The physical properties of kraft pulp along a brownstock line

J. M. MacLeod
Pulp and Paper Research Institute of Canada, 570 St. John's Boulevard, Pointe Claire, Quebec, Canada H9R 3J9

KEYWORDS: Kraft pulps • Physical properties • Stock preparation • Tensile strength • Tear strength • Burst strength

In the search for improvements in kraft pulp quality, a primary consideration is the concept of the inherent potential strength of any wood fiber furnish. In another report (1), the case was made that this strength potential could be determined by pulping a given chip furnish under appropriate kraft conditions in a pilot-scale digester and then measuring the physical properties of the unbleached pulp. Comparisons of the properties of mill- and pilot-scale unbleached kraft pulps showed that among bleachable-grade softwood pulps, the pilot-plant pulps were approximately 15–35% stronger in tear-tensile performance (1, 2). Thus, there is room for improvement in how pulps are produced and processed in kraft mills.

Because our earlier mill-based pulp sampling was usually conducted at either brownstock washers or dekers, it was natural to question whether changes occurred in the unbleached pulp as it progressed along a brownstock line from the blow tank to the decker (or to the screened pulp storage tower). The answer was obtained by conducting two sampling series along the brownstock line of a softwood, bleachable-grade kraft mill operating under normal "steady-state" conditions.

Results and discussion

Figure 1 is a schematic diagram of the process units along the mill's brownstock line. The blow tank provided the sampling point closest to the digester. On two days several months apart, pulp samples (approx. 1 kg, o.d. basis) were taken at each of the locations shown. The timing between samples was based on known retention times through the process units, and a "plug-flow" situation was assumed. Each pulp sample was stabilized by washing and hand squeezing it free of most of the entrained spent liquor. The samples were transported to our laboratory and processed in a standard washing, screening, and cleaning procedure (3) prior to being tested for physical and optical properties.

The results from the two rounds of sampling were essentially alike; those from the second round are shown in Table I. A step-change in kappa number across the cleaning operation was found in both sets of samples. In searching for its cause, we found that the mill's fiber reclaim system was able to recycle bleached fiber spills into the brownstock at this point, and this may have accounted for some of the kappa number drop. The brightness of the pulp also increased here, albeit by only 2–3% ISO. Another contributor may have been lignin "leaching" (4), the result of exposing the unbleached pulp to temperatures of 50–60°C while at low consistency (less than 2%).

As expected, the flat screen rejects decreased from approximately 1.4% at the inlet to the first washer to 0.2% or less at the decker; these are rejects based on the dry weight of the particular pulp analyzed.

Freeness decreased as the pulp travelled along the brown stock line. Among the successive samples, parallel curves of freeness vs. PFI revolutions were found. Although the freeness decline was only 9% from one end of the line to the other, it indicated that the pulp was responding to mechanical action, presumably at points of energy input such as stock pumps, screw conveyors, and the like. Alternatively, any re-introduction of bleached fiber from the spill collection system would be expected to cause the freeness to decline, although only at one place in the process line. The values in Table I demonstrate that the farther along the process line the pulp was sampled, the easier it was to beat to a given freeness. More dramatic effects of this type have been shown in pulps sampled across the medium-consistency operations of a kraft mill bleach plant (2).

Despite the change in freeness, the mechanical strength properties of the pulp did not change appreciably along the process line. Table I shows a variety of strength properties, all at 6900 PFI revolutions. Taking into account the experimental error range of each of

July 1987 Tappi Journal 135
I. Results from the second round of sampling

<table>
<thead>
<tr>
<th>Sample point</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kappa number</td>
<td>35.2</td>
<td>34.0</td>
<td>34.5</td>
<td>28.0</td>
<td>27.2</td>
</tr>
<tr>
<td>Rejects, % on pulp</td>
<td>1.29</td>
<td>1.56</td>
<td>0.16</td>
<td>0.05</td>
<td>0.06</td>
</tr>
<tr>
<td>Freeness, %</td>
<td>100</td>
<td>97</td>
<td>98</td>
<td>93</td>
<td>91</td>
</tr>
<tr>
<td>Burst index, %</td>
<td>100</td>
<td>98</td>
<td>98</td>
<td>93</td>
<td>94</td>
</tr>
<tr>
<td>Breaking length, %</td>
<td>100</td>
<td>97</td>
<td>101</td>
<td>99</td>
<td>100</td>
</tr>
<tr>
<td>Tear index, %</td>
<td>100</td>
<td>96</td>
<td>96</td>
<td>101</td>
<td>99</td>
</tr>
<tr>
<td>Stretch, %</td>
<td>100</td>
<td>101</td>
<td>101</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Bulk, %</td>
<td>100</td>
<td>101</td>
<td>101</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

*These freeness and strength properties were measured after 5000 revolutions in a FPI mill. The results were normalized by defining the washer wet sample (A) as having 100% response in each test. Comparable results were obtained at other degrees of FPI beating.

these measurements, there was little evidence that any of the physical properties were changing significantly from the blow tank to the brownstock decker. This is not surprising: no chemistry and little mechanical action take place along a brownstock line. When the samples were compared in tear-tensile, tear-bulk, and stretch-tensile plots, the same conclusion was reached: the samples were alike. This was true as well in comparisons of these properties at constant freeness. In addition, fiber length distribution did not change significantly from the blow tank onwards.

Conclusions

Apart from a slight decline in freeness, the softwood pulp along a typical brownstock line did not change in physical properties as it progressed from the blow tank to the brown stock decker.

Assuming that bleaching cannot make pulp stronger in a tear-tensile sense (1, 5), one must conclude that the maximum strength of unbleached kraft softwood pulp is established before it reaches the brownstock washers and that it remains unchanged through the rest of the mill. In other words, kraft pulp strength is determined in the digester and its associated depressurizing equipment. Hence, efforts to improve the strength of pulp must concentrate on digester inputs (chips, liquor, heat and chemical gradients, etc.), operating practices, and the mechanics of transferring the fully-cooked chips from the pressure vessel to the fiber line of the mill.

Experimental procedures

The mill was running a mixture of spruce and balsam fir. The pulp processing techniques used in this work were described in detail in previous reports (1, 2). The rejects values in Table I were obtained by screening the mill pulp on a laboratory vibrating flat screen having 0.25-mm-wide slots. These values are expressed as percentages of the individual pulps processed.

Kappa numbers were measured on fully-washed, screened pulp.

The beating was done in a FPI mill: standard handsheets were tested according to CPFA methods.

Literature cited


The author thanks R. Kusano, M. Cyr, and Irving Pulp and Paper Ltd. for their cooperation in this work, K. Ringsland for processing the pulp and performing the data analyses, and G. Teodorescu for reviewing the manuscript.

Received for review Jan. 5, 1987.
Accepted Jan. 15, 1987.