Use of xylanase in the production of bleached, unrefined pulp at Marathon Pulp Inc

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Abstract: Xylanase treatment of brownstock at Marathon Pulp Inc.’s mill in Marathon, ON, has decreased ClO₂ demand, decreased net bleaching costs by 3.4%, and has had several effects on the strength of the unrefined pulp without negatively affecting customer requirements. The cleanliness of the unrefined pulp has improved with xylanase treatment. The results observed over long-term mill usage of the xylanase are consistent with laboratory studies of the effects of xylanase on unrefined pulp.

Xylanase treatment is widely used in kraft mills to decrease the usage of chlorine dioxide and other oxidizing chemicals. The enzymes are added to the brownstock and act on the pulp in the brownstock high-density storage tower. Once the pulp has been treated with xylanase, the pulp is more easily bleached. The increased bleachability is used to obtain a higher bleached brightness, a decreased level of ClO₂ use, a savings in chemical costs, or other benefits associated with improved bleaching. The effect of xylanase treatment on pulp properties has received less attention than that on chemical use. However, pulp properties are critical for mills to maintain quality, and to satisfy customer needs. Identification of changes in pulp properties can help mills identify potential markets for their pulp.

From the earliest reports of xylanase in bleaching [1], it was recognized that the amount of cellulase contamination of xylanase preparations must be very low to preserve pulp strength. The maximum tolerable cellulase levels that do not affect pulp strength were quantified by Tolan [2]. The remainder of this paper is limited to xylanase treatments that do not affect pulp quality with cellulase.

Paice et al [3] reported that cellulase-free xylanase has several effects on unbleached, unrefined hardwood kraft pulp. These are summarized in Table I, and include an increase in Canadian standard freeness of 27 points, an increase in tear strength, and decreases in burst and tensile strength. These effects are consistent with what one might expect from removing 5% to 10% of the xylan from the pulp, given the role that xylan plays in interfibre bonding. The fibers have an increased stiffness with xylan partially removed.

Other researchers reported laboratory data showing that xylanase treatment has little effect on the properties of subsequently bleached, beaten pulp [4, 5]. When refined to the same level of freeness, the xylanase-treated pulp has strength properties that are indistinguishable from the untreated pulp.

Although these effects of xylanase were widely observed in the laboratory, the effects of xylanase on mill-produced pulp over long periods have not been reported. This paper reports the effects of using xylanase treatment on softwood pulp freeness and strength at the Marathon Pulp Inc. mill in Marathon, ON.

Xylanase Treatment & Bleaching

The Marathon Pulp Inc. mill in Marathon, ON, produces 560 tonnes per day (t/d) of bleached softwood pulp. The mill has eight batch digesters that produce pulp of kappa numbers 26 to 34. The bleach plant is designed to produce pulp of kappa numbers 26 to 34. The bleaching sequence is shown in Figure 1.

Following xylanase treatment, the pulp is bleached. The five-stage bleaching sequence is D.EopDED and the pulp is washed after each stage. Conditions for the bleaching stages are summarized in Table III and are fairly standard for the industry.

Xylanase treatment offers a consistent savings in chemical usage for the mill. Figure 1 shows the total kappa factor (TKf) across the bleach plant over the period, for enzyme-treated and untreated operations. The TKf is calculated from the total equivalent active chlorine used and the kappa number of the brownstock, and takes into account the use of hydrogen peroxide and oxygen in the first extraction stage. The data points shown represent the daily averages at the mill. The xylanase-treated pulp is bleached with a TKf that is 0.02 to 0.04 lower than that required for the untreated pulp on most days.

The bleaching chemical use for the mill is described in Table IV, which indicates that most of the savings in bleaching chemicals results from...
the decreased chemical usage in the Do stage.

The value of the chemical savings from xylanase treatment more than offsets the cost of the enzyme treatment. This allows the mill to save 3.4% of its bleaching chemicals cost by using xylanase treatment. Cost information is summarized in Table V.

The properties of the unrefined pulp are tracked closely by the mill. The enzyme treated pulp averages 5% higher tear strength than the average untreated pulp, Fig. 2. All but 13 days of enzyme treatment result in higher tear strength than the untreated pulp. This is clear evidence that xylanase treatment can result in a higher unbeaten tear strength more than 90% of the time.

The enzyme-treated pulp has 6% lower burst strength and 8% lower tensile strength than the untreated pulp, Figs 3 and 4, respectively. These are the same trends reported by Paice et al [3] on hardwood pulp, but of approximately 50% of the magnitude of the impacts.

Enzyme treatment resulted in a cleaner pulp, with decreases in dirt and an increase in brightness after the pulp machine. Improved pulp cleanliness with xylanase treatment has been reported previously [6]. There was little effect of enzyme treatment on freeness. The effects of xylanase treatment on pulp physical properties are summarized in Table VI.

**CONCLUSIONS**

Xylanase treatment of brownstock at the Marathon Pulp Inc. Marathon mill has decreased ClO2 demand, decreased net bleaching costs by 3.4% and has had several effects on the strength of the unrefined pulp without negatively affecting customer requirements. The cleanliness of the unrefined pulp has improved with xylanase treatment. The results observed over long-term mill use of the xylanase are consistent with laboratory studies of the effects of xylanase on unrefined pulp.
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LITERATURE

Résumé: Le traitement au xylanase de la pâte brune à l’usine de Marathon Pulp Inc. a permis de réduire la demande en ClO₂, ainsi que le coût net du blanchiment de 3.4 %. Il a aussi un effet positif sur la résistance de la pâte non raffinée sans nuire aux exigences du client. Le traitement au xylanase a amélioré la propreté de la pâte raffinée. Les résultats obtenus en rapport avec l’usage à long terme du xylanase à l’usine concordent avec les études effectuées en laboratoire sur les effets du xylanase sur la pâte non raffinée.

Table VI. Final pulp properties.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Untreated</th>
<th>Enzyme Treated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dirt (relative)</td>
<td>100</td>
<td>80</td>
</tr>
<tr>
<td>Burst strength (relative)</td>
<td>100</td>
<td>94</td>
</tr>
<tr>
<td>Tear strength (relative)</td>
<td>100</td>
<td>105</td>
</tr>
<tr>
<td>Tensile strength (relative)</td>
<td>100</td>
<td>92</td>
</tr>
<tr>
<td>CSF (relative)</td>
<td>100</td>
<td>101</td>
</tr>
<tr>
<td>Pulp machine brightness</td>
<td>89.6</td>
<td>90.0</td>
</tr>
</tbody>
</table>

FIG. 4. Relative tensile.

Parameter Untreated Enzyme Treated
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Dirt (relative) 100 80
Burst strength (relative) 100 94
Tear strength (relative) 100 105
Tensile strength (relative) 100 92
CSF (relative) 100 101
Pulp machine brightness 89.6 90.0


Keywords: Xylanase, pretreatment, bleached pulps, pulp properties, chlorine dioxide bleaching.