New Technology aimed at Improving the Sustainability of Paper

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Introduction

Mills making paperboard from recycled fibre must deal with reduced paper strength, decreased yield, system contaminants, poor additive efficiency, and increased chemical oxygen demand (COD) levels. Of these issues, loss of strength performance is the most critical. A common response to compensate for strength loss is to apply more internal and surface starch in the papermaking process. This increases starch levels in the final board and therefore in the resulting waste furnish used to make new paperboard. Starch levels in OCC can easily exceed 5%.

The starch present in waste furnish is the most expensive component by weight. Until now, it has been impossible to recycle this starch, as it immediately degrades, dissolves and exits via the effluent stream. The dissolved starch also wreaks havoc in the papermaking system, spiking microbial activity, reducing pH, increasing conductivity, interfering with additive performance, reducing strength, and increasing effluent COD levels.

Solenis developed the Biobond[1] program in an effort to solve these issues. This new program enables the recovery and reuse of starch in waste paper, thereby increasing yield, improving strength, and eliminating the issues caused by degraded starch in papermaking at the source. This paper describes this innovative technology and highlights technical performance and sustainability advantages for packaging papermakers. Results from commercial applications will be presented to demonstrate benefits of yield increase, strength increase, additive efficiency improvement, and reduced COD levels in effluent.

Sustainability and the Paper Industry

The landscape of pulp and paper manufacturing has changed rapidly and significantly over recent decades. Several key market shifts are driving these changes including the increased use of recycled or recovered fibre, lightweighting of paper-based packaging, and replacement of printing and writing papers by electronic media. A common thread connecting most of these market shifts is the industry's drive towards improved sustainability. The pulp and paper industry has made great strides in the last 50 years to become much more attractive in terms of sustainability and reduced environmental impact. Examples of these improvements are widespread implementation of sustainable forestry practices, elimination of elemental chlorine bleaching, and increased recovery rates and manufacture of recyclable packaging. The primary raw material, wood fibre, is bio-sourced, renewable, and biodegradable. Additionally, wood fibres can be recycled numerous times to make new paper, and recovery rates are high; it is estimated that over 250 million tons of recovered fibre will be used in 2014, representing over 50% by weight of all paper production[2]. Although the pulp and paper industry has a favourable sustainability story, consumers, brand owners, and governmental agencies are increasing pressure on all industries to further improve in this regard. As a result, pulp and paper manufacturers have dramatically increased efforts to lessen the impact of their operations on the environment and become more sustainable. These efforts include sustainable fibre certification, expansive water, energy and emission reduction initiatives, and improving the recyclability of end products.

Suppliers to the pulp and paper industry have played a critical role in improving the sustainability of their customers' operations and products. Of these, providers of specialty chemicals have had a particularly significant impact on pulp and papermaking process efficiency and end product sustainability. Notable advances in recent decades made possible by specialty chemicals include the conversion to alkaline papermaking in the 1980s, the introduction and success of synthetic dry strengths in the 1990s, and the move to inorganic mild oxidising biocides in the early 2000s. Each of these advances has had a definite positive impact on sustainability. Alkaline papermaking enables the use of fillers that can substitute fibre in some grades by up to 30%, dry strength resins have dramatically expanded the use of recycled fibre, and improved biocides have increased on-machine efficiencies by 5-10 percentage points. With a long history of providing new innovations, such as those mentioned above, to meet market needs, Solenis has recently introduced and launched a new program entitled "Biobond. Improving the Sustainability of Paper program" specifically designed for mills making recycled packaging grades. This innovative treatment program has been widely successful with numerous paper machine conversions in Europe, and is now expanding into other regions of the globe.

Program Overview

The Biobond program is designed to achieve one critical objective: to recover and reuse the starch already present in the incoming waste furnish. The value in terms of yield and paper strength that can be generated as a result of recovering this waste starch is quite significant and has not been fully realised in practice until now. This is because virtually all of the waste starch that enters the paper mill as raw material in the recycled furnish quickly degrades upon pulping and is lost before it can be retained in the papermaking process. In many cases, paper makers are not fully aware of this scenario and that potentially millions of dollars per year of a valuable and usable raw material are literally being washed away with the effluent. Consider the financial impact if this starch could be recycled along with the fibre. Starch cost is typically three times that of recovered fibre by weight; if waste starch could be recovered and reused, the need for adding fresh starch at the size press or wet end could be significantly reduced. Synthetic dry strength agents could also be reduced or eliminated. Lower basis weights could be achieved without strength loss. Additionally, the negative impact of this degraded starch on the papermaking process is very significant causing pH to decrease and conductivity to increase in the paper machine wet end, which has serious ramifications for additive efficiency, deposit control, and final board quality. By recovering and reusing waste starch, the new program addresses all of these issues with dramatic performance improvements in three key areas; yield, paperboard strength, and efficiency. The performance gains in these three areas directly translate into improvements in both the environmental and sustainability aspects of the process and end paperboard product.

Recovering and reusing waste starch represents a very difficult technical challenge. For decades waste starch was known to degrade and cycle up in the white water loop, but was considered to be "dead" in terms of reactivity, ability to be retained, and strength impact to the final board. Successfully turning this situation around required a multifaceted approach that would accomplish two main technical objectives: prevent the incoming waste starch from biologically degrading in the stock loop and effectively retaining the preserved starch onto the fibre. The new treatment program consists of several differentiated chemistries working together holistically, an approach that is needed to accomplish these challenging technical objectives.

Starch preservation is the first step and can be accomplished effectively with thorough and consistent application of the right microbiocides. Traditional organic biocides typically used to treat starch or fibre, such as isothiazolin and gluteraldehyde, will preserve starch but the dosage rate required to do so effectively is too high to be economically viable. The program addresses this problem by the use of BAC (bromide-activated chloramine), an inorganic mild oxidiser that kills a wide range of microorganisms quickly and cost-effectively. Treatment of the entire stock loop system is usually necessary to keep the starch in a preserved state throughout the range of normal operating conditions on the paper machine. After the optimum BAC microbiocide treatment program has been designed and implemented, most of the available starch should be in a preserved state. The second step is to retain this starch in the paperboard. If this starch is not retained it can cause serious contamination and deposition issues throughout the paper machine system. This step is perhaps the most critical and the most challenging. The successful development of the starch retention portion of the new program took several years of field trial work and laboratory research, culminating in a unique fixation and retention program utilising two differentiated polymer chemistries. The end result is that most of the available loose starch is fixed to the fibre and retained in the final board, improving yield and providing additional strength.

The Biobond program preserves, recovers, and reuses an expensive and valuable raw material that would otherwise be lost. Yield and paperboard strength are significantly improved, but there are also very significant side benefits that must be mentioned. By keeping starch from degrading and solubilising in stock and white water loops, pH is maintained or increased. Conductivity levels are significantly reduced, as starch and fillers are no longer solubilised (see *Figure 1*). The result is a much cleaner system with more effective reactions between fibres and chemical additives. Operating efficiency is improved along with critical parameters such as sizing efficiency, wet web strength, dry strength, and deposit control. Finally, COD levels in effluent are reduced by up to 25%, thereby reducing waste water treatment costs, and reducing environmental impact (see *Figure 2*).

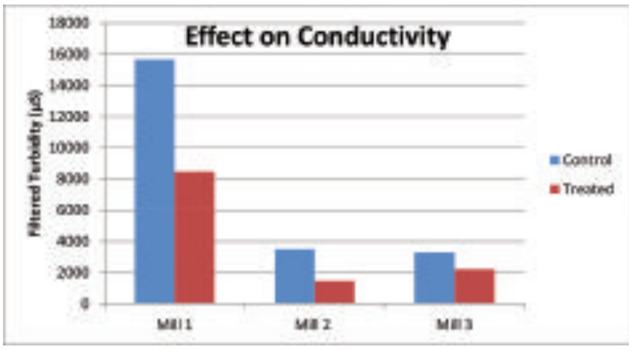


Figure 1: Effect of Program on Conductivity

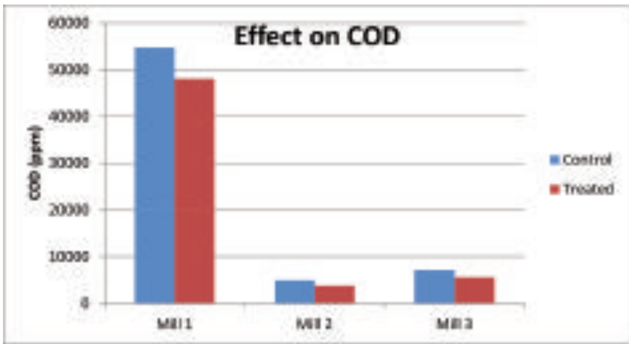


Figure 2: Effect of Program on Effluent COD

Program Benefits

How big is the opportunity to increase yield, improve strength, and increase efficiency in a typical recycled containerboard mill? To calculate the potential yield benefit, it is necessary to know how much starch is available to recover. Starch contributions come primarily from the native starch applied on the paper machine via size presses and spray booms, as well as wet end cationic starch applications and starch-based glues applied in corrugating and converting. The average starch level in old corrugated container (OCC) furnish is estimated at 5% by weight, although the actual percentage can vary significantly by geography. For example, the OCC collected in Europe and Asia contains higher levels of starch due to the high number of size presses used in the manufacture of containerboard - in some cases over 50 kg of surface starch per ton of paperboard is applied in these regions in order to meet strength requirements. The picture is quite different in North America, where most size presses on recycled containerboard machines have been removed or bypassed over the years due to the desire for speed increases. Also, there is less need for starch addition on the recycled paper machines in North America because of the high quality of local OCC available. Assuming a global average of 5% starch by weight, the program is shown to recover over 50% of this starch, effectively improving yield by 2.5 - 3.0%. With recovered fibre and starch prices projected to continue to increase in the long term, this level of yield increase represents a significant cost savings for recycled packaging mills.

The starch applied on the paper machine is used to accomplish one main objective – improved paperboard strength. The ability to reuse waste starch as a strength agent has very positive cost-savings implications. Strength programs are typically the most expensive additive programs used on the paper machine, whether they are size press starch applications, internal cationic starch applications, or synthetic dry strength resins. Most paper machines currently using the program elect to leverage the additional strength gained from recovering waste starch by reducing the amount of fresh starch applied at the size press. In these cases, size press starch reductions of more than 20% have been demonstrated (see *Figures 3 & 4*). Additionally, there is a potential to reduce the usage of expensive synthetic dry strength agents which are being used more extensively due to the general decline in recovered fibre quality. In many cases, these synthetic dry strength programs can cost as much or more than size press starch treatment. The new program has reduced or even replaced synthetic dry strength applications in some cases, generating cost savings of up to $10/ton. Finally, this added strength can be used to reduce basis weight. This is a very important benefit, especially for mills seeking to manufacture lightweight recycled linerboard and corrugating medium grades.

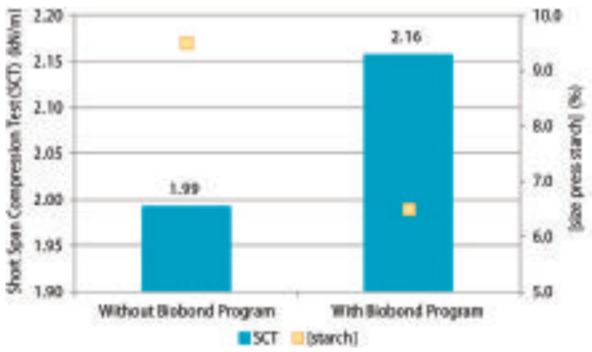


Figure 3: Testliner Production: Increased Short Span Compression Test (SCT) and Reduced Starch Concentration

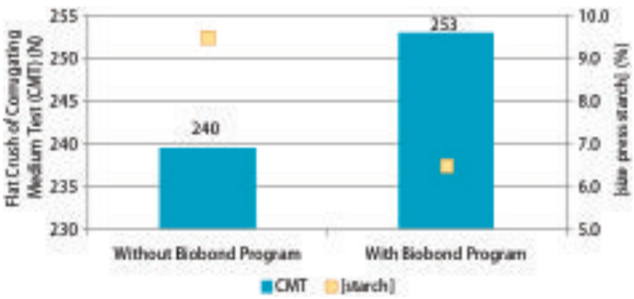


Figure 4: Fluting Production: Increased Corrugating Medium Test (CMT) and Reduced Starch Concentration

As previously mentioned, the program prevents the solubilisation of waste starch. Dissolved starch wreaks havoc in the papermaking system by spiking microbial activity, reducing pH, increasing conductivity, interfering with additive performance, reducing strength, and increasing effluent COD levels. Mills can realise multiple obvious benefits by preventing these phenomena. In most cases, improved uptime due to break reductions, a result of a cleaner system with reduced potential for deposits have been noted (see *Figures 5 and 6*). Further, the resulting improvement in additive efficiencies results in direct and measureable cost savings, particularly for retention aids, cationic coagulants, sizing chemicals, dry strength agents, and defoamers. Several dollars per ton of additive savings have also been realised.

Fig 5: Before the program: walls of whitewater chest show high levels of deposition

Fig 6: After the program, whitewater chest walls are clean with no deposition

Finally, the positive impact of this program on sustainability cannot be over-emphasised. Virtually every improved parameter can be directly tied to a quantifiable sustainability or environmental benefit. Increased yield translates to reduced starch and fibre usage. Improved strength translates to reduced fibre, additive, and energy usage. Reducing the COD load in effluent reduces energy and water usage, lowers treatment costs and reduces sludge production and landfilling. All of these improvements contribute to reduced carbon dioxide emissions. The yield benefit alone eliminates thousands of tons of CO_2 emissions per year on a typical recycled containerboard paper machine. Over the years, several industry groups have conducted carbon footprint studies on various grades of paper and paperboard. The results of these studies vary significantly and are influenced heavily by the fibre source used in manufacturing (virgin vs. recycled), the type of energy used in manufacture, (fossil fuel vs. biomass), and the geography where the paper was produced. Based on these studies and others, it is reasonable to estimate that the total amount of carbon dioxide emitted per ton of recycled containerboard manufactured ranges between 0.4 and 1.2 tons[3,4,5]. Using an average figure of 0.8 tons CO_2 emissions per ton recycled containerboard, we can calculate that the 2% yield increase provided by this new program can eliminate 4,000 tons of CO_2 emissions when used on a typical recycled containerboard machine making 250,000 tons per year of paperboard. With global production of recycled containerboard currently exceeding 100 million tons, global implementation of this new technology program could have a very significant positive impact to the environment, reducing CO_2 emissions by over 2 million tons/year.

Summary

The documented benefits from European paper mills of this new program are summarised in Table 1.

Parameter	Typical Benefit	Financial Impact ($/ton savings)
Basis Weight	2.0% decrease	$4.90
Yield	2.5% increase	$3.90
Surface Starch Application	15% decrease	$4.30
Fresh Water Usage	2.0 m3/ton reduction	$1.50
Cleaning Program	Eliminated	$0.90
Retention Aid Program	25% decrease	$0.75
Effluent COD	20% reduction	Varies

Table 1: Documented Benefits from European Paper Mills

This unique, innovative treatment program resolves a long-standing industry problem: the recovery and re-use of starch that is present in incoming waste paper furnish. The negative system side effects associated with solubilised starch are eliminated. Yield, strength, and operating efficiency are significantly improved, thereby making the manufacture of paper much more cost effective and much more sustainable.

REFERENCES

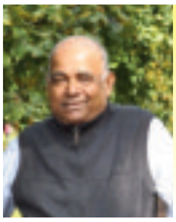
1 All references to “Biobond” in this article are to Solenis’s service mark “Biobond. Improving the Sustainability of Paper”

2 RISI - Outlook for Global Recovered Paper Markets 2012

3 Arjowiggins Graphic – “Recycled Paper Guide” 2010

4 United States Environmental Protection Agency “Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from the Pulp and Paper Manufacturing Industry” 2010

5 The Climate Change Working Group of ICFPA “Calculation Tools for Estimating Greenhouse Gas Emissions from Pulp and Paper Mills – Version 1.1” July 2005



A letter from India

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Wood Productivity by Indian Pulp and Paper Mills

Can the wood productivity be raised to more than 50 tonnes/hectare/year?

While the shortage of quality wood raw materials for the pulp and paper industries will continue to last for ever in India, recycled fibres will come to be seen as a panacea to meet the demand of total paper production, which is set to rise from the present 13 million tonnes to 20 million tonnes in 2020; an increase of more than 50% from the present state. The few mills based on agro-based resources, have been able to survive in spite of the stringent environmental regulations in the country. Meanwhile, all the wood-based mills have raised their plantation land to different extents to meet partially their raw material requirements, but what about productivity?

How much wood per hectare is produced is quite important. ITC, for example, has promoted so far 125,000 hectares of farm forestry plantations, increasing the productivity to 20-58 tonnes/hectare/year, compared to 4-6 tonnes/hectare/year, from improvised seedling plantations, through intensive research and development efforts. From a mere 4-6 tonnes to 58 tonnes, *i.e.* 10 times more wood can be availed from 1 hectare of land. The figure is often reported to be touching even 100 tonnes/hectare/year. What about other mills?

In front of the limitation in getting degraded land from the Government because of national policies, many mills are having plantation programmes based on Farm forestry and Agro forestry. In fact, there seems to be no way out and if the productivity figure can be enhanced, solutions to the raw materials’ crisis could be on the horizon.

The plantation programmes followed by the mills are mostly using Clonal technology. Clones from the chosen parents are selected and multiplied in mist chambers using the most favourable environmental conditions, to improve their survival rates, which are then propagated in the land available to the mills or supplied to the farmers, through voluntary contract schemes. Villagers find these schemes quite attractive and each mill has a separate department for forestry and plantation to induce and encourage farmers for such plantations. Banks and many societal organisations including Panchayats (Village community centres) are involved to propagate such programmes.

The time has come for mills to examine how to increase the productivity from their own land in line with the R & D efforts of ITC Ltd. It should be taken as a challenge in R & D, spreading new available technologies such as tissue culture. The possibility of introducing the improvised clonal plantations added by tissue culture etc should be sought out quickly by the mills using wood as a source of raw materials.

Mechanical harvesting techniques, faster rotation of harvesting and even nanotechnology applications can be pursued, to raise productivity further. We will discuss the new technologies available which are adaptable for raising productivity in the next issue.