

# Charge monitoring improves paper machine performance

Ian Padley, Global Solutions Team Manager Tissue, BTG Eclépens SA  
Manfred Sailer, Market Manager, BTG Instruments GmbH

## INTRODUCTION:

Ionic charge variation or excessive charge demand are all too often the hidden enemy in papermaking wet end chemistry, impacting all grades. Sheet defects, excessive chemical usage and poor runnability are all problems which can arise from issues with charge. In this article, we review the basic chemistry of ionic charge and explain how electrokinetic effects can be harnessed to measure charge. Armed with modern and convenient measurement technologies, both lab and online, we look briefly at strategies the papermaker can employ to mitigate unwanted charge impacts and forecast how the latest developments in data management and modelling will allow us to control more complex operational scenarios.

### In 2011, BTG wrote about charge measurement as follows:

Imagine a typical scenario faced by a tissue machine operator where chemistry has got out of control. Your machine is using a recycled fiber furnish and making some towel grades; but you are finding it very difficult to reach the wet tensile specification. This important end-user property is delivered by a chemical, a cationic polyamide-epichlorohydrin in fact, but you don't know that just that it is 'wet strength resin'. So, if the lab test for wet tensile is low, let's just add some more, OK?

Well, no. Perhaps when the next shift arrives, there will be foam overflowing the wire pit. Felt dewatering is suddenly quite poor, but we don't see that, what we see is wet streaky Yankee coating, poor crepe, web breaks and repeated crepe blade changes. And still the wet tensile is poor. Maybe the new shift operator has seen this before, they shut down, clean the felt, drop the backwater, restart on fresh water and less wet strength resin, and for a while things may be better. Or maybe he just turns up the antifoam pump and things can then get even worse!

What really happened here? The problem with chemistry is that we tend to see only end effects, not visual things like when troubleshooting the mechanical operation of the machine. If we understood a little bit of paper mill chemistry, we might speculate that we had some poor waste rich in anionic trash in the furnish. This trash consumed the wet strength resin before it reacted with the fiber, but by increasing the resin pump, we put more unreacted chemical into the system, filling the felt, creating foam and destabilizing the Yankee coating. But we still don't know for sure. What we have is a chemical soup we need to unravel, not just to save chemical cost, but to improve the machine operation, as every tissue maker knows that any chemical imbalance will eventually end up on his or her Yankee.

### Ian Padley, 'No more soup' (2011)

So, in the intervening years, the problem is solved, right? Actually no, if anything it has got worse, not just in tissue, but across all paper grades. There are a number of reasons for this.

Firstly, the deteriorating and uncertain quality of wastepaper in recycled grades. Then the imperative to further close the water cycle of a paper machine and to reclaim every fiber which may escape in effluent, leading to a cycle up of contaminating materials.

Finally, not to neglect the de-skilling of some industry sectors and the loss of experienced technicians both from mill and suppliers who previously kept chemistry issues in balance.

Fortunately, our understanding of the issues and our ability to measure them and apply effective control measures has increased in the intervening years, and now we also have effective and innovative solutions for the scarcity of skilled and experienced technical staff across the industry. But first, let's look at some papermaking chemistry basics.

## Papermaking charge chemistry basics

### Composition of the furnish

Let us consider what is in your stock pipe and chests; it's a mixture of fibres, fines, pigments, chemical additives and ions in water. Quite different particles in composition and in reality, the differences in size and charge are even bigger.

Fibers are huge but carry little charge. Fines - which can still be seen by the naked eye - are smaller but with higher charge. Natural fibers and fines carry a negative charge.

Pigments are small and highly charged, they might be anionic or cationic.

Chemical additives can show very different charge characteristics, most have a cationic charge to effectively react with the anionic fibers and fines.

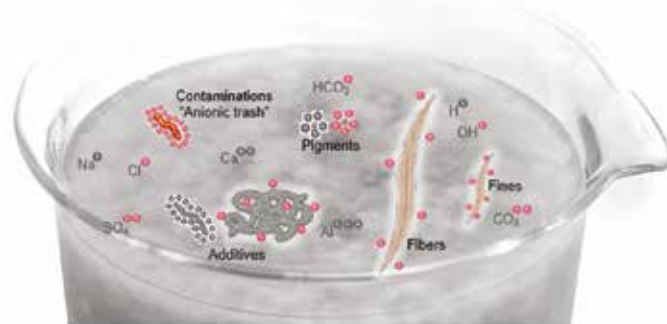


Figure 1: Whats in your furnish?

Retention aids are often long and branched molecules with little charge whereas fixatives are small with high charge. The same is true for anionic trash – a synonym used for anionic interfering substances – a rather small particle with high charge.

Small molecules and particles with high charge results in velocity and reactivity.

Further charge carriers are dissolved salts, for example  $\text{HCO}_3$  (hydro carbonate) which is also known as water hardness. Salts also exist of anions and cations which decay in water. They might originate from the tap water, process water and chemicals.

The amount and type of salts dissolved in water cause the conductivity, noting that a high amount of dissolved salts will lead to a high conductivity and as this material is non-volatile, we see significant increases in conductivity in cases of high water closure.

This is a problem as conductivity does influence particle surface charge and therefore should always be looked at.

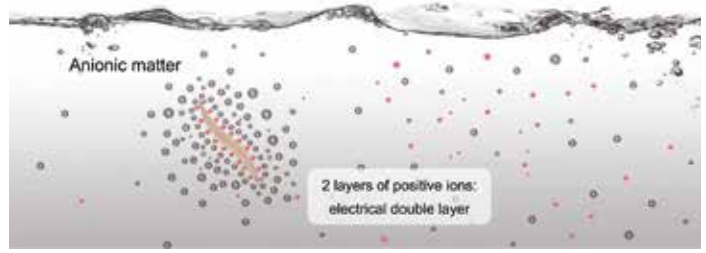
**Size matters**

**Let us return to the size of the particles for a moment.**

Salts/ ions – or particles smaller than 1 nm - in solution are considered as a real solution. The water is clear. Components in a size range of 1 nm to 500 nm are considered as colloids. It is important to note that a colloid simply refers to a state of size and not to specific substances.

If we look at colloids in a water phase, the solution is still clear but one property of colloid systems that distinguishes them from true solutions is that colloidal particles scatter light. If a beam of light passes through a colloid, the light is reflected (scattered) by the colloidal particles and the path of the light can therefore be observed. The scattering of light by colloids is known as the Tyndall effect.

Finely dispersed solutions – 500 nm till 100  $\mu\text{m}$  – are already turbid. Coarse dispersed particles can be seen with the naked eye. Particles with a size bigger than 1 nm – the colloids – start showing the so-called electrokinetic effects or electrokinetic phenomena. This is our friend when we want to measure what is really going on in our furnish.



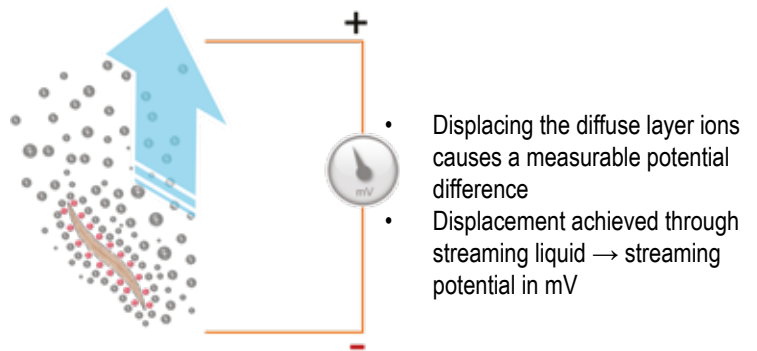
**Figure 3: The electric double layer for an anionic particle**

**Electrokinetic effects**

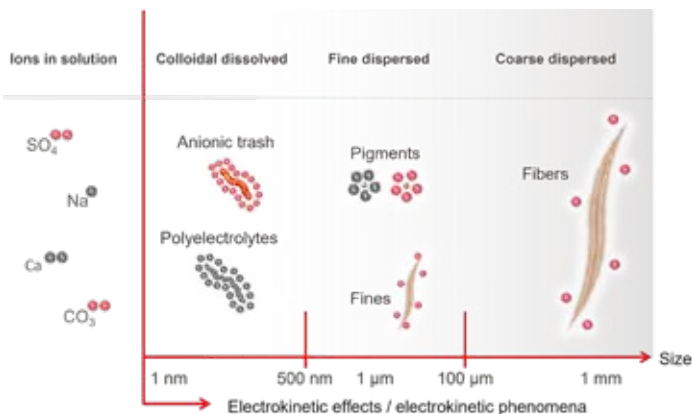
“Electrokinetic” in this context refers to a measurement of movement or velocity and voltage or current. In fact, an electrokinetic phenomenon results from the differential movement of two phases where the interface is an electrical double layer.

The electrical double layer consists of ions, that are electrostatically attracted by the surface charge of the particle.

These so-called counter ions establish a stationary layer close to the particle surface, as well as a diffuse and mobile layer further away from the particle. It is the mobility of the diffuse ion layer, that allows us to measure charge:



**Figure 4: Measurement of streaming potential.**



**Figure 2: (above) Size and eletrokinetic impact.**

**Particle charge measurement with PCD**

To measure the charge of a particle, we take advantage of this electrokinetic phenomenon by inducing a shearing effect in the liquid sample via a mechanical piston and measuring the voltage potential. Addition of an automatic titration device to neutralize the sample with an opposite charged ionic reagent allows us to build a highly accurate and quantifiable measurement of particle charge.

**Figure 5: (below) Particle charge measurement.**

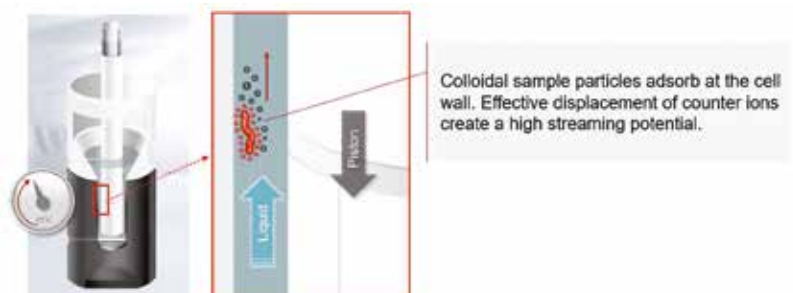
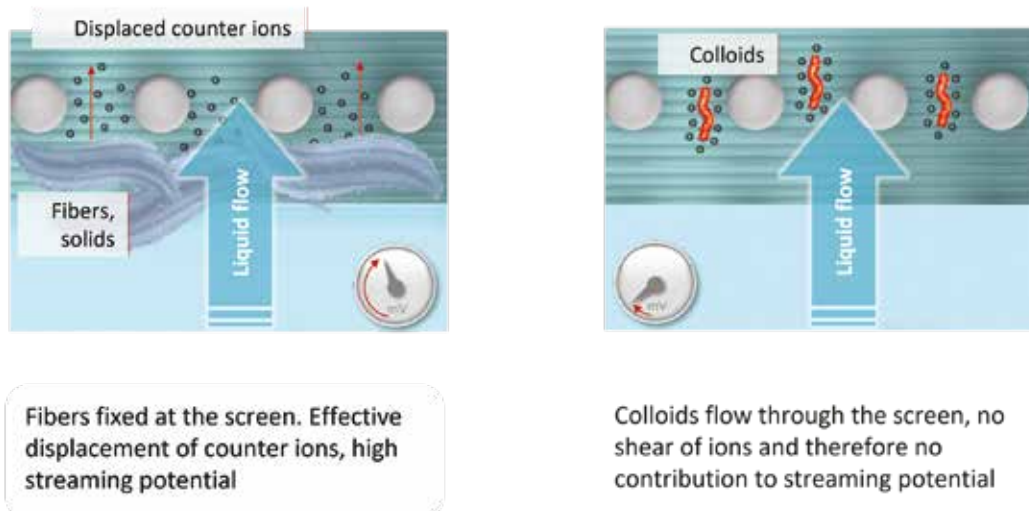


Figure 6: Zeta Potential Measurement.



**Zeta potential measurement with SZP**

To measure charge on a larger fiber, the technique is to use a fine screen to fix the fiber and displace their counter ions in a liquid flow induced by vacuum and thus generate the streaming potential, which is used to calculate the Zeta Potential. So, by use of two lab techniques, we can map both particulate and fibrous charge.

**The importance of measurement**

As we have seen, paper fibers are inherently anionic or negatively charged, due to the carboxyl functional groups on the fiber. Many functional chemicals will have the opposite cationic (positive) charge and thus we have an electrostatic attraction between fibers and chemical we can exploit to put the chemical where it needs to be, i.e., on the fiber. Wet strength, some dry strength, starch, coagulants and de-bonder chemicals all work like this. Already we can see the complexity of several charged functional polymers competing for space on the fiber!

However, the furnish stream may also have the so-called 'anionic trash' comprising pitch, stickies, fines or ash which will quickly eat up the cationic additive before it can react with the fiber. In the illustration below, we need an extra 50% of wet strength agent just to overcome the anionic trash and reach the paper wet strength target; but these wet-strength or trash combinations are also the cause of foam and drainage issues on many paper machines.

The solution to this might of course be to neutralize the trash with a non-functional cationic polymer, but how to do this in the right place and right amount?

**Using the measurements**

The key to good chemistry management therefore is objective measurement, and the techniques most often applied measure the electrical charges on furnish and chemicals. For many years, papermakers have known about particle charge detection (PCD) measurement of the soluble or fine particle charge. PCD can not only measure the residual chemical in solution but also the troublesome anionic trash. System Zeta Potential (SZP) will directly measure the charge on the fiber. The higher this negative charge is, the better it will retain the cationic additive. Both measurement techniques are now available in several easy-to-use commercial options.

To exploit these techniques trained technicians would build a map of SZP and PCD charge for all the stock and water streams, noting chemical additions and modifying these to get the best results. They ask the questions:

- Which furnish stream has the highest chemical retention potential?
- How much anionic trash is present?
- How much fixative to neutralize the trash?
- Did my functional additive retain on the fiber?

And so a new chemical control strategy, based on measurement, not guesswork, is built. By using these means we can control chemical usage, optimize first pass retention and even improve the crepe efficiency.

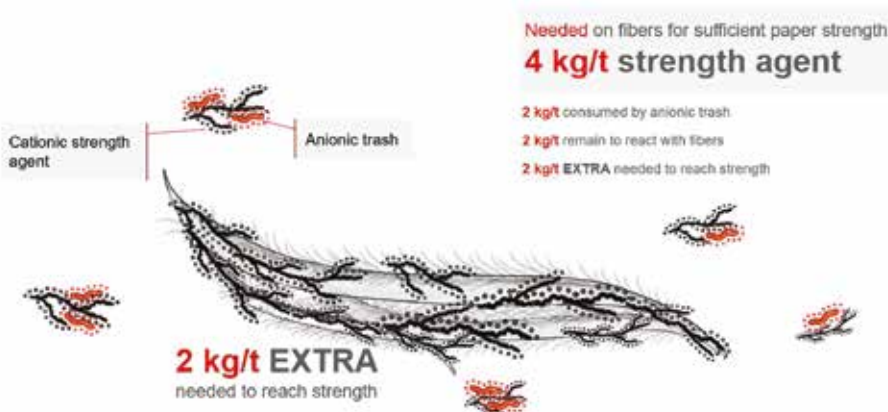


Figure 7: Impact of anionic trash.

### The future of charge measurement and control

All this has been known for some time (the original article was 2011 and the science predates that by many years) but the future lies in automating both the measurements and control functions. The driver here is the scarcity of trained and experienced lab staff at many mills to constantly monitor and control system charge.

The latest innovation is to take the PCD measurement on-line in a straightforward single point measurement to continuously read out the particulate charge. Combined with a thorough understanding of system charge chemistry via charge mapping as described above, this would ideally allow direct control of appropriate chemistry, most typically a cationic polymer used as a 'trash collector' or retention aid.

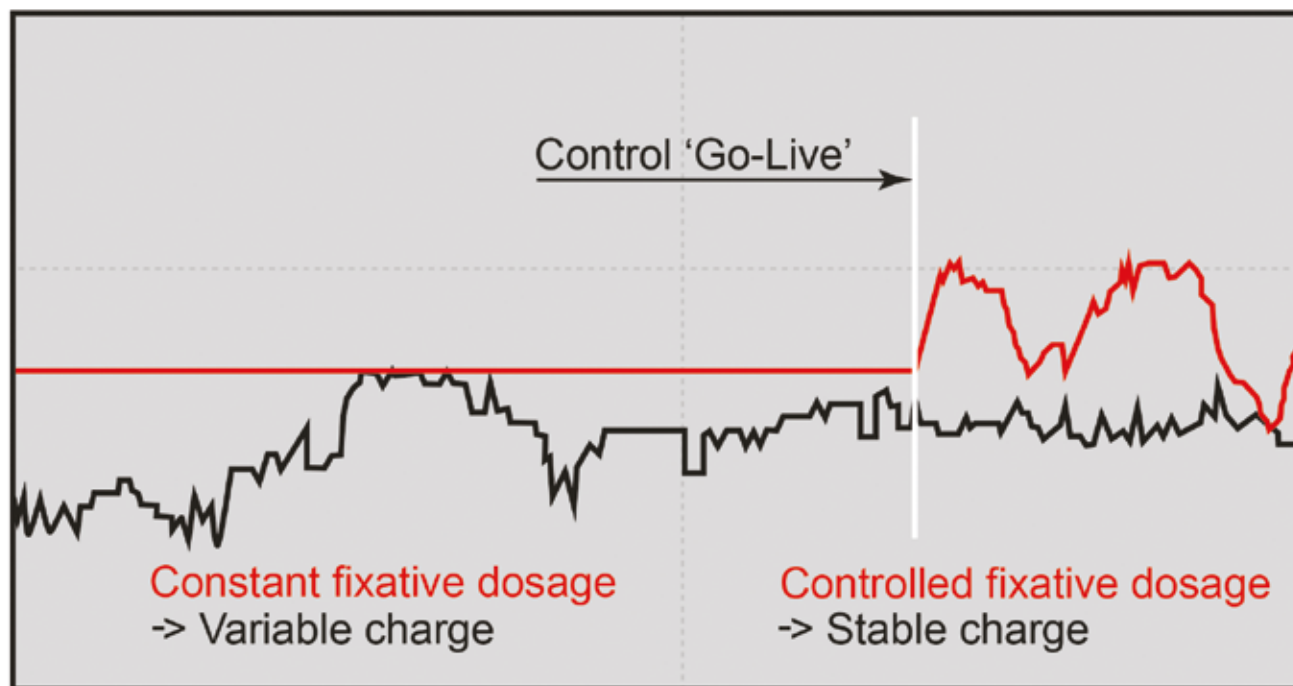
Here is an example of a control loop on a tissue machine going into action. The result of this control: higher machine speed, long blade life, better crepe ratio and fewer web breaks.

This has proved a successful approach in classic closed control loops for stable systems but the promise for the future is to combine multiple and complex process inputs into a multi-variate model of the system chemistry, and then use this model to control critical process inputs, including chemistry. This should allow us to extend the benefits of charge control to more challenging and complex systems.

### 40% Chemical savings and more stable quality

Back to our opening story. In fact, this describes the case in a Middle East tissue mill which ended up with a typical chemical soup. Trained experts patiently mapped this and suggested the appropriate actions to change addition points and control trash and retention. Not only was this client able to reduce their chemical spend by a staggering 40%, they also were able to achieve much improved tissue machine operation with stable quality and fewer web breaks, thus reducing to just weeks the payback time for the initial investment in instrumentation and training. This story is repeated many times for customers who decided to stop guessing and start to measure their chemistry and 'get out of the soup'.

*Figure 8: Here is an example of a control loop on a tissue machine going into action.*



For many more details on how to use charge control to improve paper machine operating efficiency including information on lab measurement and mill-proven on-line measurements, please visit BTG at [www.btg.com](http://www.btg.com), and check out our animated guide to charge control on the PTI web platform (<link: <https://youtu.be/MHjI9D2zxxY>>).

### About BTG

The BTG Group is a multinational provider of integrated, highly specialized process solutions for the global pulp and paper industry. Every day our people help customers achieve sustainable gains in business performance through our application know-how and industry-leading technologies. This includes world-leading rods and beds for film-metering size presses; high-performance ceramic and cermet coating blades; high-performance tissue creping doctors and doctor holders, specialty doctor blades and pulp and paper process control sensors and laboratory instruments. All of these technologies are supported with expert services and application support.