L sequence eventually stabilized around 91% ISO.



5. Final viscosities using both D and L were virtually identical.



trials. The results of some of these studies are given in **Table I** and demonstrate that when M was substituted on approximately a pound-for-pound basis for D1, the resultant pulp quality was similar to the reference sequence. These studies also pointed out that there are differences in the stage-to-stage brightness development when comparing the Monox-L and chlorine dioxide bleaching sequences. Typically, the M1 stage can be at a lower brightness level than is desirable for a corresponding D1 stage. The P2 stage following an M stage will also exhibit a lower brightness than that of a D-P2 stage. However, the final D2 stage is much more efficient in a (C+D)(E+P)MPD sequence than in a (C+D)(E+P)DPD sequence. In the Monox-L sequence, it is quite easy to increase the pulp brightness by as much as 13-15 points in the final D stage. This type of brightness increase would not be possible using the standard (C+D)(E+P)DPD sequence.

Other laboratory work indicates that it is important that the M charge be controlled to provide optimal brightness without a loss in pulp strength. **Figure 1** depicts a typical plot of brightness development and pulp viscosity as a function of Monox-L charge. As the Monox-L charge is increased, the pulp will exhibit a brightness increase up to a point where incremental charge increases lead to little or no brightness gain. Above this point is the region of bleach overcharge. The viscosity of the pulp is not drastically affected by the increased charge until the overcharge region is reached. As the brightness levels off, the viscosity begins to drop significantly. It is important to learn where this overcharge region occurs in an actual mill process. A substantial part of the plant optimization process at Kymmene involved understanding this relationship and adjusting charge values to obtain maximum brightness and viscosity.

Plant optimization

During the plant trial experiences with Monox-L, the objective was to determine whether acceptable-quality pulp could be produced using this replacement for chlorine dioxide. To ensure that the final pulp brightness met the mill specification of 90-91% ISO (International Standards Organization), charge levels were set higher than were indicated by the laboratory data. Brightness levels were met and viscosities were within normal ranges. As a result, when the commercial unit was brought on-line, the initial charge levels were again set at higher than normal levels.

In the plant experience, as in the laboratory data, we noticed that the brightness responses following the M stage were different than those after a D stage. The first few months of operation with Monox-L were run using brightness targets of the standard chlorine dioxide sequence. As a result, the entire Monox-L system was, in reality, over-charged. The desired final brightness was obtained, but the viscosity was about 10% lower than that obtained with the standard sequence. Personnel from Quantum worked with the engineers and operators at the Kuusanniemi mill to reduce these charge levels. Once the relationships between brightness, viscosity, and charge levels were understood, the plant began to gradually decrease the charge levels in the Monox-L sequence. Brightness targets in the M1 and P2 stages were reduced

by 6% ISO. Even with these reductions in brightness targets, the final 90-91% ISO brightness was still achieved. **Table II** gives the chemical consumption, brightness, and viscosity data over the course of this process. Even with lower P-stage brightness, the final D stage is much more responsive following an M stage, and no problem was encountered meeting the 90-91% ISO brightness target. As the M charge was reduced, the final pulp viscosity increased to the same level as that of the standard sequence. In addition, the cleanliness and physical properties of the Monox-L sequence were comparable to those of the reference sequence.

Figure 2 is a graphic representation of the chemical charges used in the Monox-L system during the period from April to November 1989. Notice the gradual lowering of the chemical charges. In **Fig. 3**, the final pulp brightness and viscosity are plotted over the same time period. As the chemical charges were reduced, the brightness stayed the same and the viscosity increased.

To emphasize the comparison of Monox-L with chlorine dioxide, **Figs. 4 and 5** present the results from a two-week period in August 1989 where either M or D were used in the D1 stage. **Figure 4** shows that the brightness of the M sequence has taken a more stable position close to 91% ISO, compared to the D sequence. In **Fig. 5**, the final pulp viscosities are virtually identical.

During the entire optimization process, Kymmene realized a cost savings when using Monox-L. When the charge levels were optimized, this amounted to an approximate savings of US\$ 5/ton of pulp.

Environmental results

The reported results of the first plant trial indicated a 10-30% increase in TOC, COD, and BOD values when comparing M to D1 stages. With the optimization of the M sequence, these values decreased considerably. **Table III** gives the effluent characteristics for the M stage as compared to the standard D sequence. Notice that the values for the effluent leaving the mill are no higher for the Monox-L sequence than for the reference (D) sequence. Kymmene continues to report that the environmental properties of the Monox-L and chlorine dioxide systems are similar.

Generator operation

The 20-ton/day commercial Monox-L generator started up very easily. The system is fully automated and controlled with a Damatic computer. From the beginning, Kymmene has been able to reach the designed capacity. The pH and concentration of the product have been very consistent. With over a year of operating time, no corrosion has been noted with the generator. Very little manpower is needed to operate the Monox-L generator. The operation was handled by existing chemical preparation operators. Full capacity is realized within five minutes of startup. Complete shutdown is accomplished in even less time.

Conclusions

In over a year of operation at the Kymmene mill in Kuusankoski, Finland, Monox-L has proven to be an

III. Effluent characteristics for the M stage

	<i>COD</i> , mg/L	<i>BOD</i> , mg/L	<i>CHCl₃</i> , mg/L	<i>ClO₂</i> , mg/L	<i>TOC</i> , mg/L	<i>TOCl</i> , mg/L
Filtrate (D or M)						
D	1280	310	0.5	160	715	93
M	1500	340	17	0	582	160
M*	1275	289	14.4	0	495	136
Acid channel						
D	2200	655	12	0	811	244
M	1920	630	8	0	695	211
Alkaline channel						
D	5560	755	4.4	0	2240	345
M	4650	600	2.9	0	1790	221

* Monox-L bleaching agent as 23 g/L vs. chlorine dioxide at 10 g/L raised tower consistency to 11.5% for L vs. 10% for D. M filtrate is more concentrated.

effective replacement for chlorine dioxide in the D1 stage of a 600-ton/day softwood line. During the course of this year, the Monox-L process underwent continual optimization which reduced chemical consumption and effluent loading while increasing pulp strength and economic savings. During the entire optimization process, the pulp brightness met or exceeded mill specifications. Kymmene reports the performance and operational reliability of the Monox-L generator has been excellent.

The optimization process at Kymmene has served as a learning tool for other mill operations. The process has

given us information to more effectively use laboratory data for quicker optimization of subsequent plant trials and commercial installations. □

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