Enzymes are widely used in many industries including pulp and paper. Ever since their inception, enzymes have been extremely attractive “green” technologies. They are nontoxic for workers, for discharge into the environment or for end-users, and are derived from renewable resources. A fairly recent and intriguing new development is in the use of enzymes to modify the quality of fiber. Enzymes will assist in widening the refining window, allowing paper quality specifications to be met and/or production costs to be reduced.

**FIBER MODIFICATION ENZYMES**

Buckman’s newest technology, Maximyze, is a family of products based on cellulase enzymes. These enzymes have proven to be effective on both bleached hardwood and softwood species.

The enzyme hydrolyzes parts of the cellulose, which leads to delamination of the cell walls, facilitating their collapse. The enzyme-treated fiber can then be refined more easily, which moves the refiner curve to the left (see orange lines in Fig. 1). As a result, the papermaker can choose whether to change paper strength characteristics while maintaining the applied refining energy (from A to B and from D to E), or to keep the paper strength specifications constant, but reduce the applied refining energy (from A to C and from D to F). Fig. 1 provides a graphical representation of this decision-making process.

Table 1 shows examples of possible °SR values and paper characteristics. The first line is the blank (untreated but refined pulp). The second line shows the impact of Maximyze while leaving the refiner energy constant. The third line shows the impact when the refining energy is reduced.

Mills must determine the maximum level of refining energy that can be applied while preventing the pulp freeness from dropping below a certain level. This freeness target is...
typically determined by how fast (or slow) the paper machine’s former section can drain and hence how fast the machine can run or produce product. As you can see in Table 1, with Maximyze, the °SR is lower than in the initial stage, which has a positive effect on drainage.

**CASE HISTORY**

This mill produces various tissue grades with virgin bleached pulp. The mill’s objectives for running fiber modifying enzymes were to reduce refining energy, reduce the percentage of long fiber, and increase speed of the machine. The conditions were as follows:

- production of 90 tons per day
- speed of machine: 1500 m/min
- grammage of paper produced: 17 g/m²
- furnish 50% long fiber; 50% short fiber, bleached pulp
- temperature in the pulper: 48 °C
- pH between 6.8 and 7.2

**Table 1**

<table>
<thead>
<tr>
<th>Untreated but refined (A and D)</th>
<th>°SR in the pulper</th>
<th>°SR after the refiner</th>
<th>Refining energy kWh/ton</th>
<th>Tensile index Nm/g</th>
<th>Air resistance (Gurley)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant level Refined + treated with Maximyze (B and E)</td>
<td>30</td>
<td>55</td>
<td>150</td>
<td>100</td>
<td>140</td>
</tr>
<tr>
<td>+ Maximyze but reduction in refining energy (C and F)</td>
<td>30</td>
<td>40</td>
<td>100</td>
<td>70</td>
<td>80</td>
</tr>
</tbody>
</table>

**Figure 2** below on the Maximyze trial summarizes the first short trial in the mill. The enzyme was dosed at 500 g/ton in the pulper. After three reels, the enzyme effect was seen in the tensile strength improvements. Machine direction and cross direction tensile strength increased. One of three long fiber refiners can be switched off. During the production of reel 13 to 18, we were also able to switch off the short fiber refiner. Since the paper still had very good strength characteristics, the dosage of Maximyze was gradually reduced.

From reel 16 to 18, the dosage was 250 g/ton and from reel 19 to 24 only 125 g/ton. In the meantime, the Yankee pressure dropped from 7 to 5.5 bars. From reel 19 the refiner for short fiber had to be switched on again. The speed of the machine was kept constant during this short trial. At reel 25 the trial was stopped. The effect of the enzyme diminishes slowly since we had residual enzyme working for some time. At reel 28 and 29 it is clear that the tensile strength is dropping. Additional refining energy needs to be applied in order to keep the strength specification of the paper.

The mill was converted to the product and has been running Maximyze 2545 for almost two years.

The return on investment achieved by the mill (calculated per day using 90 tpd production) was as follows:

- Reduction in refining energy: -44 kWh/t
  \[ \times 0.07 \text{ €/kWh} \times 90 \text{ tons} = 277 \text{ €} \]
- Reduction in % long fiber: begin situation 50% FL – 50% SF, with enzyme 40% LF – 60% SF.
  The difference in price is 34 €
  Or savings per day = 306 €
- Stopped completely dry strength aid: 216 €
- Cost of enzyme: 315 €
- Total net saving = minimum 484 €/day

**SET CLEAR GOALS**

Process knowledge is an important consideration when preparing to use an enzyme. Enzymes are very specific and are only effective in a certain pH and temperature range, so the proper work needs to be done to select the best enzyme. Sufficient contact time is required for the total reaction. The enzyme can be denatured by oxidizing chemistries.
It is essential to set clear goals for the project. Decide what you are trying to achieve and what measurements will be used to determine success or failure. Data collection is the key, e.g. you could envisage a reduction in production cost by considering the increased use of less expensive fiber.

The following schematic summarizes the major advantages of using Maximyze in mills with and without refiners in the process. Typically, in European mills producing linerboard using OCC, there is no refining. However, refining is employed in the fine paper and specialty paper mills. The tissue industry to date has had the most to gain from the introduction of enzyme technology, especially on grades requiring high refining.

**CONCLUSION**

The benefits of enzymes used for fiber modification have been proven. This technology has still only scratched the surface of the overall market potential. We will continue to grow to meet new challenges and opportunities in the changing marketplace to aid in both cost reduction and improved product quality.

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