PREVENTING LOSS AND RESTORING WATER RETENTION VALUES TO PULP BY FIBER LOADING

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ABSTRACT

Significant paper strength loss occurs when never-dried bleached kraft pulps are dried prior to paper manufacture. This loss in strength is a problem for the use, of dried market pulp and recycled papers. The objectives of this study were to investigate the effect of fiber loading on restoring the water retention value (WRV) to once-dried bleached chemical kraft hardwood pulp and to explore the possibility of preventing the loss in WRV resulting from drying by fiber loading never-dried pulp. We fiber-loaded pulps on a laboratory scale, prepared handsheets, and measured WRV and Canadian Standard Freeness (CSF). Our results show that fiber loading restores WRV and increases the CSF of once-dried bleached kraft hardwood pulp. Fiber loading prior to drying also prevents loss in WRV when the pulp is dried.

INTRODUCTION

The loss of pulp strength in drying, which affects dried market pulp and the recycling of recovered papers, has been the topic of extensive yearch studies [1,2,3]. When kraft pulp is dried, both the specific surface and specific volume of pulp are reduced [4]. Specific surface is easily recovered by refining, but specific volume is more difficult to recover by refining without an unacceptable increase in filtration resistance. The degree of difficulty in restoring specific volume of kraft pulps is inversely proportional to the yield or lignin level. We think that at the lower lignin levels, irreversible bonding of cellulose components occurs within the fiber walls, At higher lignin levels, lignin or hemicellulose or both tend to prevent irreversible bonding of cellulose components [5,6]. We reasoned that fiber loading of bleached pulp prior to drying should tend to prevent the irreversible bonding within the pulp fiber wall by preventing contact of cellulose components within the cell wall.

For rapid screening, we measured the Canadian Standard Freeness (CSF) of the pulps as a measure of filtration resistance and water retention value (WRV) as a measure of specific volume. Water retention value has been shown to correlate well with handsheet strength properties [7,8]. We investigated the effect of drying on unloaded and fiber-loaded never-dried pulp, with respect to WRV and CSF. We also investigated the effect of fiber loading prior to drying on WRV loss. For purposes of comparison, we studied the effects of direct loading of the pulp with precipitated calcium carbonate (PCC).

EXPERIMENTAL PROCEDURE

Materials

A fully bleached never-dried northern hardwood kraft (20% birch, 80% aspen) was used for the experiments. The pulp was supplied by Potlatch Corporation (Cloquet, MN). Calcium hydroxide used for fiber loading was Mississippi Codex hydrated lime (Mississippi Lime Company, Alton, IL); comparative direct loading of pulp was done with papermaker grade (HO) PCC obtained from Specialty Minerals, Inc. (Bethlehem, PA).

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Equipment

A Hobart (Troy, OH) mixer was used to mix calcium hydroxide into high consistency pulp. Subsequent reaction with carbon dioxide was carried out in a 305-mm-diameter pressurized disk refiner manufactured by Sprout Bauer (Springfield, OH) using refiner plates at 0.6-mm-wide gap setting.

METHODS

For fiber loading, 500-g batches of pulp at 20% consistency were mixed for a few minutes with dry calcium hydroxide in a Hobart Mixer. The pulp mixtures were then reacted with carbon dioxide in the holding chamber of a refiner pressurized at 207 kPa. After 10 min retention, the pulp was passed through the refiner at wide (0.6-mm) plate gap. Exit temperature was less than 40°C.

A portion of the never-dried pulp obtained from the pulp manufacturer was dried on a 380-mm-wide experimental Fourdrinier paper machine so that both never-dried and dried pulp could be fiber loaded. Fiber-loaded never-dried pulp was also dewatered, made into 10-g pads, and dried on hot plate for evaluating the effect of recycling of dried fiber-loaded pulp. Direct loading of PCC to slurries of paper-machine-dried pulp was done for comparison purposes.

Freeness was determined according to Tappi Method T227. WRV was determined according to TAPPI Method T256. The WRV values were calculated by Tappi Useful Method 256 after compensating for ash content of fiber pellets after centrifuging. Calculations were based on the weight of fiber after subtracting the weight of filler contained in each sample. Ash values were determined according to TAPPI Method T 211 (ash is reported as calcium carbonate).

RESULTS AND DISCUSSION

Fiber loading increased the WRV of both never-dried and once-dried pulp. The WRV of never-dried pulp was initially 1.56 g/g (Figure 1). Fiber loading of this pulp to ash levels of 10%, 21%, and 31% increased WRVs to 1.86, 1.86, and 2.08 g/g, respectively. We expect that this increase in WRV resulting from the addition of fiber-loaded PCC tiller will correlate with an increase in handsheet strength properties.

Drying the pulp resulted in an expected decrease in WRV, from 1.56 to 1.33 g/g (Figure 1). Fiber loading of dried pulp with 10%, 21%; and 31% PCC increased WRVs to 1.48, 1.58, and 1.72 g/g, respectively. Again, WRV was increased in proportion to the level of fiber-loaded PCC added. Direct loading of dried pulps with commercial PCC to levels of 10%, 21%, and 31% also increased WRV (1.42, 1.49, and 1.60 g/g, respectively), but not as much as did liber loading.

Typically when WRV is increased, CSF is reduced. However, we found that fiber loading increased CSF (Figure 2). Initial CSF of never-dried pulp was 566 mL. Drying the pulp reduced CSF to 560 mL. This small reduction in CSF was expected because the pulp was unrefined. Fiber loading with 10%, 21%, and 31% PCC increased CSF of never-dried pulps to 732, 742, and 742 mL, respectively, and CSF of dried pulps to 721, 724, and 717 mL, respectively. For both types of pulp, CSF restoration reached a plateau after the 21% level of PCC.

Fiber-loaded never-dried pulp was dried to determine the effect of fiber loading on recycling of pulp. We found that WRV of the recycled pulp was proportional to the level of fiber-loaded PCC (Figure 3). The WRV of the dried pulp without any PCC was 1.33 g/g. The dried pulp that had been fiber loaded with 10%, 21%, and 31% PCC had WRVs of 1.19, 1.27, and 1.37 g/g, respectively. These results were lower than we had expected and can be explained by the fact that not all the fiber-loaded PCC was retained when we made the fiber-loaded never-dried pulp into pads for drying.

For pulps fiber-loaded with PCC, we expect that deposits of PCC crystals within the fiber wall were responsible for improvements in WRV. Also, WRV improvements were possibly due in part to the high pH of the calcium hydroxide and the gentle processing of pulps at high consistency. High consistency processing tends to produce strength in pulps without producing fines because in this kind of processing, fiber-to-metal contact is avoided and fiber-to-fiber contact occurs more frequently. The relative reduction of fines by high consistency processing tends to result in higher CSF values compared to those for pulps processed or refined at lower consistency.

CONCLUSIONS

- Fiber loading, through the deposit of calcium carbonate within the fibers, restores water retention value (WRV) and freeness of once-dried bleached kraft hardwood pulp.
- Fiber loading prior to drying prevents some of the loss in WRV.

REFERENCES

1. Carlsson, G., and Lindstrom, T., "Effect of Carboxyl Groups and Their Ionic Form During Drying on Hornification of Cellulose Fibers," Svensk Papperstid., 85(15), R146(1982).

2. Blechschmidt, J., Klein, R., and Naujock, H.-J., "Reactivation of Waste Paper Stock," proceedings from the EUCEPA Symposium, Recycling in Production of Pulp & Paper, Paper no. 11:97(1983).

3. Bichard, W., and Howard, R.C., "Basic Effects of Recycling on Pulp Properties," J.Pulp Pap. Sci., 18(4), J151(1992).

4. Klungness, J. H., and Caulfield, D. C., "Mechanisms Affecting Fiber Bonding During Drying and Aging of Pulps," Tappi Journal, 65(12), 94(1982).

5. Laivins, G. V., and Scallan, A. M., "Mechanisms of Hornification of Wood Pulps," proceedings from Products of Papermaking conference, Baker, C. F. ed., Pira vol. 2, 1235(1993).

6. Buchert, J., Oksanen, T., and Viikari, L., "Role of Hemicelluloses in the Hornification of Bleached Kraft Pulps," Holzforschung, 51(4), 355(1997).

7. Buttel, H., and Jayme, G., "Determination and Significance of the Water Retention Value (WRV) of Various Bleached Pulps: Relationship Between WRV and Other Pulp Properties," Wochbl. Papierfabr., 96(6), 180(1968).

8. Roffael, E., "Detection of Hornification During the Drying of Never-Dried Pulps," Holzforschung, 33(2), 33(1979).

Figure 1
Water Retention Values and PCC Levels

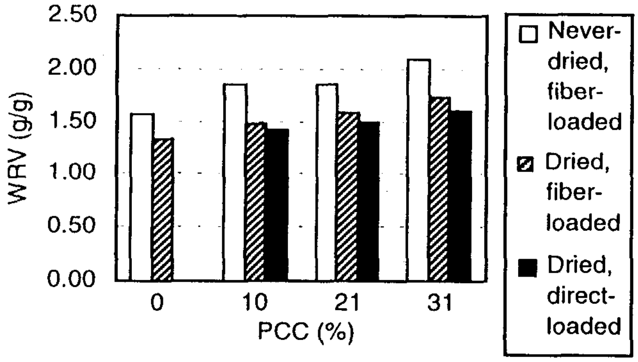


Figure 2
Canadian Standard Freeness and PCC Levels

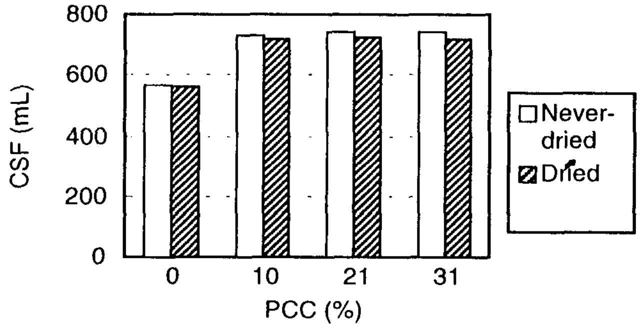
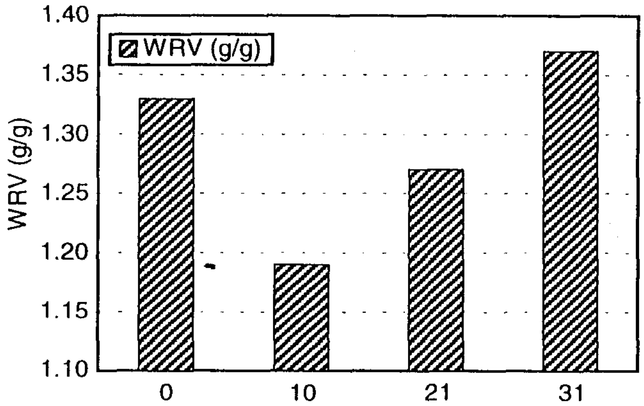


Figure 3
Effect of Fiber Loading on WRV Loss



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