Alkaline peroxide mechanical pulping of hardwoods

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After being steamed, the chips are compressed in a screw press and are gently shredded to allow the bleaching chemicals to penetrate.

The growth of CTMP with prebleaching has brought about many new developments, particularly in ways to brighten the high-yield pulp that is made in the conventional sulfite or alkaline sulfite pretreatment processes. In June 1989, our company introduced a process we call "alkaline peroxide mechanical pulping" as an improvement to the conventional prebleach CTMP process. This process is unique in that the chips can be fully bleached before the refining process by impregnating them with peroxide bleach liquor.

By fully bleaching the wood chips prior to refining, several advantages can be realized. Energy consumption in the refining process can be reduced by as much as 35%. Because the need for a bleach plant is eliminated, the installed cost for an alkaline peroxide mechanical pulping system is less than that of a prebleach CTMP system.

The new process is similar to conventional peroxide bleaching in many respects. The process variables that influence pulp bleaching have a comparable effect on the performance of the new process. The roles of chelants, washing, consistency, temperature, and chemical charge on the brightness of the pulp are the same in both processes. In other words, the alkaline peroxide mechanical pulping process can be configured to provide fully bleached pulp equivalent to prebleached CTMP pulp. One difference, however, is that by bleaching the chips before refining, the reaction variables for bleaching also affect the development of pulp strength.

Our on-going work is aimed at exploring the range of pulping and bleaching possibilities for the new technology. Here, we will look at some of the advantages and applications of alkaline peroxide mechanical pulping.

The basic technology

The basic flow sheet for the alkaline peroxide mechanical pulping system is shown in **Fig. 1**. The configurations of the equipment center on these basic components:

- Multiple stages of chemical impregnation
- Refining, washing, and a final stage of refining.

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Though alternatives can be considered at each point in the process, the process can be described as a means of bleaching the wood while it is still in the form of chips. To more fully delineate some of the subtle differences of chip bleaching, let us review the basics of the new system.

Chemical impregnation

The key to effective chip bleaching is a thorough distribution of the chemicals throughout the wood chip matrix. The chips must first be well presteamed before any mechanical compression can occur. A well-steamed chip will compress without shattering, which means fewer fines are generated in the process. After steaming, the chips are compressed in a rugged press to squeeze out some of the water-soluble organic components of the wood. More importantly, the chips are gently shredded to open up the wood structure, thus allowing for increased penetration of the bleaching chemicals.

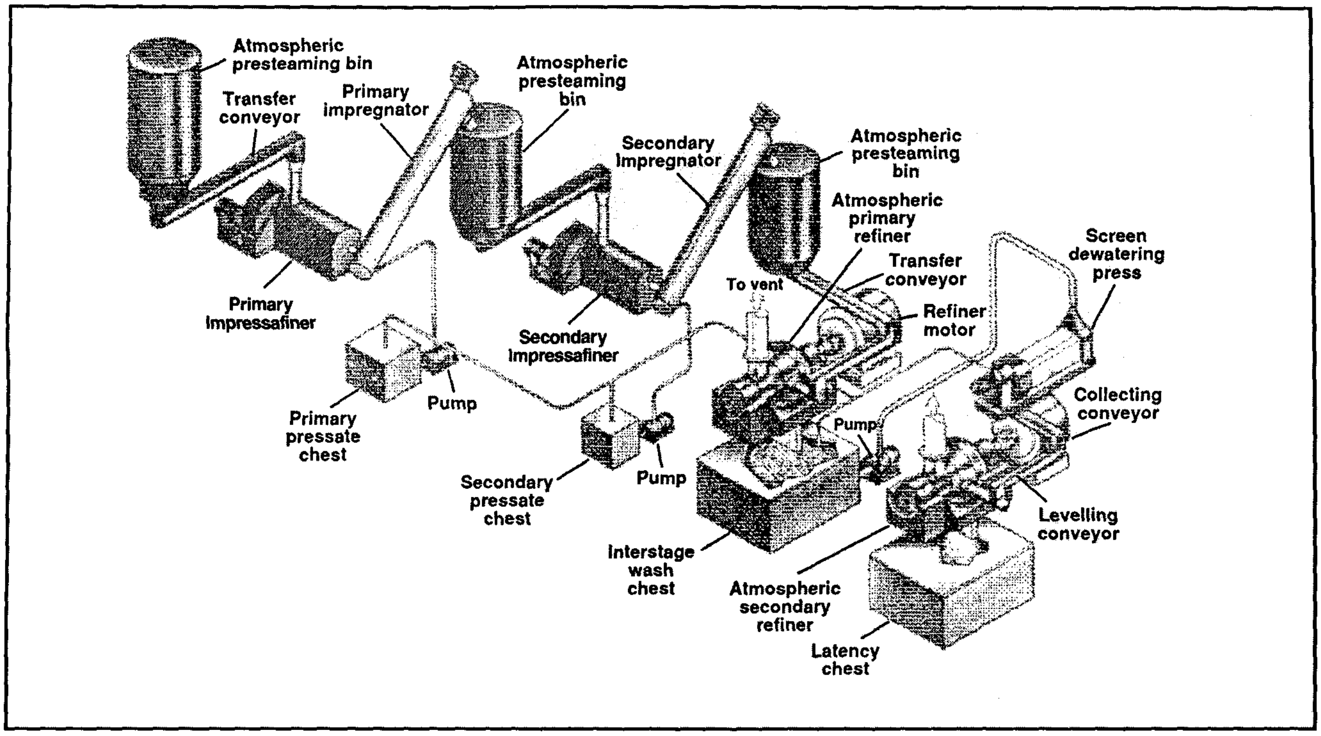
The result of proper impregnation can be seen in the photographs in **Fig. 2**, where aspen chips are shown before, during, and after two stages of impregnation. In the first stage of impregnation, a high-compression (4:1) screw in the press allows for maximum squeezing, while shredding the chips in preparation for the introduction of chemicals. Chemicals are added to prepare the wood for pulping and bleaching.

In the center photo of Fig. 2, the chips have been impregnated with 0.5% H_2O_2, 1.5% NaOH, 0.1% DTPA, 0.05% $MgSO_4$, and 2.0% sodium silicate. The addition of peroxide increases the brightness of the chips in the first stage of impregnation. More importantly, the chips are being "deactivated," or cleansed of the contaminants that limit the response of the bleaching reactions. The amount and type of chemicals used can be optimized for specific wood species.

The second stage of impregnation relies on a high-compression screw as well, to squeeze out of the chips as much of the first-stage chemicals and reaction products as possible. This form of washing helps to improve the bleaching reactions that occur after the second impregnation zone.

Key measures of squeezing and impregnation performance are the squeeze ratio and the absorption ratio. Both ratios vary from stage to stage, depending on the incoming moisture level and the degree of pressing that can be

1. The basic flow sheet for the alkaline peroxide mechanical pulping system, including two Sprout-Bauer Impressafiners®



2. The result of proper impregnation: aspen chips before, during, and after two stages of impregnation

achieved. A higher number indicates improved performance. These equations describe the performance of the impregnation system:

Squeeze ratio = (fluid expressed, kg/min)/(wood fed, kg/min)

Absorption ratio = (fluid uptake, kg/min)/(wood fed, kg/min)

For example, the first stage of impregnation may have a squeeze ratio of 0.33 since the wood is fed at a 50% solids contents and is squeezed to 60%. (For 100 kg/min, say, at 50% solids, we have 50 kg/min of wood and 50 kg/min of fluid. To bring the solids up to 60%, we must take away 16.5 kg/min of fluid. Dividing the 16.5 kg/min of fluid expressed by 50 kg/min of wood gives 0.33.)

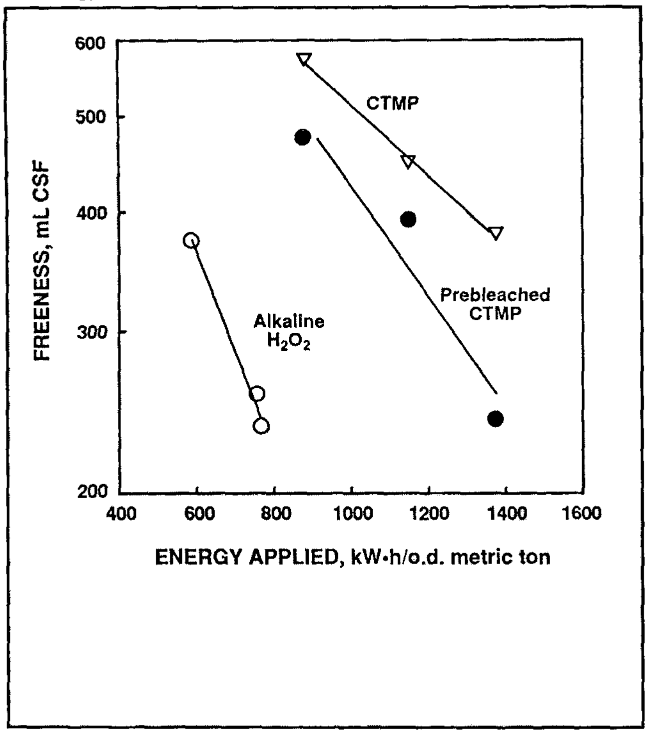
When the chemicals are added, the solids contents of the chips will drop to 35%; thus the absorption ratio is 1.85. In the second stage of impregnation, the chips can be dewatered to a consistency of 58%, giving a squeeze ratio of 1.13, while a typical absorption ratio for the second stage will be closer to 2.0.

The second-stage compression screw has a design that allows for maximum residence time and drainage surface area to maximize the amount of fluid that can be expressed from the chips, improving the fluid uptake in the second impregnation zone. As shown in Fig. 2 (right), the chips after the second impregnation stage look more like a mass of pulp than chips. In addition, the impregnation with peroxide, caustic, and stabilizers can fully brighten the chip. In this case, the chips exited the refiner at a brightness of 85 with 3.5% H_2O_2 applied.

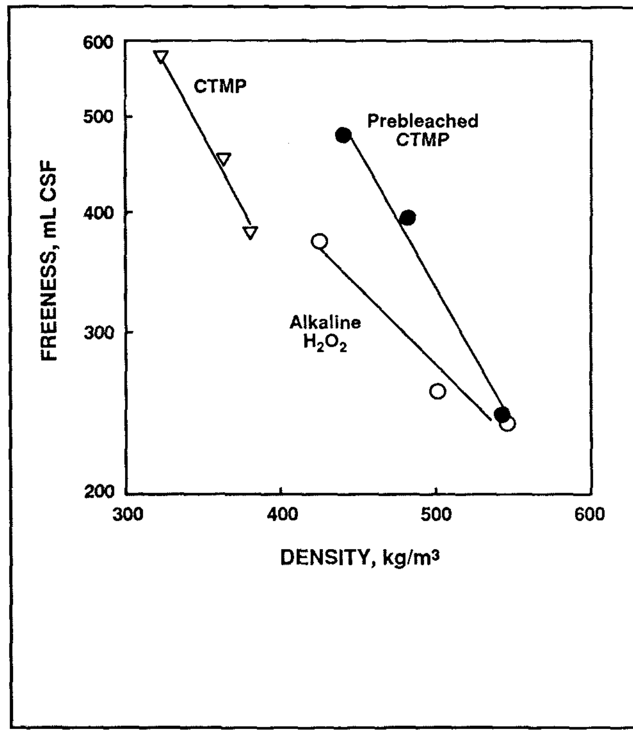
Refining and washing

The refining configuration in the alkaline peroxide mechanical pulping process can be less complicated than the typical CTMP system with prebleaching. With the new process, it is possible to use atmospheric refiners rather than pressurized refiners. The choice of refiner design

3. Energy requirements for aspen for each process



4. Sheet densities for aspen for each process



depends on the flexibility desired in the system.

For example, if a fully bleached pulp is required without a separate bleach plant, then an atmospheric refiner should be used to minimize the darkening reactions that will occur when a refiner is operated under pressure. If the best fit for a mill site is to take advantage of the energy savings of the new process while accepting a lower brightness or slightly higher peroxide consumption, a pressurized refiner can be used. The installation of a pressurized refiner would allow for the production of TMP or of CTMP with very high freeness (>700 mL CSF).

Regardless of the refiner design, the application of mechanical energy in the primary stage is usually limited to 300-500 kW•h/o.d. metric ton, since it is difficult to apply energy to chips that have a highly alkaline chemical charge. For this reason, the pulp should be washed between stages to remove the residual chemicals. The secondary refiners can be either pressurized or atmospheric, based on the same design criteria used to decide on the primary refiners. Since the pulp is less alkaline in the second stage, the refining process can be operated at more conventional energy levels.

From the secondary refiner on, the design consideration for the process flow is based on the usual process parameters. The pulp should be screened, cleaned, and thickened for storage. The rejects from the screens and cleaners can be processed in a separate reject refining system or, in some instances, merely returned to the wash chest ahead of the secondary refiners. The requirement for a bleach plant depends strictly on how closely the system design adheres to the true design concept as shown in Fig. 1.

If the full chemical charge is applied in the impregnation stage and the refiners are atmospheric, then the pulp will be comparable to a fully bleached CTMP. At most, a single-stage bleach plant for two to three points of brightness increase may need to be installed.

Pulp quality from the new process

The basic pulp quality parameters of prebleached CTMP and alkaline peroxide mechanical pulping were reported earlier for both spruce and aspen.[1] At equivalent chemical charges, the pulp properties of the new process were equal to prebleached CTMP. The brightness of the pulp is largely a function of the amount of peroxide applied, while the pulp strength and the energy consumption depend mainly on the amount of caustic.

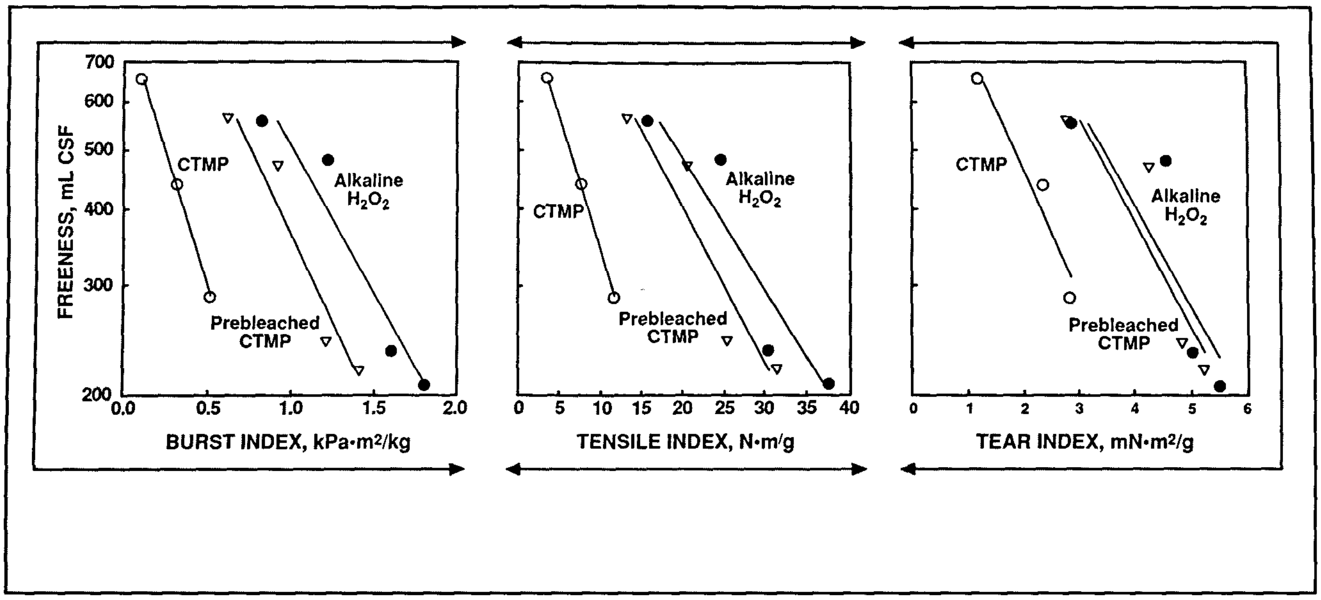
This success with aspen and spruce led us to study the effects of the new process in pulping of other species that did not respond as well to the conventional CTMP process with prebleaching. For this research, a mixed hardwood blend was pulped using both techniques.

Aspen

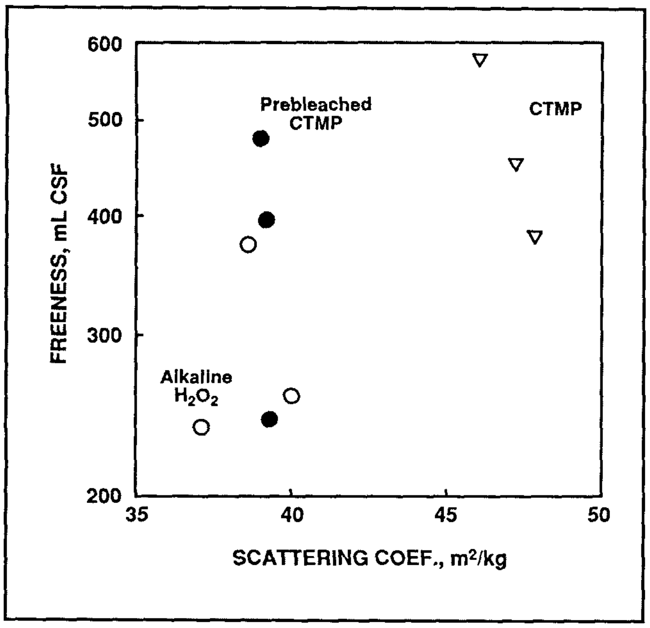
Studies on alkaline peroxide mechanical pulping of aspen as compared to traditional CTMP and prebleached CTMP show the promise of the new process for low-density hardwoods. The results presented here were obtained for a charge of 1.4% sodium sulfite and 1.8% caustic for the CTMP and a charge of 3.8% hydrogen peroxide and 4.5% caustic for the alkaline peroxide mechanical pulping. The CTMP was bleached with 4.5% hydrogen peroxide and 4.3% caustic to produce prebleached CTMP for comparison.

[1]Bohn, W. and Sferrazza, M., Alkaline peroxide mechanical pulping, a revolution in high-yield pulping, 1989 International Mechanical Pulping Conference, TAPPI PRESS, Atlanta, p. 184.

5. Comparisons of strength properties for aspen



6. Comparisons of scattering coefficient for aspen



7. Brightness responses of the three pulp types for an aspen furnish

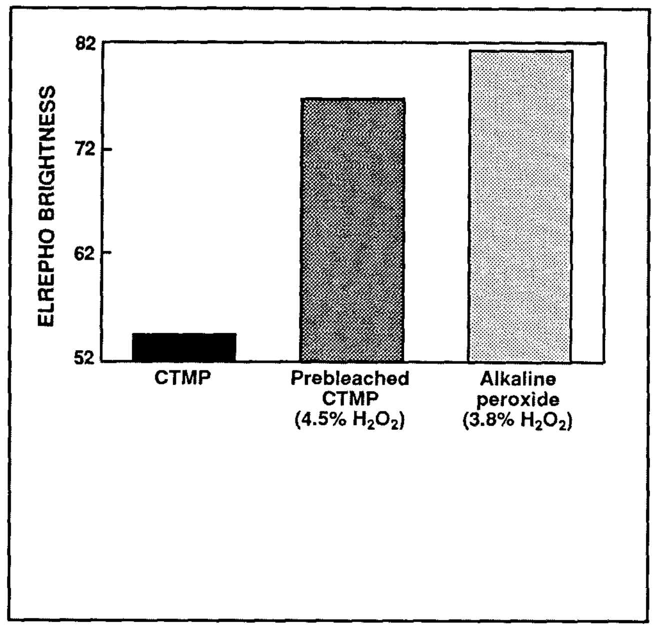


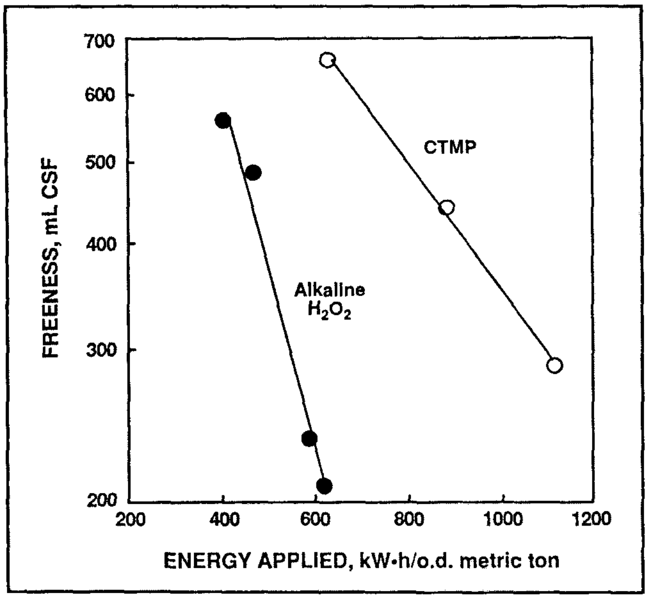
Figure 3 reveals one of the main advantages of the new process—the substantial energy savings available over the CTMP process. For aspen, alkaline peroxide mechanical pulping can be produced at an energy savings of up to 50% over that of CTMP. Because the new process utilizes caustic in the pretreatment stage, it will produce a pulp that is more dense than the pulp produced by the CTMP process. The alkaline peroxide mechanical pulp density is within 5-10% of that of the bleached CTMP, as shown in **Fig. 4**.

Pulp strength available with alkaline peroxide mechanical pulping will be comparable to that of prebleached CTMP for aspen. **Figure 5** shows some of the strength properties. Burst and tensile strengths can be further improved by increasing the caustic charge, as demonstrated in earlier studies.[2] The presence of alkali in the pretreatment stage of alkaline peroxide mechanical pulping also has advantages in the development of long fibers, which leads to improved tear strength.

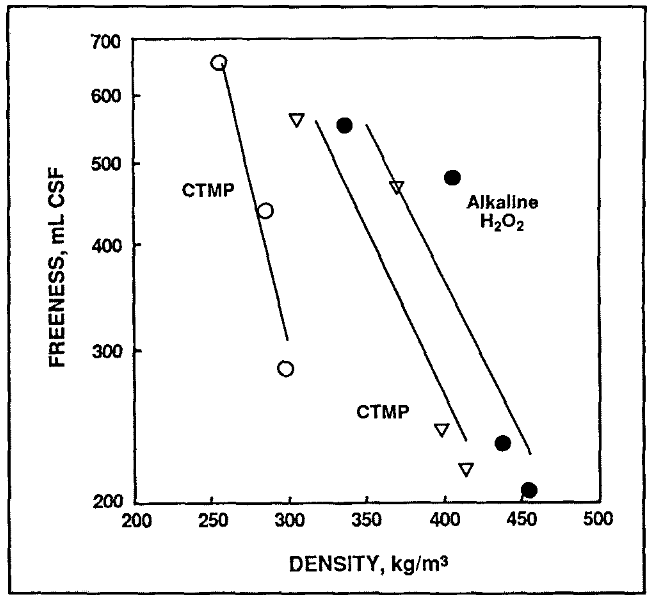
The usual problem with the use of high concentrations of chemicals is a loss of opacity. As **Fig. 6** reveals, the addition of 4.5% caustic in the new process results in a light-scattering coefficient equivalent to that of prebleached CTMP. The brightening response depends on the concentration of peroxide. However, in the studies conducted on aspen, the brightness levels obtained were equal to those of fully bleached CTMP at equivalent or

[2]Bohn, W., Alkaline peroxide mechanical pulping: high yield pulp for the 90s, TAPPI 90 Proceedings, TAPPI PRESS, p. 47.

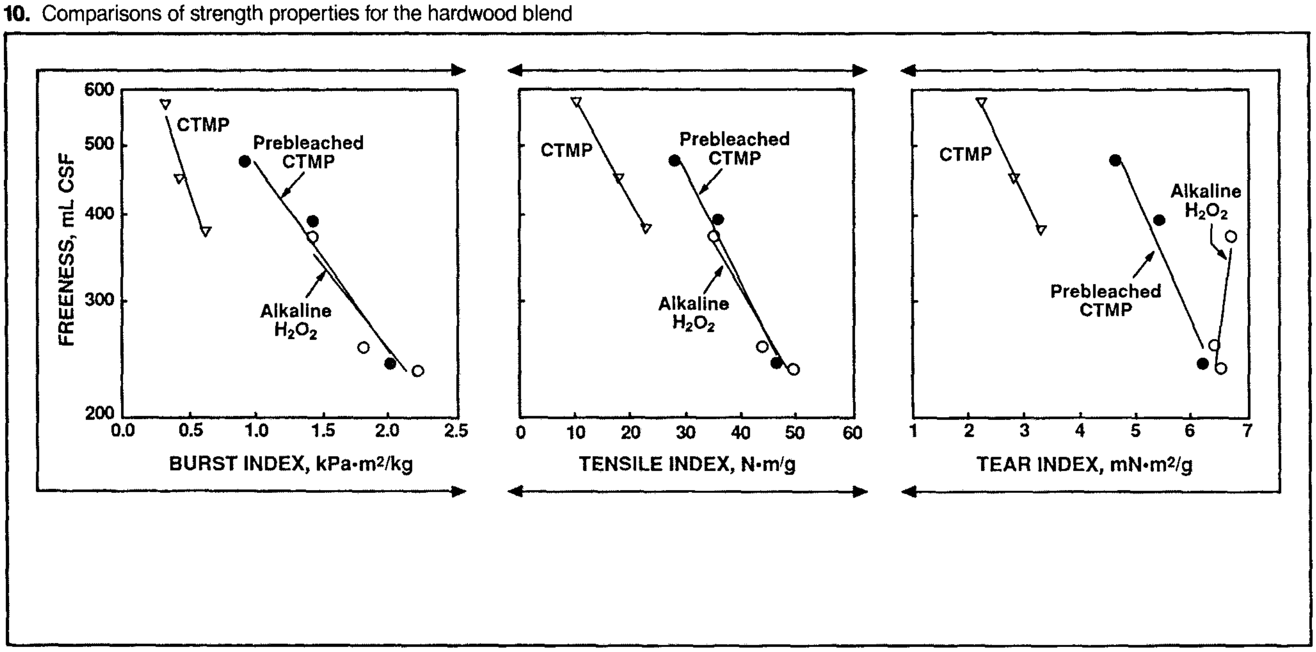
8. Energy requirements for the hardwood blend



9. Sheet densities for the hardwood blend



10. Comparisons of strength properties for the hardwood blend



lower chemical charges. **Figure 7** illustrates the brightness response of the three pulp types for this study.

The major difference between alkaline peroxide mechanical pulping and prebleach CTMP is the absence of the bleach plant to achieve a fully bleached pulp. From an operating standpoint, alkaline peroxide mechanical pulping will also be less costly because the use of all the caustic in chip pretreatment reduces energy consumption.

Mixed hardwood

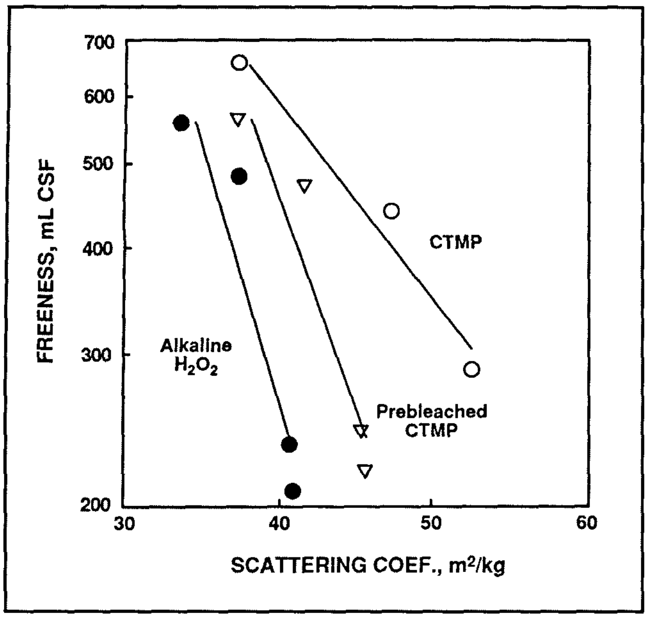
A mixed hardwood furnish has presented a greater challenge in producing high-quality pulp for printing and writing grades with conventional CTMP technology. Therefore, it was important to know how the new process would perform with a hardwood blend.

For this study, the mixed southern hardwood CTMP was produced using 4.7% sodium sulfite. The alkaline peroxide mechanical pulp was produced using 3.3% peroxide and 4.9% caustic. Bench-scale bleaching of the CTMP with 4.3% peroxide and 4.6% caustic produced pulps for comparing results for CTMP with prebleaching.

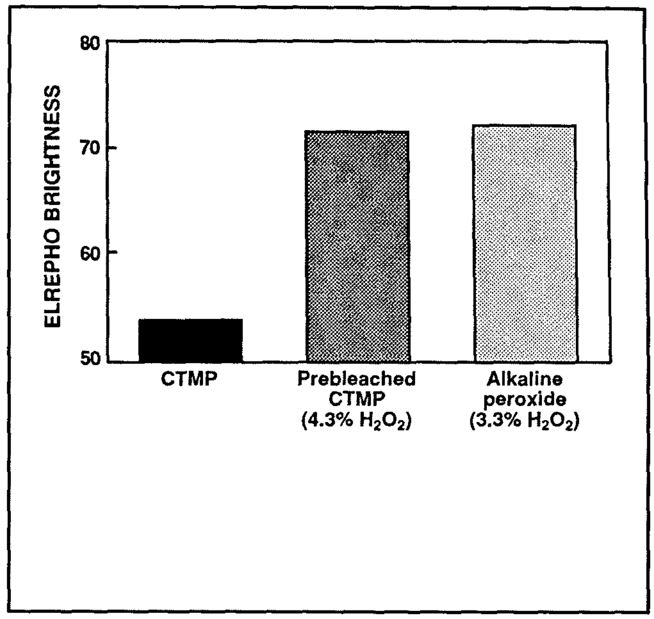
As in the aspen trials, energy savings are substantial for the new process. **Figure 8** shows energy reductions of up to 50% over that of CTMP. Pulp densities for prebleached CTMP and alkaline peroxide mechanical pulping were again fairly comparable, with the new process producing a slightly denser sheet, as **Fig. 9** shows.

Pulp strength was slightly better in the new process. In **Fig. 10**, the burst and tensile strengths of the samples for the new process were 15-20% higher than those of the

11. Comparisons of scattering coefficient for the hardwood blend



12. Brightening responses for the hardwood blend



prebleached CTMP samples. Tear strength for fully bleached CTMP was similar to that for alkaline peroxide mechanical pulping. Again, the presence of alkali in the pretreatment stage will aid in development of long fibers.

The light scattering of the alkaline peroxide sheet was slightly lower than that of the bleached CTMP, as **Fig. 11** shows, because of the high concentration of caustic. If optical properties have to be optimized for a particular product, the caustic charge in the alkaline peroxide process could be reduced. This reduction would improve opacity and scattering coefficient, while strength properties comparable to those of prebleached CTMP would still be retained. The brightening response for the alkaline peroxide process was similar to what would be obtained from a fully bleached CTMP, as **Fig. 12** shows. Again, a strong economic advantage lies in eliminating the need for a separate bleach plant.

Conclusions

The new process has been developed to meet the demands for high-yield pulps. The technology offers advantages over CTMP with prebleaching in terms of operating and capital costs, while producing pulps of similar or better quality.

Alkaline peroxide mechanical pulping essentially bleaches wood chips with an alkaline peroxide liquor before refining. The alkalinity in the impregnation stage defines both the pulp strength and the energy consumption of the process. Energy savings for hardwood furnishes are in excess of 35%. The multistage impregnation of the pulping liquor washes contaminants and stabilizes the wood against side reactions that consume peroxide. The result is a fully bleached pulp at the discharge of the refiners.

In an alkaline peroxide mechanical pulping system, there is no need to install a bleach plant after the refining system. Consequently, the installation costs are dramatically reduced for a high-yield pulp mill. The results that have been obtained from different species with the new process have proven promising.□

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