Enzyme Technology Improves Efficiency, Cost, Safety of Stickies Removal Program

Until recently, enzymes have been used only for narrow niche applications in the pulp and paper industry. During the mid- to late-1980s, for example, mills began experimenting with enzyme delignification in the wake of a chlorinated organics (dioxins/furans) scare that eventually gave rise to the EPA’s Cluster Rules in late 1997.

The promise of better, more environmentally sound pulping and bleaching technologies based on enzymatic support never gained momentum after the Cluster Rules promulgated, and today only a small handful of mills around the world are using enzymes as an integral part of their chemical pulping/bleaching processes.

A similar handful of mills are using enzymes for pitch control, another technology that offers considerable environmental and cost/efficiency gains versus traditional chemical approaches, but for various reasons hasn’t yet taken off in the industry. Limited use of enzymes in waste treatment and other areas has been reported by some mills, but not much progress is expected in these arenas for the foreseeable future.

The application of enzymes in the pulp and paper industry likely would have languished and disappeared altogether if Buckman Laboratories had not picked up the ball in the early 1990s. As Philip Hoekstra, Director-Applications, R&D, at Buckman, explains, “at that time we decided to devote considerable research effort to enzymes because there was so much promise with them.

“First, they are biodegradable and environmentally safe,” he says, “and they tend to have very low toxicity characteristics. There are literally millions of enzymes in nature and many are widely utilized in other industries to increase efficiency and/or cut costs as well as to improve overall environmental performance and safety.” Overall, the track record with enzymes over several decades has been very good in a wide variety of industries and consumer products, Hoekstra emphasizes.

As a result of Buckman’s efforts, several new enzymatic technologies are now being increasingly used throughout the paper industry, including “green” boilout approaches to replace traditional and sometimes hazardous chemical programs, and enzymatic stickies control at deinking/recycling plants. In fact, the company’s Optimyze stickies control product recently received the EPA’s Presidential Green Chemistry Challenge Award for advanced pollution prevention technology.

In use at dozens of mills in Europe, North America, and elsewhere around the world, Optimyze was commercially introduced to the paper industry in May 2002. Since then, the technology has been used to control stickies in a variety of recovered paper furnishes, including ONP (old newspapers), OCC (old corrugated containers), and MOW (mixed office waste) papers.

Hoekstra says that most recycling mills employing this new technology report a major reduction in the use of solvents and other chemistries usually needed to clean a paper machine and its components. Product quality and machine runnability have improved dramatically, reducing downtime and waste. In addition, lower quality recovered paper can be used in many of these mills’ processes rather than landfilled.

Evolution of Technology

Buckman got started with enzymes in the paper industry by developing a technology to specifically attack biofilms (slime) on paper machines in Europe, Hoekstra
notes. “We have 80-90 paper machines in Europe currently using this technology,” he points out, adding that “from our base of success there, we broadened the search for new enzyme applications in the paper industry. We have been in the stickies control business for many years, so it was a natural evolutionary path for our enzyme research.”

Hoekstra says that today more than half of operating U.S. paper mills use recovered fiber in their processes, and that half of these use recycled fiber exclusively. The recovery rate for all types of papers in the U.S. has recently risen above 50%, according to current AF&PA figures, and overall, recovered paper accounts for some 40% of the U.S. paper industry’s fiber needs.

Inherent with the massive amounts of recycled fiber now being used by U.S. pulp and paper mills is a host of contaminants that, no matter how carefully and thorough the recovered paper is sorted, invariably find their way into a mill’s fiber processing stream. These include polyvinyl acetate (PVAc) used in products such as self-stick labels, glues, tapes, etc., which are also called pressure sensitive adhesives.

Recent estimates place a billion dollar-plus tag on the stickies problem in the U.S. alone. About 75% of that can be attributed to lost production caused by downtime for cleaning paper machine components.

The Optimize enzyme is specifically effective with resins such as PVAc, facilitating a chemical reaction in which the vinyl acetate chemistry is hydrolyzed to vinyl alcohol. In the process, stickies are reduced in size and made less tacky.

“If stickies are rendered non-tacky, they’re not going to stick to each other and form larger globules that can be seen in the sheet and cause other converting problems down the line. They’re not going to stick to machine components and framing, and they won’t clog up felts and fabrics,” Hoekstra explains. “If they’re not visible, basically they’re not a problem.”

Figure 1 shows the effects of Optimize treatment of stickies. On the left, polyvinyl acetate particles have agglomerated to form large globules that can cause not only breaks and downtime on the paper machine but create operating system breaks and problems on converting equipment as well. The globular particles can also cause paper to double feed through printers, etc. On the right in this figure, Optimize enzyme treatment keeps the particles small, dispersed, and non-tacky.

Figure 2 is a scanning electron microscope photo of the surface of a stickies particle showing the effects before and after enzyme treatment. As can be seen on the right, the surface is very smooth after treatment compared with that before treatment on the left.

**Process Applications**

Before taking the Optimize technology to the mill trial level, Hoekstra, says that laboratory methods were necessary to determine if and how effective it might be on a mill’s specific furnish—if at all. In most cases, detailed lab tests are still conducted with each customer’s furnish before a program is launched at a mill.

“We need to know in the lab which enzyme works best in a mill’s system before we ever go to the mill,” Hoekstra says. “A mill will ship us a container of their thick stock and we will use the same type of screening they use to collect the stickies, which are then transferred in a heated press to a clean sheet of paper. Standardized image analysis is used to measure and examine the stickies, which are then treated with enzymes accordingly. If we see a significant drop in stickies, we are ready to take that specific technology to the mill.”

The enzymes have to be in a suitable form for use at a mill, Hoekstra explains. It’s best that they are in a liquid solution so they can be injected using traditional methods, and that they have a long shelf life. They also must be in a concentrated solution such that application rates are reasonable. To accomplish this, Buckman’s team developed some advanced, proprietary stabilization technologies, which have subsequently been patented.

There are no typical points in a mills process to apply the enzyme treatments, according to Hoekstra. This has to be determined on a case-by-case basis. “For example, we might add the treatment at the pulper, then add some at

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**Figure 1.** Results of enzyme treatment on stickies (no treatment on the left and after Optimize treatment on the right).

**Figure 2.** Electron photomicrograph of the surfaces of a stickies particle before enzyme treatment (left) and after treatment (right).
the paper machine wet end, especially if there was, say, a stickies problem in the wire. The enzymes do need a little time to work, and recirculation of a machine’s white water typically provides that.”

Addition of the enzymes is obviously determined to a large degree by the type of system and equipment a mill has. For example, Hoekstra says, “you wouldn’t want to add them at or ahead of a drum pulper in a recycled line, because these lower-temperature systems are designed around keeping stickies contaminants large for easy removal.” Breaking the contaminants down with enzymes would be counterproductive.

Although process temperature is a consideration, especially very high temperatures, enzymes can be specialized to work in a wide range of cool to hot. Buckman has an enzyme used to clean starch systems, for example, that works up to boiling temperatures. The Optimyze enzyme works generally in a range of 80ºF to 160º F.

The pH of a system is also a consideration. The Optimyze enzyme tends to be most effective on the alkaline side, working in a pH range of 6.5 – 10. Thus, if a paper machine or feed system is particularly acidic, it would be best to go back somewhere in the system before the pH drops to find the best addition point, Hoekstra explains.

Enzyme development is a constantly evolving science, he points out. “Today, developers are searching hot springs, steam vents under the ocean, etc., to find organisms that produce enzymes under some very severe conditions. These can be modified and adapted to applications in almost any industrial process.”

Generally, if stickies are not visible, as Hoekstra emphasizes, they are not really a problem. A portion of the stickies made non-tacky and broken up by the Optimyze technology remain in the furnish and become part of the finished sheet. But some are removed by various “kidneys” in a typical mill’s process line, and go to waste treatment and/or landfill. Dissolved air flotation clarifiers/savealls are one way of removing them, and they can also be removed with the flotation deinking sludge.

No process modifications are usually required to use the enzymes in a recycling line. “Basically, it’s no different than with any of our other chemical agents used at a customer mill, where our technical people are on-site most of the time,” Hoekstra says. Cost-wise, Optimyze competes well with most traditional agents used for stickies control, he adds.

**Mill Experiences**

The dozens of mills currently using Optimyze enzymatics to control stickies all report significant gains over traditional chemical approaches they were using. One U.S. mill, for example, produces coated paperboard for conversion to food boxes. It produces 400-plus tpd using 100% OCC as its furnish.

Stickies problems were causing significant deposition problems on this mill’s paper machine and related runnability and off quality problems in the sheet. The high level of paper machine breaks was causing significant operating downtime. Kerosene and other harsh chemical solvents were being used to remove the deposits.

After launching an Optimyze enzyme program, paper machine deposition was reduced 75% and machine breaks/downtime were reduced accordingly. Off-quality product tonnage dropped and the mill’s use of cleaning chemicals was practically eliminated. With holes and other stickies related quality problems rectified, customer complaints fell to almost none.

As shown in Table 1 below, this coated paperboard mill experienced a $1.33 million annual return by eliminating stickies. Forming fabric changes were cut by four per year and paper machine breaks were reduced to the tune of 45 annually, together representing a million dollar savings.

A mill in Brazil producing 270 tpd of linerboard using 100% OCC was having significant downtime problems due to stickies. Stickies in the sheet were also causing breaks at the mill’s customer converting operations. The mill was having to use a higher quality, more costly OCC in an attempt to minimize these problems.

When the mill switched to Optimyze technology, product quality improved immediately. Production breaks were almost totally eliminated (reduced by 30/month), giving a much more efficient operation. In fact, the mill achieved record production after the switch. In addition, it was able to use a poorer quality OCC, cutting produc-

<table>
<thead>
<tr>
<th>Problem Caused by Stickies</th>
<th>Benefits of Control</th>
<th>Annual Savings</th>
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</thead>
<tbody>
<tr>
<td>Reduced life of forming fabrics</td>
<td>Reduce four fabrics/yr</td>
<td>$100,000</td>
</tr>
<tr>
<td>Downtime for cleaning fabrics, etc.</td>
<td>Increase production</td>
<td>$170,000</td>
</tr>
<tr>
<td>Chemicals used for cleaning</td>
<td>Replace chemicals</td>
<td>$160,000</td>
</tr>
<tr>
<td>Paper machine downtime</td>
<td>Eliminate 45 breaks/yr @ 2 hours each</td>
<td>$900,000</td>
</tr>
</tbody>
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**Total possible annual return from eliminating stickies: $1,330,000**

Table 1. Savings realized by switching to enzymatic stickies control at a 400 tpd coated paperboard mill.
tion costs even further.

The following two photographs show the buildup of stickies being doctored from dryer cans at this mill before the use of enzymes and the subsequent elimination of stickies after the Optimyze program was started.

Continuing with a few other sample cases, use of Optimyze technology allowed one U.S. mill to produce tissue and toweling products that easily met a fast food chain’s stringent quality and fiber content requirements (at least 65% post consumer fiber). In fact, this mill was able to boost recycle fiber content to 100% and still meet the requirements, while other mills supplying the restaurant chain had to use much higher percentages of virgin fiber.

Another U.S. mill that produces more than 1,000 tpd of various grades of tissue from 100% recycle fiber was experiencing severe stickies deposits in its press felts. When the deposition approached a critical level, which was happening much too frequently, production had to be stopped and solvents used for cleaning. Hoekstra says the mill was using several hundred gallons of kerosene and other solvents per day during these cleaning cycles.

Also, press section showers are used continuously in an attempt to keep this machine’s press felts clean. The water used in these showers is recycled within the paper mill system, which meant that this source too was building up high levels of stickies and re-depositing them in the cleaned felts and on other paper machine components. Clearly, another solution was needed.

The mill now adds Optimyze to the water used in the felt cleaning showers. As a result, downtime for solvent cleaning has been reduced from 1.81 hours per week before the treatment to an average of 0.73 hours per week. This represents a 60% reduction in downtime and the amount of solvent used for cleaning the machine is reduced by a corresponding amount.

Similar problems were occurring on another paper machine in this mill and the same strategy was used to solve them. With this machine, the average downtime for solvent cleaning dropped from an average of 1.6 hours to 0.46 hours per week, representing a 70% reduction in downtime and solvent usage. This 70% gain would have been closer to 80% if, during three weeks of the recent period, a cleaning shower had not been inadvertently turned off.

In many other case studies involving almost every grade sector, from multi-ply coated boxboard to packaging grades, stickies have been reduced dramatically with the enzymatic control program, resulting not only in higher quality products and fewer converting customer complaints, but significant reductions in culled production and increased use of lower quality and much less costly recovered fiber.

Finally, but certainly not least important, Hoekstra points out that using enzymes to control stickies problems has many safety and health related benefits. Not only are most solvents and mineral oils costly, they also can create potential safety and environmental issues. As shown by extensive paper machine air sampling studies, “ecotox” toxicity evaluations, and skin patch testing programs, enzymes represent absolutely no threat to the health and well being of humans as well as other terrestrial and aquatic life.

“Enzymes themselves are not living things. They are just proteins that catalyze specific reactions. One of the nice things about enzymes being focused on just one specific chemical reaction is the fact that they will not interfere with other chemistry in the sheet, such as sizing or strength additives,” Hoekstra explains.