MORE WITH LESS: PROFITABLE AND SUSTAINABLE SOLUTIONS FOR WET-STRENGTHENED TISSUE GRADES

VLADIMIR GRIGORIEV, APPLICATIONS & MARKETING, PULP & PAPER EMEA, GERMANY
ERIC PADOVANI, APPLICATIONS & MARKETING, PULP & PAPER EMEA, FRANCE
INTRODUCTION

Wet strength resins (WSR) are important in producing quality tissue grades. WSR’s must meet regulatory requirements while balancing costs.

Wet strength resins (WSR) are critical for achieving desired quality targets for most tissue grades, such as towel, industrial wipes, facial tissue, hankies and napkins. The predominant WSR in the market is based on the polyamidoamine-epichlorohydrin (PAE) chemistry. There are almost no practical alternatives to PAE resins, especially when it comes to permanent wet strength that can develop under pH-neutral conditions [Ref 1]. For some grades, where temporary wet strength is acceptable, glyoxalated-polyacrylamide (GPAM) chemistry can be used [Ref.2]. Otherwise, PAE resins rule the wet strength world.

In the current, highly competitive tissue market, quality and price must be balanced and profitability is always of great importance. In order to achieve high levels of wet strength, especially needed for towels, high WSR dosages are required, often reaching 30 kg/t (as received) or even more. The cost is generally 5-20 €/t or more thus making WSR the most expensive chemical application in tissue production. Consequently, the economics of wet-strengthened grades largely depend on the resin efficiency.

In the past decade, the cost pressure in tissue production also comes from stricter regulations of chloro-organic materials, which are suspected carcinogens. The three commonly regulated materials found in PAE resins are 3-chloro-1,3-propandiol (CPD), 1,3-dichloro-2-propanol (DCP) and absorbable organic chlorine (AOX). The regulator’s concerns arise from migration of these materials from the wet-strengthened paper to food or their discharge with waste water, potentially harming people and the environment.

IMPROVING PAE CHEMISTRY

Since mid-1980s, however, the PAE chemistry has undergone a huge transformation with regard to much lower residual levels of chloro-organics. These developments are well reviewed [Ref 3]. Nowadays, very clean PAE resins are available. These are produced using highly sophisticated manufacturing processes and therefore naturally come with an additional manufacturing cost.

The existing resins in the market have different levels of CPD, DCP and AOX and are classified as generation (G) 1, 2, 2.5, 3 and 4. The higher the G-number, the cleaner the resin. In the EU countries, the G1 resins are not used anymore since they have to be labeled as toxic and carcinogenic. The predominant resins marketed in the EU for tissue and towel are G2 and G2.5; whereas, the G3 and G4 resins are primarily used in products designed for direct food contact, e.g. coffee filters or sausage casings. The cleaner resins are highly technical materials and tend to cost more. Therefore, the main drivers for selecting an optimal WSR are regulatory targets and the cost that have to be balanced out.

Figure 1. Major factors affecting profitability of tissue production.
USE LESS WSR AND ACHIEVE MORE BENEFITS

The regulatory pressure on the bottom line continues to increase. The most recent restriction will be imposed by the EU Directive 2010/75/EU that comes into effect in 2018 and will reduce the AOX limit in effluent in the wet-strength paper production from 150 to 50 g/t of paper produced [Ref 4]. Furthermore, not only the governmental bodies police chloro-organics (e.g. FDA, Bfr, EU Directives), but the industry self-regulates through eco-labeling (EU Flower, Nordic Swan) or requirements imposed by retailers (e.g., Lidl, Aldi). Many producers in the EU and elsewhere are looking for new solutions to stay compliant with more stringent requirements without significantly increasing the cost burden of their operation.

Attuned to the industry needs, Kemira has developed a number of cost saving and sustainable technologies for wet-strength tissue production. These include high efficiency and low AOX resins as well as complimentary functional promoters that further improve the efficiency of WSR. Higher efficiency helps not only use less resin and reduce the operating cost, but also reduce the level of AOX and other chloro-organics in tissue sheet and effluent. This paper reviews Kemira’s advanced solutions, which allow tissue makers to get more benefits by using less WSR.

**HIGH-PERFORMANCE WET STRENGTH RESINS**

The obvious solution to reducing the cost of wet-strengthened tissue is to use less WSR, without jeopardizing the sheet quality targets, for which Kemira offers high-performance Kemira FennoStrength® resins. Quite often, we see opportunities to reduce the resin dosage by around 10-15% and sometimes even by up to 25%. In Table 1, the most recent industrial cases are summarized. Lower dosages allow for chemical savings as well as lower AOX in paper and effluent. There are often additional benefits achieved for machine runnability related to more balanced charge, such as a lower risk of deposits, felt plugging or excessive foam.

<table>
<thead>
<tr>
<th>MILL</th>
<th>GRADE</th>
<th>FIBERS</th>
<th>WSR DOSAGE VS. INCUMBENT</th>
<th>OTHER BENEFITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Kitchen towel</td>
<td>Virgin</td>
<td>-25%</td>
<td>AOX on target</td>
</tr>
<tr>
<td>B</td>
<td>Kitchen towel</td>
<td>Virgin</td>
<td>-17%</td>
<td>Less AOX in effluent, defoamer eliminated</td>
</tr>
<tr>
<td>C</td>
<td>AFH towel and napkin</td>
<td>Virgin</td>
<td>-15%</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>AFH towel</td>
<td>DIP</td>
<td>-7%</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>Industrial wipes</td>
<td>DIP</td>
<td>-10%</td>
<td>Less felt deposits</td>
</tr>
</tbody>
</table>

*Table 1. Results of industrial trials with Kemira’s FennoStrength high-efficiency wet strength resins*

Even with G2 resins, tissue makers might be able to reach their AOX targets if they select high-efficiency G2 resins, not to mention high efficiency means reduced WSR consumption and a lower operating cost. However, in many cases tissue producers must still resort to cleaner G2.5 resins.

A drawback of G2.5 resins is that they are generally more expensive to run. Not only is the product cost higher due to higher manufacturing costs, but their efficiency decreases in the post-cleaning process. To overcome this problem, Kemira has developed an improved manufacturing technology that allows production of a clean G2.5 resin without a loss of efficiency.
HIGH-EFFICIENCY WSR WITH LOWER COST-IN-USE

Various generations of standard market resins are compared to high-efficiency resins produced by Kemira in Figure 2. With standard market resins, the cleaner the resin, the lower its efficiency and, therefore, the higher dosages needed to reach wet strength targets. Higher WSR consumption, combined with already a high price of cleaner resins, make the cost-in-use increase significantly. However, the cleaner resins produced by Kemira according to the advanced manufacturing process, maintain their high efficiency. Thus, the cost-in-use for Kemira’s high efficiency G2.5 and G3 resins is significantly lower compared to equivalent market resins.

Figure 2. Comparison of Kemira’s wet strength resins (blue) of various generation to standard market resins (gray) with regard to the AOX level in the resin (as 20% solids) and on-machine efficiency. The bubble size represents the cost in use.

BENEFITS OF HIGH-EFFICIENCY WET STRENGTH RESINS

- Chemical savings
- Lower AOX in paper and effluent
- More balanced charge
- Lower risk of foam and deposits
- Improved dewatering and machine runnability
Further reduction in the WSR consumption can be achieved by using complimentary additives, referred to as functional promoters or WSR promoters. Kemira offers two types, anionic and cationic promoters, sold under the Kemira FennoBond® trade name.

**ANIONIC FUNCTIONAL PROMOTERS**
Anionic promoters provide the most benefits when high levels of WSR are used. WSR’s are high charge polymers and tend to overcationize fibers, resulting in decreased resin retention and its low efficiency. Besides over-usage, unretained WSR can cycle up in the short loop, causing runnability issues such as excessive foaming, felt plugging and decreased dewatering. With the help of anionic FennoBond, fiber charge can be rebalanced, allowing for a more effective retention of WSR, thus improving the economics and keeping machine runnability under control. Lower dosage of WSR also means lower AOX levels in effluent.

**CATIONIC FUNCTIONAL PROMOTERS**
Another innovative solution for reducing WSR consumption is Kemira’s cationic functional promoter or cationic FennoBond. The chemistry of cationic FennoBond works through a different mechanism compared to anionic FennoBond. Cationic FennoBond polymer reacts with fibers and forms strong covalent bonds, contributing to both dry strength and wet strength development. Yet these bonds are hydrolyzed in water, making the wet strength temporary, as shown in Figure 4.

For many tissue and towel grades, permanency of wet strength is not required. Tissue products such as AFH towels, napkins or facial tissues are normally not used for longer than 10-20 sec, which is enough time for cationic FennoBond to provide the required wet strength. Tissue makers can use extra wet strength from cationic FennoBond to reduce the WSR dosage. With lower WSR consumption, lower AOX levels can be achieved as well as improved machine runnability.

In addition, cationic FennoBond can boost dry strength, giving more flexibility to tissue makers in optimizing their process parameters, especially refining. Less refining could provide opportunities for higher bulk, improved softness, less dust and enhanced dewatering. Thus, cationic FennoBond provides benefits of unique sheet characteristics, lower AOX and overall cost-savings.
CASE: FENNOSTRENGTH HIGH-EFFICIENCY WSR ACHIEVES LOW AOX TARGETS AND REDUCES COSTS FOR TOWEL PRODUCER
CHEMICAL SAVINGS AND FURTHER REDUCTION IN AOX

A towel producer wanted to achieve low AOX levels as required by their customer. Reducing chemical costs was important for their machine.

THE SOLUTION
Kemira offered a new, high-efficiency G2.5 FennoStrength WSR. Figure 5 shows the trial summary. Results of the trial showed 25% less resin was needed to maintain sheet quality and AOX targets. This resulted in more than 10% net savings for the towel producer.

Figure 5. Machine trial summary for replacing G2.5 WSR with Kemira’s high-efficiency G2.5 WSR.
CASE: ANIONIC FENNOBOND IMPROVES SAFETY AND INCREASES EFFICIENCY FOR A TOWEL MANUFACTURER
ANIONIC FUNCTIONAL PROMOTER IMPROVES PRODUCT HANDLING SAFETY AND PROVIDES ECONOMIC BENEFITS

A towel manufacturer needed to improve the safety of using carboxymethylcellulose (CMC) powder used in the make-down area to control fiber charge and provide dry tensile.

THE SOLUTION
To help improve the safety hazards due to old CMC technology, including dust and slippery floors, Kemira replaced the CMC with FennoBond, a synthetic anionic product that is supplied in liquid form and only requires a pump to feed the chemical. Figure 6 summarizes the results from an industrial trial.

KEY BENEFITS
- WSR REDUCED FROM 23 TO 18 KG/T (-22%)
- DRY AND WET TENSILE STRENGTH ON TARGET
- IMPROVED CHARGE BALANCE AND RETENTION (WW SOLIDS FROM 1.0 TO 0.9 G/L)
- NET SAVINGS 10%

MACHINE OVERVIEW
GRADE
- 21 g/m² kitchen towel

MACHINE
- 2 layer Crescent
- 200 t/d, 1650 m/min

CHEMICALS
- Wet strength resin added to outlet of machine chest
- CMC before level box

Figure 6. Machine trial summary for using anionic FennoBond functional promoter, demonstrating a safer alternative to CMC and improved WSR efficiency.
CASE: CATIONIC FENNOBOND PROVIDES COST SAVINGS FOR A NAPKIN MANUFACTURER
PARTIAL REPLACEMENT OF WSR WITH CATIONIC FENNOBOND IMPROVES PRODUCTIVITY AND COST SAVINGS

A napkin manufacturer needed to increase the strength of their product, but also improve refining energy costs.

THE SOLUTION
Kemira's cationic FennoBond was added after WSR, resulting in an almost immediate boost in both wet and dry tensile strength. The increased strength provided flexibility for optimizing other process parameters. Refining was significantly reduced, generating energy savings. In addition, with less refining, dewatering improved and productivity increased. An increase in wet tensile strength gave an opportunity for decreasing WSR consumption by 13%. Even though the WSR efficiency or AOX were not the targets in this case, lower WSR dosage contributed to the overall savings and should also help lower AOX in effluent and paper.

KEY BENEFITS
- INCREASED DRY (+24-25%) AND WET TENSILE (+16-19%)
- REFINING ENERGY FROM 55 TO 37 KWH/T (-24%)
- WSR CONSUMPTION DOWN (-13%)
- PRODUCTION INCREASED (+2-3%)
- NET SAVINGS >90 K€/A

MACHINE OVERVIEW

<table>
<thead>
<tr>
<th>GRADE</th>
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<tbody>
<tr>
<td>17 g/m² napkin</td>
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<table>
<thead>
<tr>
<th>MACHINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 layer Crescent</td>
</tr>
<tr>
<td>70 t/d, 1400 m/min</td>
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<table>
<thead>
<tr>
<th>CHEMICALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet strength resin, 1 Kg/t added to outlet of machine chest</td>
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</tbody>
</table>

CATIONIC FENNOBOND TRIAL

Figure 7. Machine trial summary for using cationic FennoBond functional promoter, providing flexibility for less refining, reduced WSR consumption and overall savings.
CONCLUSION

Wet strength resin (WSR) is a key contributor to the cost of a tissue machine operation. The WSR application cost can further increase due to limitations on CPD, DCP and AOX levels in paper and effluent. Kemira has developed a number of advanced solutions to allow tissue makers to remain compliant with regulations while keeping the chemical cost under control.

These solutions include:

- High efficiency and low AOX FennoStrength resins
- Functional promoters
  - Anionic FennoBond for charge balance and improved WSR retention
  - Cationic FennoBond for partial substitution of WSR

Additional benefits from increasing WSR efficiency can be improved machine runnability and increased productivity.

Kemira’s WSR technologies exemplify sustainable chemical solutions, giving tissue makers valuable opportunities to achieve more with less.

REFERENCES
2. C. Campbell, H. Goldsberry, K. Wittich and F. Higa; Grade specific optimization: Permanent (PAE) versus temporary (GPAM) wet strength utilization; Tissue World magazine, September/October 2015.

paper@kemira.com
www.kemira.com