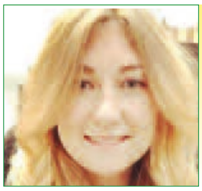

Comparison of Polymeric Dry Strength Systems

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Polymer chemistry is vitally important in paper manufacture. Polymers are integral to the control of the following technologies, all of which Axchem can supply:

- retention and drainage,
- recycled fibre stickies control fixatives,
- clarification,
- de-watering,
- Dry Strength agents,
- temporary wet strength,
- water phase and fibre charge control,
- creping chemistries,
- wire and felt contamination control,
- COD control, and
- deposit control.

Historically, naturally sourced starches have been a valuable biopolymer providing dry strength, retention and other performance benefits. Starch has been "the backbone" of many papermaking solutions for over a century. The purpose of this study was to evaluate and quantify how synthetically manufactured polymers develop various strength related properties. More important, is to focus on the advantages these new generation polymers may have to different paper making requirements.

Polyacrylamide products used for generating dry strength are as a rule much lower in molecular weight than those used for retention. These products are not aggressive floc formers, but work to strengthen the fibre-to-fibre bond and so generate dry strength. In addition, over time these polymers purge the system of fines, so the system 'encourages' natural strength from the higher fines retention in the system.

The polymers used in this investigation all use acrylamide as their backbone. However, importantly they have been "tuned" to develop dry strength performance.

Polyacrylamide products specifically for drainage and retention applications tend to be much higher in molecular weight than the above dry strength products. These products are available as free flowing powders, emulsions, dewatered / water in water or oil free emulsions.

The polymers tested in this study were free Glyoxalated Polyacrylamides GPAM; PVAm produced using the patented Hoffman degradation reaction, Starch and Anionic Polyacrylamide.

For the purpose of these tests, the GPAM used was in a form that is ready to use without the need for an expensive on site chemical generator. Onsite generation is normally preferred due to the volumes needed. The benefit of this type of polymer is that it is very reactive with the hydroxyl (OH) groups on cellulose fibres.

The second dry strength agent which has been investigated is a Hofmann Polyvinylamine (PVAm) *in situ* with an anionic counter type APAM (anionic Polyacrylamide)

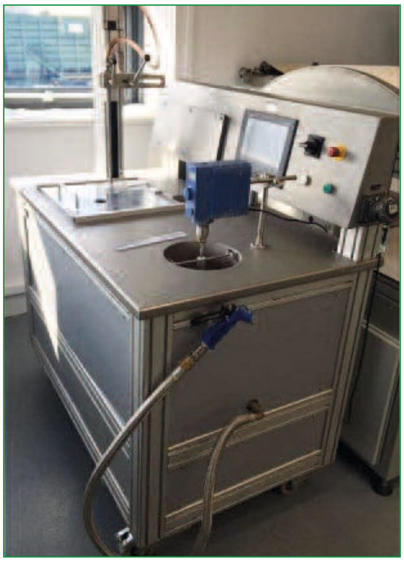

Figure 1. AxForm Dynamic Handsheet Former

Figure 2. AxForm Press and Dryer

Test Method

Five sheets of paper were prepared for each dose of dry strength agent tested using the AxForm Dynamic Handsheet Former (*Figure 1*). The AxForm Dynamic Handsheet Former (DHF) has full machine speed / efflux control and an automated chemical dosage system. It is possible to simulate paper machine speeds of up to 1300m/min producing a 200mm x 850mm sheet of paper, with basis weight capability of 40 to 200gsm being possible. All the prepared sheets were pressed and then dried on the AxForm Press and Dryer (*Figure 2*) prior to testing.

The weight of each paper strip was determined to calculate the exact grammage. Using a standard template, the following samples were taken: 10 x MD and 10 x CD strips and four 10 x 10cm squares. The paper was tested for burst and CST using Lorentzen & Wettre laboratory test equipment: a Compressive Strength Tester (CST) (*Figure 3*) and Burst Strength Tester (*Figure 4*).

Figure 3. L&W Compressive Strength Tester STFI.

Figure 4. L&W Burst Strength Tester.

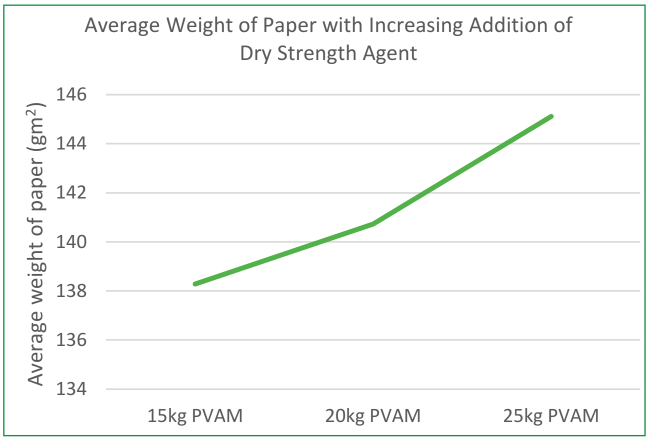

Figure 5. Weight of paper strip increasing as the dosage of dry strength agent increases.

As would be expected, the first observation made was that as the dosage of dry strength agent increased, the weight of the paper also increased (*Figure 5*). In part this shows the impact of increased retention. Therefore, the weight for each strip was taken into consideration and data are reported as an index to ensure consistency within the results produced.

Observations

In this evaluation the control points used were: (1) paper without any chemical additions (Blank) and (2) paper with the addition of a standard retention / drainage programme. These data points were then used as a reference for the comparison of the other dry strength agents under evaluation.

Compression Strength Result

Both GPAM and PVAm proved they could yield significantly higher compressive strength when compared to the control papers (Blank and Retention Aid). The addition of 30-35kg/T (as received) of GPAM was able to generate the highest amount of compressive strength for MD samples of paper, with a 19.8-22.2% increase in strength compared to the blank (*Figure 6*). When looking at CD samples, 25kg/T of PVAm achieved the highest compressive strength, with a 22.7% increase in strength, and 25kg/T of GPAM providing the second highest compressive strength increase of 21.3%. Although in real life, the dosage levels on a paper machine will be considerably lower as seen in (*Figure 7*).

Burst Strength Results

The use of 20kg/T of PVAm provided a 34.2% burst strength increase when compared to the blank control and 25kg/T of

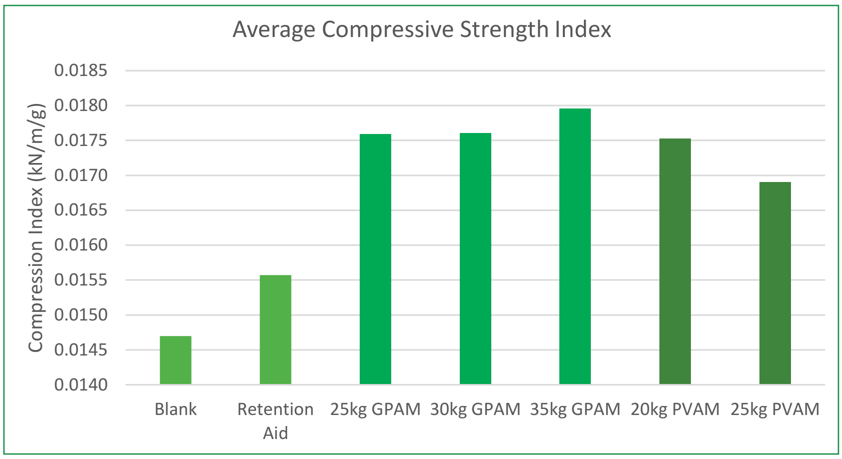

Figure 6. Average Strength Compressive Index of samples of paper with a varying dose of dry strength agent in comparison with controls (Blank and Retention Aid).

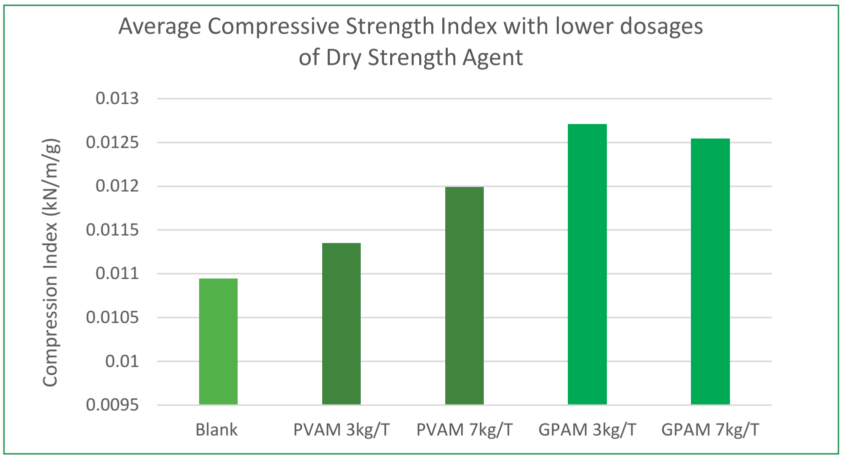

Figure 7. Average Compressive Strength Index of samples of paper with lower varying dosages of dry strength agent in comparison to control blank paper.

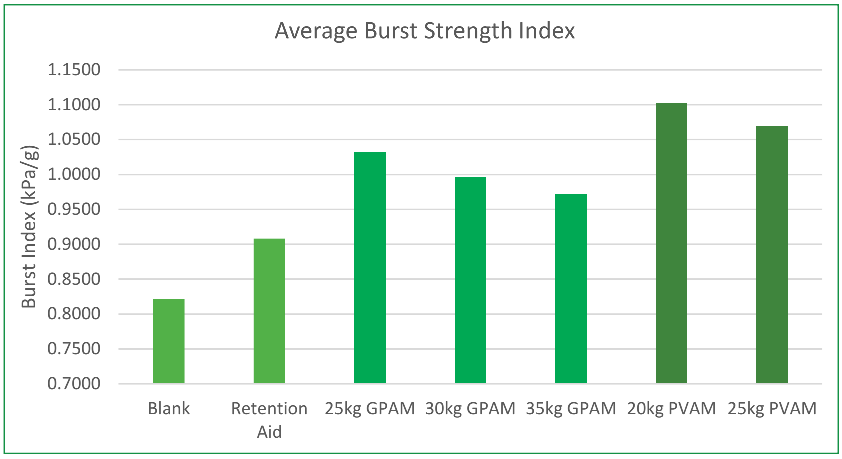

Figure 8. Average Burst Strength Index for varying dosages of GPAM and PVAm compared with two control measures (Blank and Retention Aid).

PVAm providing a 30.1% burst strength increase when compared with the blank control (*Figure 8*). The use of 25kg/T of GPAM provided a 25.6% burst strength increase.

Conclusion

Polymeric Dry Strength agents do have the potential to provide an increase in Compressive Strength and Burst Strength in paper. A dosage of 35Kg/t of GPAM yielded the highest compressive strength, while the highest burst strength was achieved with 20kg/T of PVAm; however, these high dosages will not be required to achieve an increase in strength on a paper machine. It can be observed (*Figure 7*) that as little as 3kg/T of PVAm and GPAM provide a significant strength increase when compared to the blank control.

Future Prospects

Future work is planned to establish the optimum balance between strength aid dosage and overall paper strength. For instance, 25kg/T of GPAM was found to provide the second highest strength for the compressive strength test for CD samples of paper and the third strongest compressive strength, with only 0.11% strength difference between the second highest strength increase (provided by 30kg/T GPAM). Therefore, it may be beneficial to develop a compromise to establish the best overall strength results, which provides the optimal balance between burst and compressive strength, thus making an overall stronger sheet of paper through the addition of a dry strength agent.