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Glyoxalated Polyacrylamide as a Dewatering and Strength Booster in Recycled Furnish

Abstract:

Strength and productivity are key characteristics that papermakers must control to produce a sheet of desired quality at a target production rate. The limitation of OCC availability and quality, increase of mixed waste content, faster machine speeds, higher energy cost and so on, provide a significant challenge for recycled board making to maintain the paper strength as well as good runnability to enable the production targets to be achieved. Dry strength aids, based on starch or polyacrylamide, are most commonly used in recycled board production. The application of glyoxalated polyacrylamide (GPAM) on recycled board, on top of the earlier mentioned dry strength's, is a growing application that is getting more traction, being used as a booster for improving productivity by balancing the charge on the fines and the fibres and providing improvements to the sheet dewatering. In this presentation we review use of GPAM as a boosting agent to improve dewatering, supporting the paper makers to achieve their increasingly challenging goals when working with recycled furnishes.

Keywords: *amphoteric dry strength, gpam, glyoxalated polyacrylamide*

Glyoxalated Polyacrylamide As A Dewatering and Strength Booster in Recycled Furnish

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Introduction

Dry strength is a key characteristic of paper and board, affecting both end-use characteristics and manufacturing efficiency. The fundamentals of strength development in the sheet start with the choice of fibers and their treatment in the refining operation (Fig. 1). Virgin fibers, especially Kraft softwood, produce the strongest sheet, but this pulp is costly. Driven by the high cost of virgin fiber and also by environmental pressure, the paper and board makers move towards the use of less expensive mechanical pulp, hardwood and/or recycled fibers, which inherently produce a weaker sheet. In case of recycled fibers, the biggest challenge is that quality of recycled fibers has been deteriorating dramatically in the latest decades, creating significant challenges for the industry. Operational means such as refining, fiber fractionation, headbox consistency, wire/jet speed ratio or wet pressing can be effective in improving strength but can interfere with other objectives such as production rate or sheet bulk.

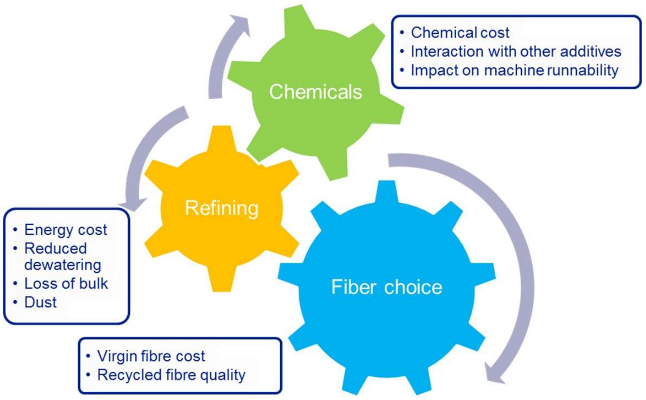


Figure1 – The key tools for achieving target sheet strength and their potential limitations. The optimal use of these has to be carefully considered in order to achieve the desired sheet quality at the lowest production cost.

Achieving the desired sheet qualities at a competitive production cost is often challenging with only fiber composition, refining and operational changes. Strength chemicals can provide an extra tool for strength control that gives papermakers expanded flexibility of the papermaking process and can help gain economic benefits.

Dry Strength – Chemicals

A variety of strength chemicals are available in the market. Various natural polymers and synthetic resins are employed for controlling sheet strength of paper and board. Starch is the most common strength aid due to its availability and relatively low cost. However, starch exhibits some limitations such as the plateauing effect on strength at high dosages and subsequently a negative impact on the dewatering rate and machine productivity [1].

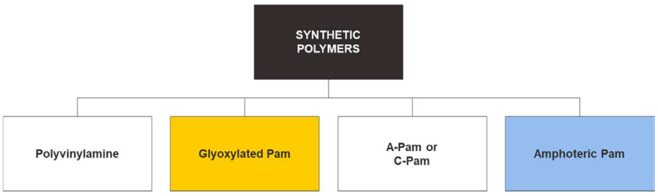


Figure2 – Acrylamide based dry strength chemistry choices

These limitations of starch and its unstable market price drive the growth of synthetic dry strength aids. In some cases synthetic strength aids are used to complement starch or replace it in order to reach higher strength targets. In other cases, synthetic strength aids help improve the efficiency of starch, reducing starch usage, decreasing COD, improving dewatering and reducing the overall production cost. Among the most common synthetic strength chemistries are polyacrylamide-based resins (Fig. 2). Amphoteric polyacrylamide based, is one of the most common dry strength in the market, has been used in many recycle fiber based liner grades.

In the past years, there has been a tendency to combine two strength chemistry to find the best synergy and to give the most optimum performance of strength performance from the chemistry [2]

Glyoxalated PAM dry strength (GPAM) is more often nowadays used as a booster on top of the amphotheric dry strength. This mostly due to utilize the advantages of GPAM over amphoteric PAM dry strength (Am-DSR) such as GPAM gives benefit for dewatering (and often retention) improvement.

Glyoxalated PAM dry strength (GPAM)

GPAM is synthesized by reacting glyoxal with a cationic polyacrylamide in a slightly alkaline aqueous solution. The reaction describes in figure 3. The reaction is typically carried out at a temperature of 50-80°C. The glyoxal is added to the polyacrylamide solution in a stepwise manner, with each addition being followed by a period of stirring.

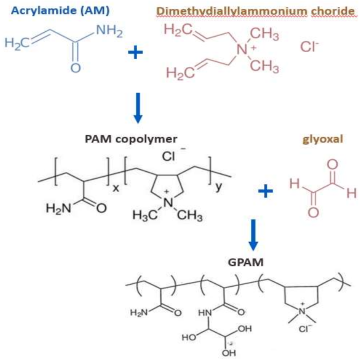


Figure 3: GPAM synthesis

The specific conditions for the synthesis of glyoxalated polyacrylamide can vary depending on the desired properties of the final product. For example, the molecular weight of the polyacrylamide, the amount of glyoxal used, and the reaction temperature can all affect the properties of the product [3]

Higher charge of GPAM compared to Am-DSR is preferred in the high conductivity and high cationic demand systems. Unlike conventional GPAMs that tend to gel within 1-4 weeks, Kemira GPAM technology is stable for at least 4 months even at 35oC (see Fig. 4).

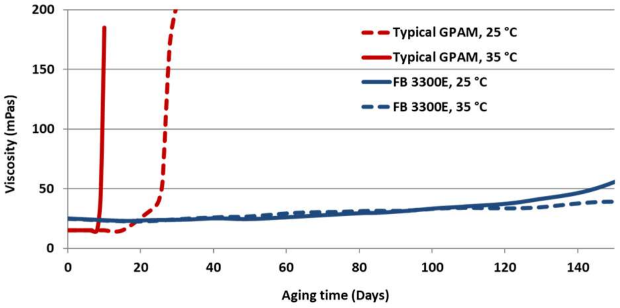


Figure 4: Improved stability of GPAM

GPAM Mechanism

There are two reactive sites of glyoxalated PAM which will react to fibers (Fig. 5). The amino group of the GPAM will react with the carboxyl and hyrdoxyl groups of the fibers to form hydrogen bonds. While the aldehlyde group will react with the hydroxyl group of the fibers to create covalent and/or hemiacetal bonds. Those bonds formed depending on pH condition.

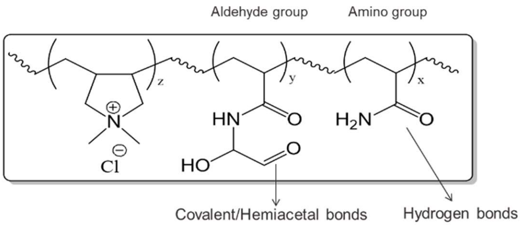


Figure 5: GPAM interaction with fibers

Based on this mechanism, GPAM will give benefits as follow :

- Dry strength performance enhancement
- Temporary wet strength which give potential stronger wet web on machine
- Dewatering

Kemira Laboratory Test

Example of laboratory test utilized typical south east asia recycle old corrugated container performed. Conductivity of the prepared stock was measured at 2,700 µS/cm and pH 6.58.

150 gsm handsheet made as per TAPPI T205 SP-06. Burst strength and stock dewatering tests were performed based on TAPPI T403 0m-22 and TAPPI T221, respectively

Following lab test shows the effect of GPAM as additional component for Am-DSR.

Experimental conditions, 100% local SEA OCC which has 2,700 µS/cm conductivity and pH 6.58. Standard TAPPI handsheet 150 gsm is made to evaluate the burst strength.

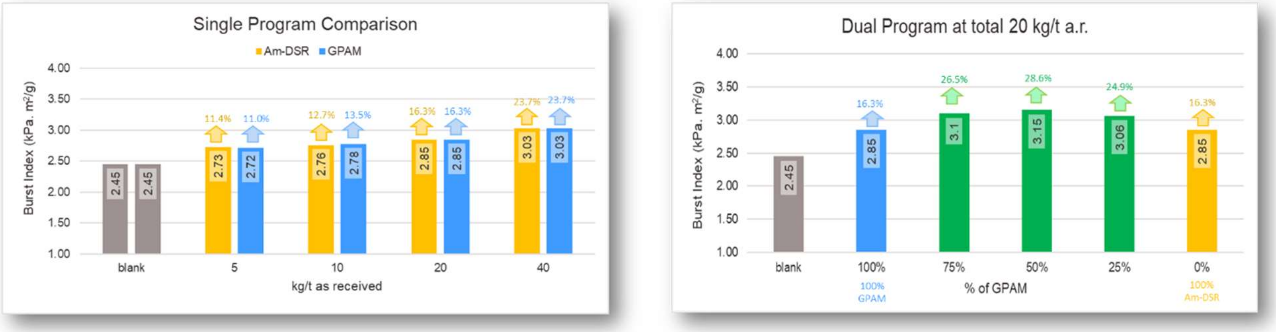


Figure 6: Comparison of single strength program vs dual strength program to the burst index

As seen in Fig 6. GPAM by itself can be potentially substituted by Am-DSR on 1 : 1 on wet basis with similar burst performance. As single component, GPAM gives benefit of faster dewatering rate than Am-DSR as shown in Fig 7.

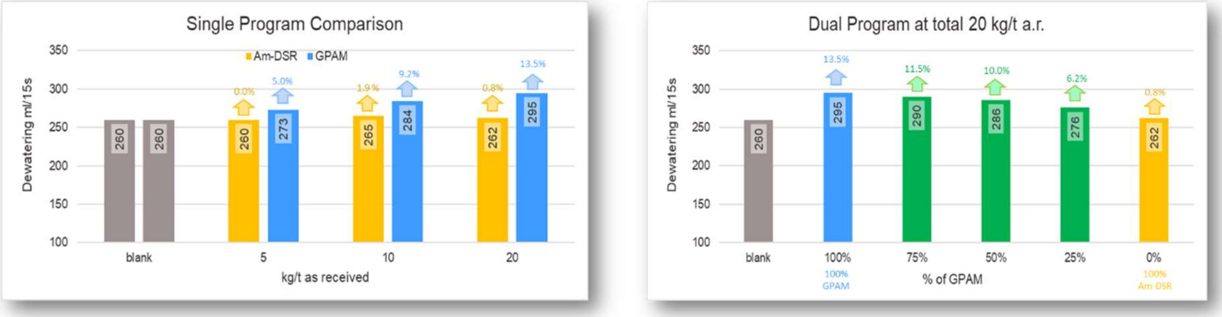
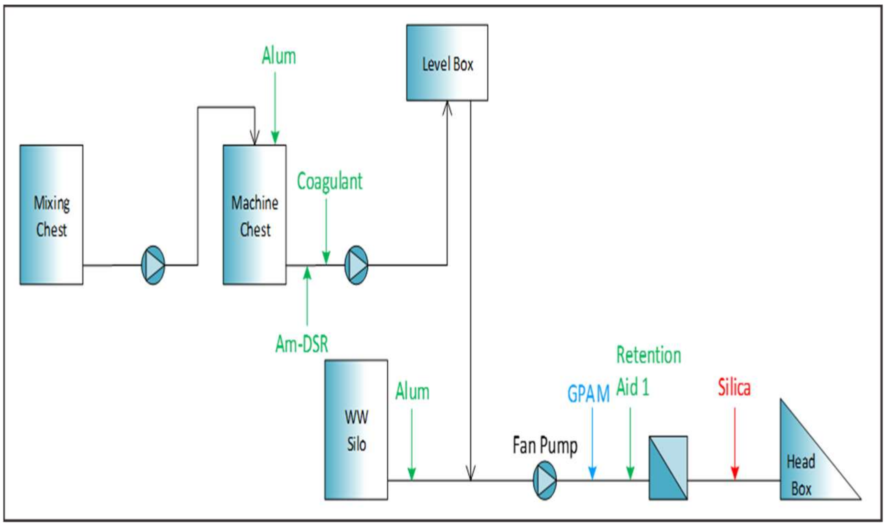


Figure 7: Comparison of single strength program vs dual strength program to the dewateing rate

However, observed in this laboratory test, when GPAM is added on top of Am-DSR will give improvement in both strength (bursting) and dewatering.

Succesful Customer Cases

Case 1. GPAM : A Potential Replacement for Retention Chemical in Recycled Paper Bag Grade (Fig. 8)



MACHINE OPERATION
Single ply, fourdrinier machine, 560 m/min
30% recycle OCC, 55% mixed waste, 15% Broke
pH 6.5 - 7.0
55 – 80 gsm paper bag

CHEMICAL ADDITION
Alum = 15 kg/t (total)
Coagulant = 0.5 kg/t
Am-DSR = 7.0 kg/t
Retention Aid 1 = 0.5 kg/t (optimized from 0.7 to 0.5)
GPAM = 1.2 kg/t (added)
Silica = 1.2 kg/t (removed)

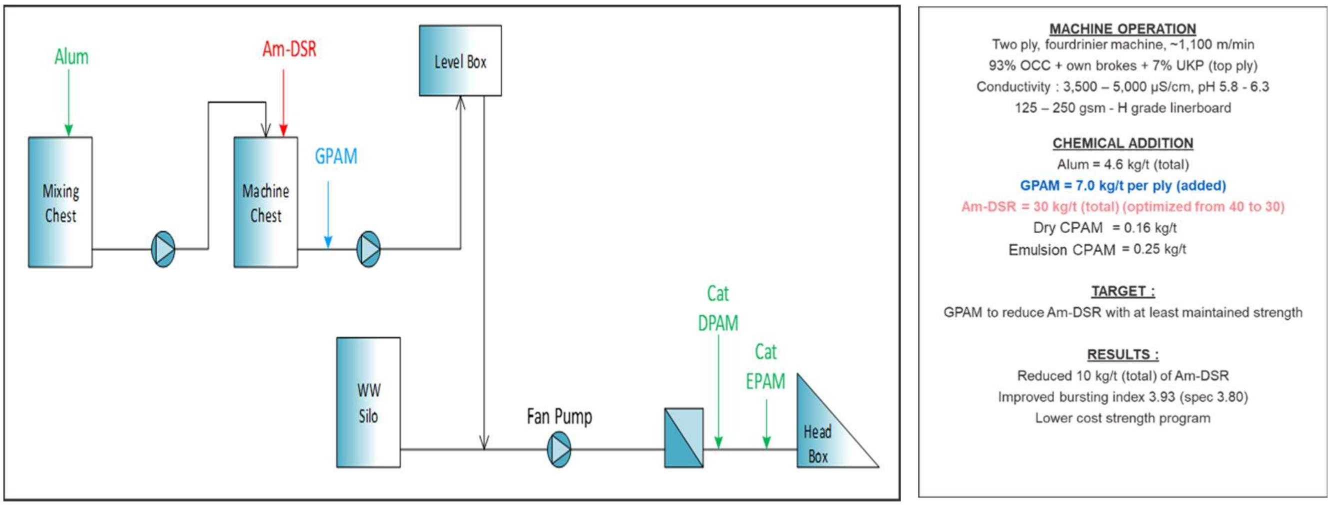
TARGET
More cost-efficient retention program
Maintained tensile and burst strength & formation

VALUE OBTAINED
~ 5% higher MD/CD tensile and bursting strength
Maintained dewatering rate
~20% lower tray ww consistency and turbidity

Figure 8: Background system information and additions points of case 1

GPAM has been successfully applied to low weight basis recycled paper bag grades. In this case, GPAM was substituted for anionic silica at an addition rate of 1.2 kg/t wet basis. This resulted in a maintained dewatering rate, as well as additional benefits such as improved strength and retention. The improved strength was due to the increased bonding between fibers, while the improved retention was due to the reduced turbidity and consistency of the white water.

Case 2. GPAM is a complementary additive to Am-DSR for dewatering and retention enhancement (Fig. 9)



MACHINE OPERATION
Two ply, fourdrinier machine, ~1,100 m/min
93% OCC + own brokes + 7% UKP (top ply)
Conductivity : 3,500 – 5,000 µS/cm, pH 5.8 - 6.3
125 – 250 gsm - H grade linerboard

CHEMICAL ADDITION
Alum = 4.6 kg/t (total)
GPAM = 7.0 kg/t per ply (added)
Am-DSR = 30 kg/t (total) (optimized from 40 to 30)
Dry CPAM = 0.16 kg/t
Emulsion CPAM = 0.25 kg/t

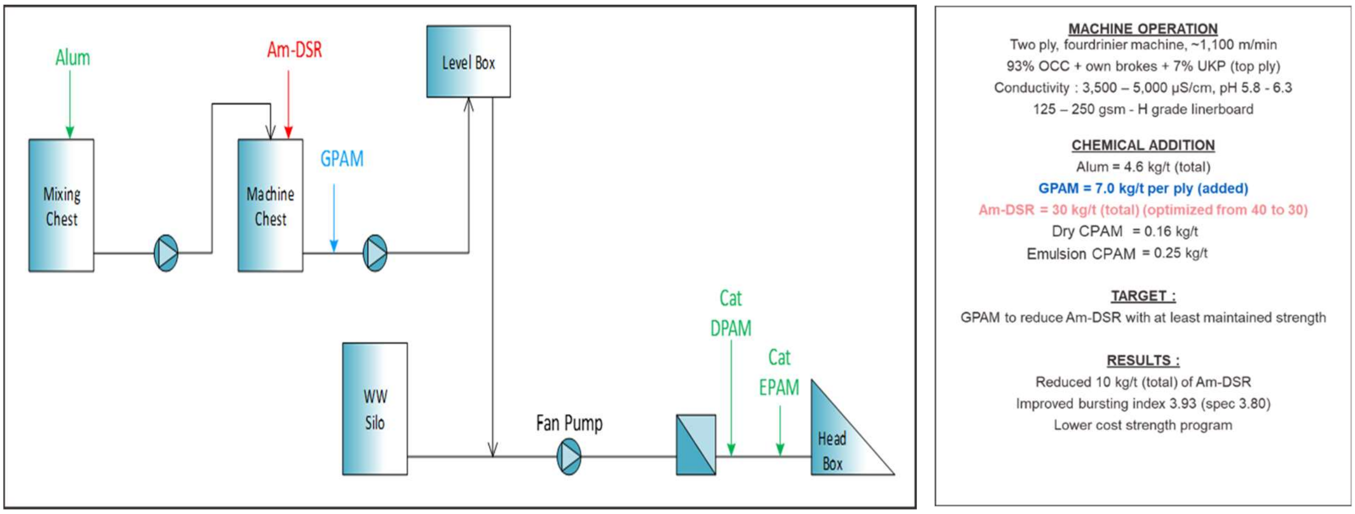
TARGET :
GPAM to reduce Am-DSR with at least maintained strength

RESULTS :
Reduced 10 kg/t (total) of Am-DSR
Improved bursting index 3.93 (spec 3.80)
Lower cost strength program

Figure 9: Background system information and additions points of case 2

Figure 9 demonstrates a successful case study in medium grade in which GPAM was added as a complementary additive to Am-DSR. The total dosage of Am-DSR could be reduced from 21.0 kg/t to 15.0 kg/t by adding 6.0 kg/t of GPAM to the existing program of single Am-DSR. This dual strength program also resulted in lower costs, while still maintaining target strength properties (RCT/CMT) and improving dewatering and retention. The effect of better dewatering and retention gives positive impact to better machine runnability. Observed less foaming issue and significant lower load to the effluent.

Case 3. GPAM as Compliment of Am-DSR for More Efficient Strength Program (Fig. 10)



MACHINE OPERATION
Two ply, fourdrinier machine, ~1,100 m/min
93% OCC + own brokes + 7% UKP (top ply)
Conductivity : 3,500 – 5,000 µS/cm, pH 5.8 - 6.3
125 – 250 gsm - H grade linerboard

CHEMICAL ADDITION
Alum = 4.6 kg/t (total)
GPAM = 7.0 kg/t per ply (added)
Am-DSR = 30 kg/t (total) (optimized from 40 to 30)
Dry CPAM = 0.16 kg/t
Emulsion CPAM = 0.25 kg/t

TARGET :
GPAM to reduce Am-DSR with at least maintained strength

RESULTS :
Reduced 10 kg/t (total) of Am-DSR
Improved bursting index 3.93 (spec 3.80)
Lower cost strength program

Figure 10 shows the benefits of using GPAM as a complementary additive to Am-DSR in a high-quality liner grade that requires high strength (burst index target 3.8). By adding up to 7.0 kg/t of GPAM, the dosage of Am-DSR can be reduced from 40 kg/t to 30 kg/t, while still achieving a slightly better burst index. This results in lower overall cost.

Conclusions

GPAM has been proven to boost performance of Am-DSR to give benefits such as improved strength, better dewatering and productivity which can lead to overall reduced cost and reduced fresh water consumption. Improved version of GPAM by itself is an easy pump and go product which has relatively long term stability storage time.

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