New Strength Technology: Opportunities for Cost Savings and Unique Sheet Characteristics

The art of tissue making requires finding the right balance between key product characteristics such as strength, handfeel softness and dispersibility in water. The “right” characteristics not only differentiate tissue products in the market but also help optimize production efficiency. One of the most critical areas of optimization is the sheet strength, which is achieved via appropriate selection of fibres, refining level and dry and wet strength aids. These are associated with a high cost and various limitations. Kemira has recently developed the Fennobond 3300E strength aid that increases flexibility of the tissuemaking process, improves sheet quality and allows for optimization of the production cost. The Fennobond 3300E resin is designed to provide both dry and wet strength. It is an effective “no COD” alternative to starch and CMC. It can also partially or completely replace the conventional wet strength resin, improving repulpibility and dispersibility of the wet-strengthened sheet in water without sacrificing the required strength targets. High solids and extended shelf life of this new strength aid provide advantages over other synthetic resins. In this paper, this new technology is reviewed and the benefits are demonstrated using laboratory data and industrial case studies.

INTRODUCTION
The tissue market is one of the fastest growing segments of the paper industry. Even though the recent economic recession slowed down this growth, the industry outlook is still positive largely due to continued growth in the emerging markets including Middle East and North Africa. However, the industry must find ways of maintaining acceptable profits in the current environment of consistently increasing cost of fibre and energy, more stringent environmental regulations and consumer demand for higher quality at a lower price.

One performance target that can differentiate the tissue product is sheet strength, which often involves a significant cost. A careful balance between wet and dry strength is critical for achieving the target wet and dry tensile without a negative impact on softness and absorbency. Of the number of means available for papermakers to control sheet strength, the choice of fibres and their mechanical treatment (refining) are the most common. However, these are also associated with the high cost of quality fibres (especially long fibres) and energy for refining. Operational means such as headbox consistency or wet pressing can be effective in improving strength but can interfere with other objectives such as production rate or sheet bulk.

In case of raw material or operational limitations, chemical means are often used as flexible and economical tools for strength control. A variety of strength chemicals are available in the market. In
this paper, we discuss Kemira’s new strength aid Fennobond 3300E. Its unique features and benefits are demonstrated using laboratory data and industrial case studies.

**FENNOBOND 3300E – UNIQUE GPAM STRENGTH RESIN**

Cationic glyoxalated polyacrylamide (GPAM) is a well-known strength resin [1-2] that is often regarded as a benchmark for generating dry strength. GPAM is a reactive polymer that can covalently bind with cellulose upon dehydration as shown in Fig. 1. The result is a generation of both dry and wet strength in paper. The reaction with cellulose is reversible in water, making the wet strength temporary and has no impact on broke repulping.

The design of the GPAM molecule can be altered to control the product efficiency and a decay rate [3-5]. A slower decay rate is desired in towel grades, whereas a faster decay is required for manufacturing toilet paper that must be readily dispersed in water at room temperature. Decay rate as a function of soaking time and GPAM dosage is presented in Fig. 2.

The traditional or first generation GPAM products have a major drawback. Their shelf-life is very limited due to tendency to gel with time due to a continuous crosslinking reaction within the polymer itself. This gelling process is further accelerated by high temperatures, making it especially challenging to use in the regions with hot climate. Keeping the product solids low (below 10%) extends the shelf life, but even then a typical GPAM with 7-10% solids would gel in 1 month at 25°C and in 1 week at 35°C. In contrast, the new generation GPAM product Fennobond 3300E with 13% solids has a greatly extended shelf life: at least 4 months at 25°C and 2-4 months at 35°C (Fig. 3). The long shelf life decreases the cost of potential losses due to gelling. It also provides flexibility in production planning, especially if GPAM is not used on every grade.

**FENNOBOND 3300E GIVES BOTH DRY AND WET STRENGTH**

Fennobond 3300E is an effective strength additive. Its ability to create hydrogen, ionic and covalent bonding makes it unique in a sense that one product can generate both dry and wet strength. A typical approach in tissue production is to use starch for dry strength and a polyamide-epichlorohydrin (PAE) resin for wet strength. Starch is capable of improving only dry strength, giving no contribution to wet strength, and vice versa, whereas, the effect of a PAE resin is primarily on wet strength with only a minor impact on dry strength.

![Fig. 1] Reversible reaction between GPAM and cellulose

![Fig. 2] Wet strength development as a function of soaking time and GPAM dosage.

![Fig. 3] The long shelf life of Fennobond 3300E provides advantage over first generation GPAM.
strength. Due to high consumption of strength aids, the chemical cost in the production of towel, hankies and napkin is substantial. High amounts of cationic chemicals can also cause runnability issues due to excessive foaming and felt plugging. Fennobond 3300E can be used to reduce total strength system cost by replacing part or all of dry and wet strength additives with one product. Fennobond 3300E is a more effective dry strength additive compared to starch, and it has a strong impact on wet strength properties (Fig. 4).

The wet strength generated by GP AM is temporary as demonstrated earlier in Fig. 2. Temporary wet strength can be useful for toilet paper, hankies and away-from-home towel grades, where wet strength properties are desired only for a few seconds of use by consumer. A complete or partial replacement of a traditional PAE wet strength resin with GP AM can still provide desired strength characteristics and, at the same time, improve dispersibility of the sheet in water, which makes it safer for disposal of such tissue or towel products in a sanitary plumbing system. Better dispersibility of the wet strengthened sheet makes it also easier to handle repulpibility of broke. Fennobond 3300E is a liquid solution and easy to handle; only dosing pump is needed. Unlike starch that makes the sheet stiffer, Fennobond 3300E does not have a film forming tendency and is less detrimental to handfeel softness.

MACHINE CASE STUDIES
Case study 1: Fennobond 3300E for dry tensile in hankies
A major tissue producer manufactures hankies using a mix of bleached long and short fibres. Wet and dry tensile are critical targets. A PAE wet strength resin (WSR) is used to control wet tensile and a first-generation GPAM to reach dry tensile specifications. Use of GPAM for dry strength enables lower refining level, which has a positive impact on the sheet handfeel softness. The incumbent GPAM product had a very short shelf life, only 7 – 14 days, which created difficulties with delivery logistics and storage. Customer was considering investment into chilling equipment to extend the GPAM shelf life. Kemira offered the new generation GPAM additive Fennobond 3300E with a significantly longer shelf life. Fennobond 3300E replaced the short shelf life GPAM at the same dosage level of 3.2 kg/t on a dry basis, providing the target dry tensile and improved wet tensile, which further allowed for a reduction in the wet strength resin by 6%. The use of Fennobond 3300E allowed the customer to avoid the cost of investment into chilling equipment as well as to achieve significant WSR savings. There have not been any issues with product stability reported for over two years since the customer switched to Fennobond 3300E.

Case study 2: Fennobond 3300E for dry and wet tensile in AFH towel
A tissue mill produces away from home (AFH) towel from a mix of bleached long and short fibres. Cationic starch is used for dry strength and a high amount of a PAE wet strength resin is added to achieve the desired wet tensile targets. Customer was interested in developing a more dispersible towel. This seems to be a current trend in many markets. Unlike kitchen towel, AFH towel does not need significant permanency of wet strength. A consumer in a restaurant or at an airport uses towel to wipe hands for only few seconds. At the same time, this towel
sometimes ends up in a sanitary plumbing system, which creates problems if the towel has too much permanent wet tensile and does not break down fast enough in water. Thus an AFH towel is desired that could satisfy two criteria: (1) towel should provide a sufficient initial wet tensile for use by consumer for a short time and (2) towel should also disperse easier in water without plugging the plumbing system.

Kemira’s strength aid FennoBond 3300E was the right candidate for this purpose. Addition of FennoBond 3300E at 1.5 kg/t (dry) to the thick stock resulted in an increase of both dry and wet tensile strength by 17 % and 23 %, respectively. The gained strength allowed for a reduction in dosages of wet strength resin by 50 % and starch by 25 %. Replacing ½ of wet strength resin with FennoBond 3300E improved towel dispersibility in water. The time required for a significant break down of the sheet in water reduced from over 3 min to less than 1 min. This opened up an opportunity for the new towel grade development. An additional benefit could be improved repulpability of the wet strengthened broke.

CONCLUSIONS
Kemira has developed FennoBond 3300E strength additive that provides both dry tensile and temporary wet tensile. FennoBond 3300E is based on the unique GPAM chemistry with an extended shelf life (120 days). This effective strength chemistry can help with improving sheet characteristics such as strength, bulk or softness and achieving unique sheet properties, such as temporary wet strength and dispersibility in water. The strength gains can potentially be used for improving tissue production profitability due to reduced sheet grammage, lower quality fibres, reduced refining leading to energy savings, productivity gains and reduced consumption of other chemicals such as wet strength resin or starch.

References: