Flash Mixing, fast and simple way to introduce wet end additives efficiently into papermaking process

Jouni Matula
Wetend Technologies Ltd
Savonlinna
Finland
Flash Mixing, fast and simple way to introduce wet end additives efficiently into papermaking process

Jouni Matula    Wetend Technologies Ltd; Savonlinna, Finland; www.wetend.com

Abstract
An immediate and effective mixing with TrumpJet® Flash mixing process makes it possible to inject papermaking additives e.g. retention aid and sizing chemicals and filler into stock very close to the headbox. The developed versatile mixing technology that exploits efficient transverse mixing principle makes it possible to mix additives in selected groups into headbox feed stock simultaneously and together with retention aid agent at the same location. As a result the process is simpler, it has a very short response time, chemical consumption can be lower and filler retention can be better and sheet properties develop positively.

Introduction
Wet end additives are a very important group of raw materials. They can be e.g. various chemicals and filler and opacity pigments. The present efficient way of paper production and high uniform quality of paper and board would not be possible without the additives. Traditionally additives are inserted in various locations of the process. Blend/mixing and machine chest are located 10–30 minutes away from slice. Sometimes starch, filler, ASA, AKD, dry and wet strength agents, fixing agent, rosin, resin, dye, NaOH, CO₂ etc can be added into the process in this location as well. Suction connection of mixing pump (fan pump 1) is about 15–30 seconds from headbox. This location is commonly used to inject the same additives like dye, defoaming agent, starch, filler, Bentonite even polymer, NaOH, sizing agent, strength agent etc.
Once we move forward normal additives inserted before the headbox feed pump (fan pump 2) are filler, sizing agent and retention aid polymer. The retention aid polymer/starch and flocculants or nano-particle are often added before the screen.
After the screen good mixing is already very important and essential for good sheet quality. In some cases only Bentonite or nano-particle/silica is added in this part of the project. If mixing is good enough to produce good formation and profiles retention aid polymer/starch can be added post-screen.
Selection of the dosage location is based on lab performance test and experience from earlier cases. Mixing of an additive is often based in dosage into the process with low mixing intensity and the actual true mixing into the stock takes place once the additive makes it way towards headbox of a papermachine. This kind of slow blending and macro-mixing happens randomly in chests, pumps, deaeration receiver, screen, piping elbows and in process loops etc.

Additive in

1 second 2 seconds 6...20 seconds

Headbox

3 - 5 meters 6 - 10 meters

From headbox feed pump/screen onwards with conventional mixing intensity

Figure 1: Principle of mixing of additive with conventional mixing intensity. The blue horizontal pipe illustrates the headbox feed pipe showing red trace of additive moving onwards from left to right. Mixing takes place slowly and randomly on its towards headbox.

Wetend Technologies Ltd, Kaartilantie 7, FIN-57230 Savonlinna, Finland Tel. +358 10 836 0100, Fax + 358 10 836 0120
www.wetend.com   e-mail: firstname.lastname@wetend.com
Domicile/Kotipaikka: Savonlinna   VAT No: FI16435711 / Y-tunnus 1643571-1
Figure 2: PM short circulation process showing different circulation loops. Single pass percentage of additive to the slice is also shown in a table at upper right corner

1. Circulating loops of PM Approach / short circulation process

If the dosage location has a long distance to the headbox, it generates some significant disadvantages:

- The long delay time keeps the chemical extended time together with stock components, it meets randomly disturbing colloidal material, entrained gas bubbles and liquids/additives circulating or injected into the process with different pH, temperature, concentration and chemical composition. Reactions may be partly meaningful with targeted results, but partly reactions are generated randomly, uncontrolled and by accident resulting to unwanted outcome.

- Several circulating loops of the PM short circulation process will keep part of chemicals in circulation longer periods thus extending the time with above, explained effect. The figure 2 shows the circulating loops and first pass percentage of additive flows to the slice.

- If additive is added into the mixing chest, approx. only 50% of the flow has straight access as a first pass flow to headbox and as much as 50% of the flow begins to re-circulate in loops. The long delay time with circulations slows down and makes it more difficult to make production adjustments. The extended delay time, multiple re-circulations of partial flows makes the whole process complex: Chemical reactions and the wet end surface chemistry is difficult to predict and follow - specially in situations when the process is not well balanced. System cleanliness also can be widely reduced due to these facts. The process can generate deposits in uncontrolled situations.

Slow blending versus fast and effective mixing of additives

If mixing of reactive additive into a complex process media is made with a fast and effective manner, outcome is a reaction or reactions with the correct manner and with targeted end result. Reaction is e.g.: \( R + K \rightarrow AB \)

Only small number of side effects may come up.

If mixing is made slowly and with a random interaction and concentrations, result is that the injected additive will meet varying conditions on its way forward in the process. There can be several different reactions:

- \( R + H \rightarrow YV \)
- \( R + K \rightarrow AB \)
- \( R + YV \rightarrow LKJ \)
Extended time and random additive concentrations bring possibilities for additional unwanted side reactions. The background and problems can be summarized as follows:

- Dosage points of additives vary from mixing chest to headbox feed pipe
- Circulating loops distribute additives across the process with large variation of time delay
- Addition points are located early in the process to “guarantee” decent mixing
- Additives have a long delay in the process before sheet formation
- Long response times in dosing adjustments and control
- Strong beliefs exist about “right” dosage locations
- Complex chemistry
- High additive consumption
- Low predictability of results
- Risk for a deposit generator

2. Mixing of the additives with advanced Transverse mixing

To make an improvement into this part of the process good and fast mixing plays an important role. Wetend Technologies Ltd has developed a TrumpJet mixing technology and about 200 mixing stations today is in use for various additives in paper and board mills globally. Mixing exploits circulated headbox stock to mix the additive fast, gentle and efficiently. Technology is based on advanced Transverse jet mixing with high mixing intensity.

2.1 Transverse mixing

Transverse mixing is not commonly well known in detail. Conventional way to dose additives into the process imitates often the transverse mixing process, but injection energy or intensity and volume of flow is so small that true mixing never can happen. Recently the mixing phenomena have been studied more in detail. The transverse mixing process, when well designed and developed, is a very powerful and efficient mixing process. The mixing takes place efficiently in several steps in the transverse mixing process. Figure 3 shows the transverse jet penetrating upward into cross flow making headway from left to right.

Figure 3: Four powerful mixing tools of a transverse jet: 1. Counter rotating vortex pair (CVP), 2. Shear layer vortex, 3. Horseshoe vortex, 4. Wake vortices
Among the important physical phenomena associated with the transverse jet is a formation of different kinds of vortical structures following the influence of the cross flow (stock heading towards headbox): 1. The counter-rotating vortex pair (CVP), which results in a complex interaction between jet flow and ambient cross flow, 2. Jet shear layer vortices 3. horseshoe vortices and 4. Wake structures and vortices. The CVP is a very robust feature of the transverse jet; it is seen to have a very important role in enhancing mixing between jet and cross flow. The horseshoe vortex and wake structures are interactions of the jet with pipe wall boundary layers. It develops mixing of flows also between the pipe wall and CVP.

The above makes it possible to mix the chemical quickly into the cross flow and to cover completely quickly and efficiently the whole cross area on the main process pipe. Figure 4 shows a computer flow modelling results for a core part of the counter rotating vortex pair in a stock pipe generated by a TrumpJet mixer.

2.2 Mixing result in a headbox feed pipe – TrumpJet Flash Mixing

A computer simulation of transverse mixing of four TrumpJets in a pipe of 800 mm (32 in) is presented in figure 5A. The results are as follows:

A. One (1) meter after injection: Counter rotating vortex (CVP) pairs are already well developed
B. One (1) second after injection: The chemical is distributed across the entire pipe cross sectional area; there is already chemical in every “corner” of the pipe
C. Two (2) seconds after injection: Good distribution of the chemical across the pipe Headbox manifold feed flange can be located here.
D. Three (3) seconds after injection: Mixing fine tunes in the headbox manifold. Prior to headbox turbulence zone deviation of the mixing from totally mixed conditions is less than 10% peak to peak and with average less than 5%

As comparison with conventional four points circular ring mixing arrangement deviation is approx. 50%.
Figure 5A: A computer simulation of transverse mixing of four TrumpJets in a pipe of 800 mm (32 in)

Figure 5B shows longitudinal development of mixing in a pipe following the pattern of figure 5A. Mixing is completed in two seconds and headbox flange can be located in this area. It depends of course also on chemical requirements and layout of the wet end. If time to the headbox is much longer, it may have some unwanted results like polymer conformation against fiber surfaces. Practically the additive is flashed into the whole volume of the process pipe in a few seconds with help of circulated headbox feed stock. TrumpJet Flash Mixing technology manages to flash mix even very tiny flows of additives into a large process flow.

3. TrumpJet Flash Mixing system for wet end additives
It is possible to mix additives with a fast and effective way close to the headbox. In order to exploit fast efficient mixing process with the best possible way and to be able to keep the system as simple as possible and to minimize necessary investment cost the TrumpJet mixing process has been developed to a versatile package to meet the above requirements.

The developed TrumpJet Flash Mixing concept makes it possible to bring two independent efficient mixing stations to a post-screen location. With the versatile mixing tools and TrumpJet models it is possible to mix at least two chemicals together with both TrumpJet Chord and TrumpJet Poco mixers (figure 6).

Regarding the wet end chemicals normally one mixing station is e.g. for cationic additives and the other is for anionic additives.
3.1 Flash Mixing of filler material before the headbox together with retention aid agent

Wetend Technologies Ltd has also developed a method to bring filler material or opacity pigment to the same mixing station as retention aid agent. Filler and the retention aid are mixed simultaneously but through separated channels into the process with TrumpJet Flash Mixing system.

The benefits can be e.g. much higher retention of fresh virgin filler material, very short response time, reduced filler content in white water, reduced filler content in rejects etc.

Figure 6: On the left: Principle of basic arrangement of mixing stations at post-screen location. On the right: A PM Approach system with three additives flash mixed at post-screen location with two mixing stations.

Figure 7: TrumpJet Flash Mixing system comprises two independent mixing stations for several wet end additives including e.g. retention aid additives, sizing agent and filler.
3.2 Typical Flash Mixing applications

- Two or three different retention aid additives can be “flash” mixed through two separate TrumpJet mixing stations at post-screen location.
- Sizing agents like ASA or AKD can be flash mixed together with retention aid polymer or starch. Result are reduced consumption of the sizing agent or improved Cobb-value and less deposits in white water and stock circulation. The improvement origins mainly from better retention of sizing agent. Mixing is made close to the headbox. Short delay time from dosage to dewatering minimizes hydrolysis side effect of sizing chemical and prevents build up of disturbing deposits
  - Filler material or opacity pigment can be flash mixed simultaneously with retention aid at post-screen location. Result with filler is e.g. improved filler retention
- Several other combinations can be constructed.

4. Mill results
4.1 Coated fine paper

A German coated fine paper line mixes wet end additives into the headbox feed stock with post-screen located mixing stations with the TrumpJet Flash mixing concept.
Figure 8: A German coated fine paper mill and TrumpJet Flash Mixing installation with two mixing stations

Operating results:
- Saving of cationic polymer and microparticle 10%
- Increase of total retention from 50% to 55–60%
- Increase of ash retention from 20% to 25–30%
- If retentions are kept the same, savings of additives is 30%
- Same or better formation
- More stable white water consistency
- Less breaks at press section
- Fresh water use zero, mixing is made with stock as injection/mixing liquid

The layout of the system is presented in figure 8.

4.2 Mill results, mechanical paper
A Finnish specialty mill mixes retention aid agent and ASA sizing agent simultaneously at the post-screen location. Operating results:
- Improved formation 20%
- The better formation resulted in increase of paper machine speed with 10–20 m/min
- ASA consumption reduced 10–20%
- More homogenized sizing
- Improved retention of ASA, less residual ASA-chemical in white water circulation
- Polymer consumption reduced 20–30 %
- Reduced microparticle consumption
- Improved control of dewatering
- Fresh water use zero, water consumption reduced 360 m³/day
Figure 9: TrumpJet Chord injects and mixes retention aid agent and ASA sizing agent into headbox feed stock at post screen location. Injection mixing liquid is stock

Conclusions and summary
Transverse mixing process is a powerful tool to mix wet end additives into papermaking stock with a fast and effective manner. TrumpJet Flash Mixing System exploits the phenomenon in a versatile mixing process to dose and mix the chemicals and filler into the process 2–5 seconds before paper machine headbox.

The additives are brought into the process one by one or in selected groups. The group mixing keeps the process simple and effective. Quality and operation can be improved in many respects. Application development is still required to fine tune the systems to meet individual requirements of various additives and different paper and board machines and grades.