

# New efficient mixing system of papermaking additives cuts fresh water consumption

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## Abstract:

Wetend Technologies Ltd has invested during past years on development of chemical and additive mixing into stock close to headbox. A TrumpJet™ jet injection and mixing system for papermaking additives eliminates completely additive post dilution with fresh water in PM Approach system process. Additives are mixed effectively into the process by exploiting circulated headbox feed stock. The system gives considerable energy savings as well as reduction of CO2 emission case by case. Overdosing of additives will be also avoided. This results to chemical savings. About 130 systems are already in operation world wide.

## Introduction

Papermaking chemicals and additives are today an essential and important part of the process. The additives are e.g. retention aids, fixing additives, starch, sizing agents, dye, biocide, optical brighteners, filler, opacity pigments etc.. It has been paid a lot of effort and keen interest to develop different chemicals to exact needs and to make the application as effective as possible. The additives play also a significant role in production costs. Importance and methods to insert and mix the additive into the stock has been neglected. This potential is not well exploited at the moment in majority of paper mills.

### 1. Conventional mixing of chemicals and additives

Good effective mixing of an aggressively reactive additive into stock is a demanding task. Reaction time of retention aid polymer with stock is a fraction of a second. Chemical hydraulic flows are very small compared to stock flow to the headbox feed manifold.

Typical hydraulic flows of additives without post-dilution for a machine making 700 ton/d can be:

- retention aid polymer 0,5 – 1,0 l/s
- retention aid nano particle 0,05 – 0,1 l/s
- retention aid bentonite 0,5 - 3 l/s
- defoaming agent 0,05 l/s
- ASA emulsion as sizing agent 0,05...2 l/s
- dye 0,05 l/s

The corresponding headbox feed flow is approx 2.000 l/s. Thus the headbox flow is 1.300 – 400.000 times greater than the chemical flow. Since complete mixing should preferably take place in a few seconds, the above numbers show how challenging the task is.

Today papermaking additives are typically injected into stock with single or multiple 90 degree side entry T-pipe nozzles or quills with the help of additional water. Systems are operated with relatively low dilution / speed up water volume. Chemically treated fresh water is often used. Injection velocity is generally about the same or slightly higher than stock. High injection velocities cannot be used in this kind of a system, because shear effect can destroy efficiency of polymers such as retention aid. Increased water volume would help in mixing; however, practical economical and environmental reasons prevent this. As a result low volume and low speed of the additive will result to minimal penetration and ineffective mixing.

The use of fresh post-dilution water has some disadvantages:

Fresh water consumption: It will increase total mill fresh water consumption, like presented in table 1 (1). The table shows fresh water consumption of seven Finnish paper and board mills used for dilution of chemicals. Consumption varied from 0,45 to above 2,5 m<sup>3</sup>/ton. The use of fresh water for dilution was with finepaper and LWC machines 10 -15% of the total amount of the mill fresh water consumption, with others it was less than 10%.

Chemical	News 1	News 2	Board 1	Board 2	LWC 1	LWC 2	Finepap	
NaOH			x	0,8				
Bentonite	31,7	8,9		x	4,6	29,2		
Talk					1,3			
Fixing chemical					13,2	13,3		
Retention polym.	27	<u>77,8</u>		<u>25,2</u>	<u>50,7</u>	25,4	<u>97,6</u>	
Spray starch				25,8				
Alum				20,0				%
Sizing chemical			72,5				2,4	
Resin				5,9				
Starch/stock	<u>41,3</u>		27,4	16,4	18,4	<u>32,2</u>		
Starch/surf.siz				5,9			x	
Colour	x	13,3	x	x	X	x	x	
Water cons. m <sup>3</sup> /tn	0,6	0,5	1,0	0,9	1,5	2,6	1,5	

Table 1: Fresh water consumption for preparation and dilution of papermaking chemicals

Energy consumption: Diluted chemical will reach process temperature as it is mixed into stock or alternatively the water and the chemical are heated already prior to injection. The latter is better way from process point view to avoid thermal shock with the stock.

In either case energy will be consumed, if incoming fresh water is colder and elevated stock/headbox temperature needs to be maintained.

CO<sub>2</sub> emission: If additional energy has to be used to heat the chemical and dilution water, this can increase CO<sub>2</sub> emission for the mill.

Example: Incoming fresh water temperature is 15 °C, headbox feed temperature is 55 °C, and total flow of dilution water for retention aid, bentonite and sizing agent is 15 l/s. The additional energy required to warm up the water is 2,5 MW with annual consumption of 21.000 MWh. The source of the required energy is either added external additional heating power or additional heat energy entering the headbox approach flow process with thick stock.

The above 21.000 MWh power consumption will correspond approx 5.800 tons of CO<sub>2</sub> gas emission.

## 2. TrumpJet™ - mixing system

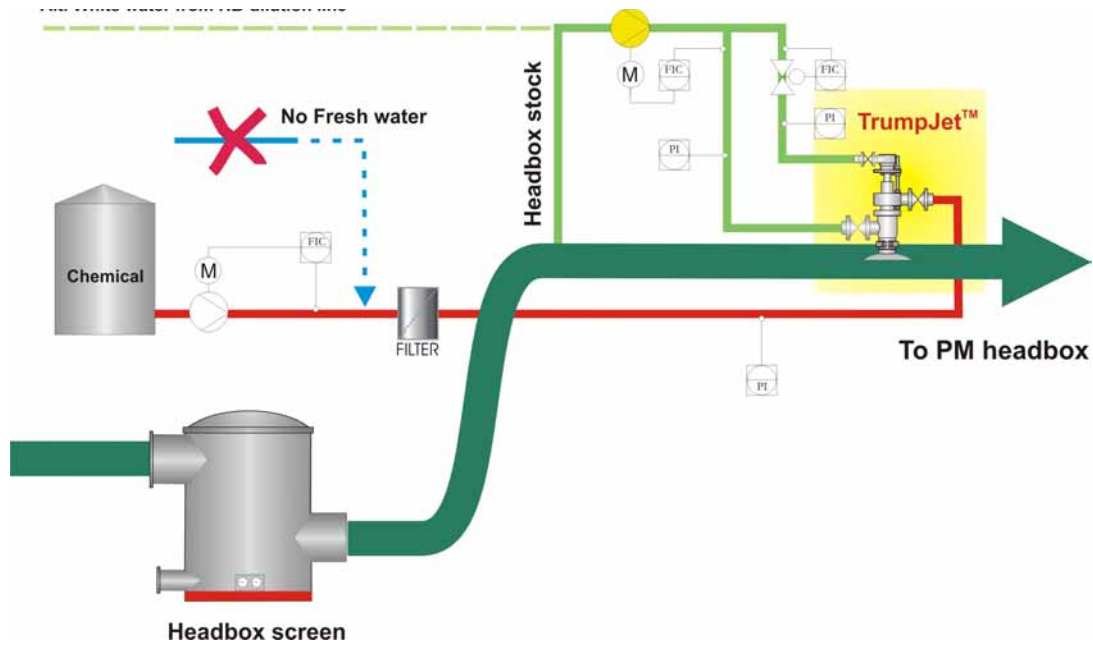
The TrumpJet mixing innovation is simple and surprising. Chemical is injected and mixed into the main process by using recirculated liquid from the main process; in paper mills it is papermaking stock. As a result use of fresh water can be eliminated completely and there is no need to consume extra heating energy. The elimination of the heating energy will reduce CO<sub>2</sub> emission of the mill.

As a result of good mixing the headbox feed stock is more homogenous. This improves quality of the end product and efficiency of production. Savings of additive or chemical can be also considerable; ranging between 10 – 60% less depending on the case.

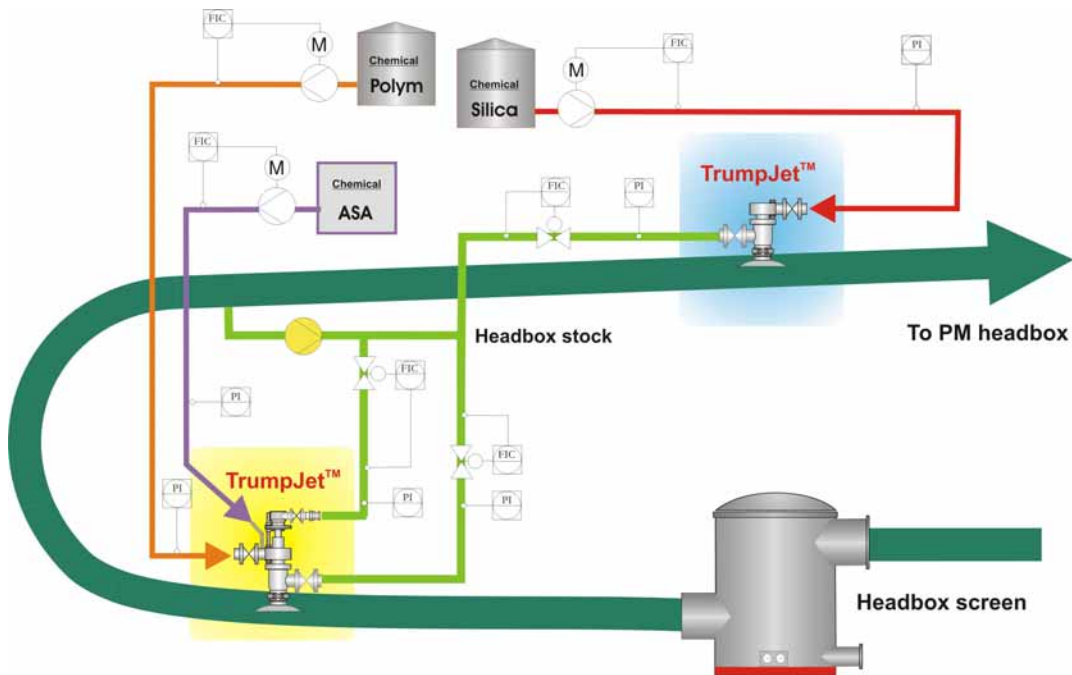
Operation: The mixing process efficiently injects and mixes a chemical (or even two chemicals simultaneously) into the main stock stream.

Fresh water is not needed. Chemical is injected with the help of high speed and high volume liquid media. It can be:

1. circulated headbox stock (primary media)
2. circulated, screened white water from headbox dilution line
3. (for thick stock and sludge applications it can also be thick stock or sludge)



a)



b)

Figure 1 a: single TrumpJet mixing station, b: a dual TrumpJet mixing station for polymer, ASA and silica

The TrumpJet mixing method has several advantages:

- Source and volume of circulated stock is unlimited. The system maintains relatively high injection flow volume and injection velocity. This results in deep penetration of chemical into stock. Good mixing takes place in 1-2 seconds.
- There are no external, additional liquids involved. The chemistry, temperature and consistency will stay the same. This results in a stable process without temperature shocks or chemical disturbances. Possible build of system deposits will be avoided

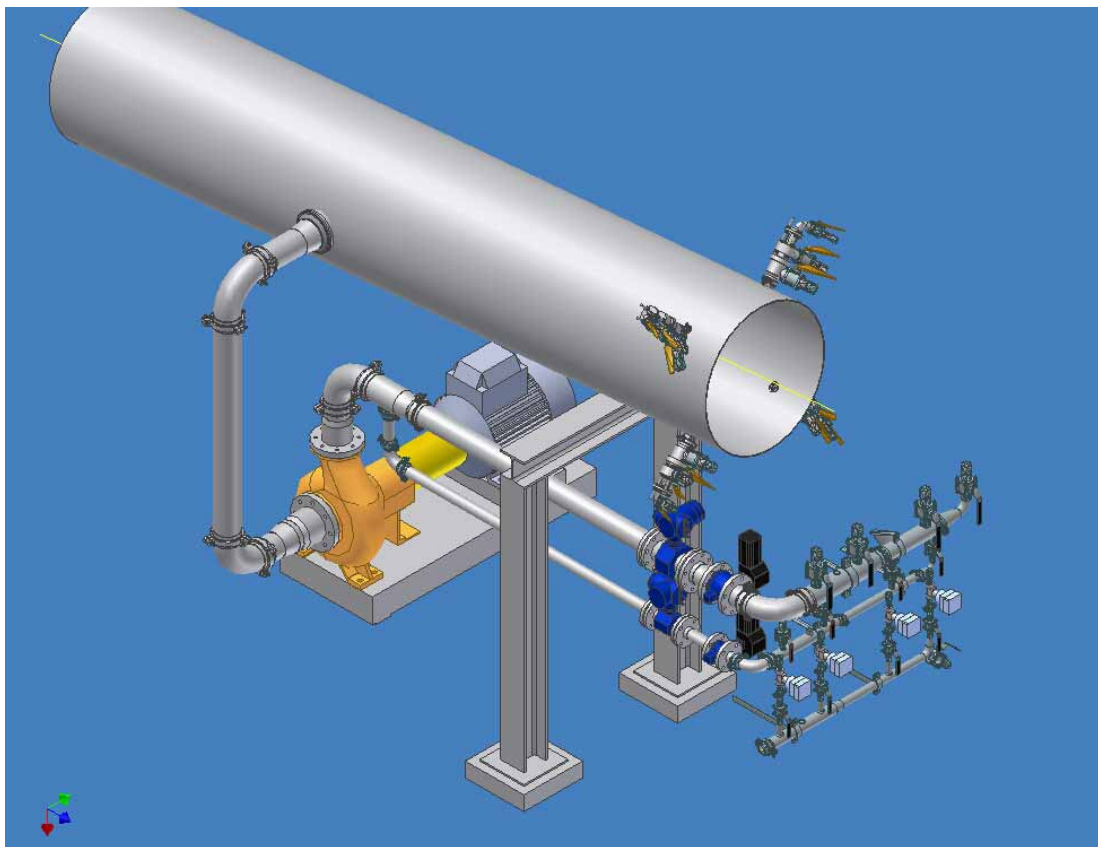
- Circulated stock is headbox feed stock after the machine screen. It is the cleanest papermaking media, there are no process or sheet dirt problem.
- Very simple hydraulic process to run

The TrumpJet mixing innovation of this system makes it possible to use stock as injection media instead of chemically cleaned fresh water.

The mixing system has the following features:

- Injection flow is a high volume, high velocity stock flow
- Chemical flow is a low velocity, gentle and undiluted chemical flow (no dilution water needed)
- Mixing flow is a small volume stock flow

Flows are directed through separate flow channels to the inner surface of the stock main process pipe where they are mixed together within a fraction of a second simultaneously when the mixture penetrates into stock. This innovation makes it possible to run the additives with help of headbox feed stock or even with thick stock.



*Figure 2: Principle layout of a TrumpJet mixing station that exploits circulated headbox stock as injection and mixing media.*

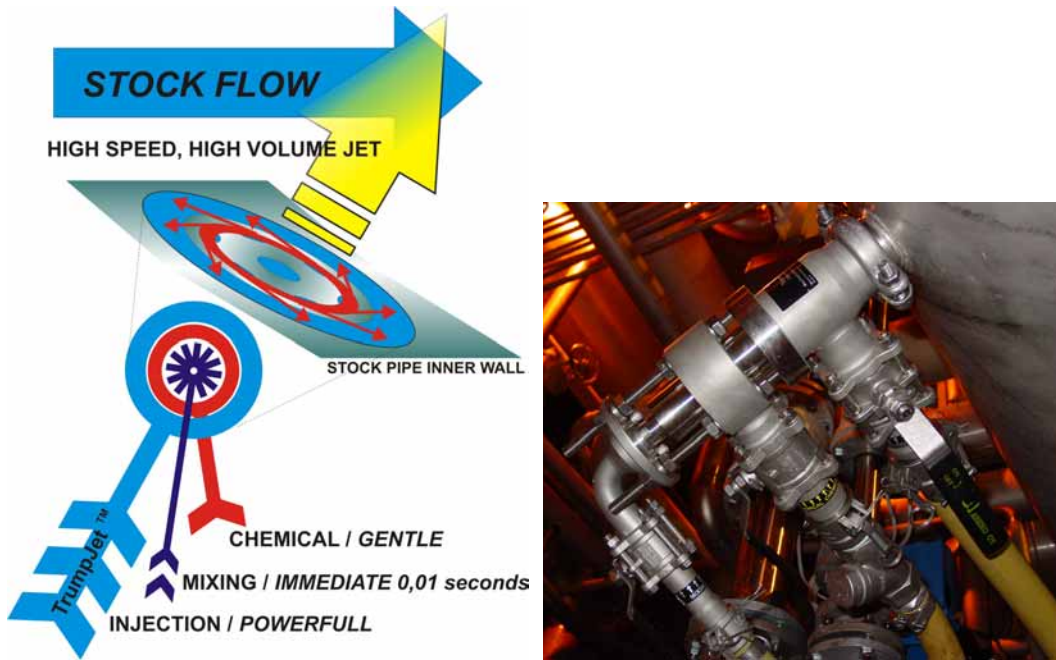


Figure 3: The TrumpJet mixing system exploits injection and mixing media to mix additive into the stock. Mixing of the three flows takes place in less than 0,01 seconds, simultaneously as the mixture penetrates into the main stock flow

**4. Results obtained**

Principal objectives of the development work were to increase sheet homogeneity and paper quality, to cut fresh water and energy consumption and to give the additives an opportunity to work with the best possible efficiency that can reduce chemical consumption. Better sheet quality will improve runnability and speed of the machine.

Table 2 shows influence of mixing in different process parameters and relationships.

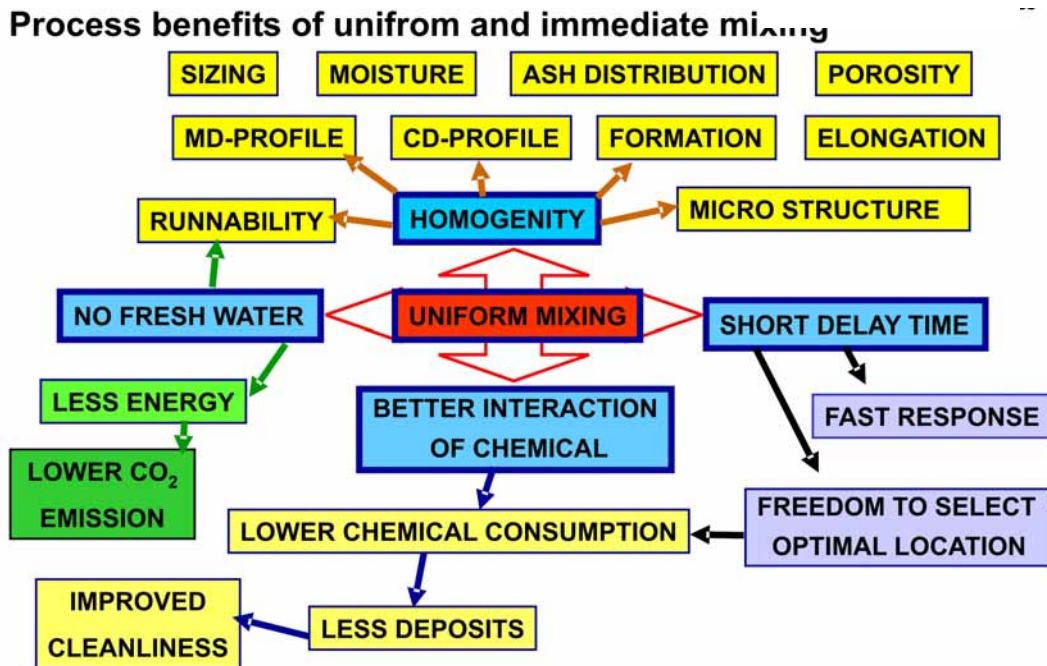


Table 2: The graphic shows influence of mixing in various process parameters

There are currently more than 140 TrumpJet chemical mixing stations in operation in 17 different countries:

<b><u>Paper grades:</u></b>	<b><u>Chemicals:</u></b>
SC paper	Retention aid polymer
Newsprint paper	Retention aid bentonite
Fine paper	Retention aid silica
Coated fine paper	Retention aid microparticle
LWC	ASA sizing agent
MFC	AKD sizing agent
Writing paper	GCC
Printing paper	TiO <sub>2</sub>
Photographic paper	Paper Dye
Release paper	Starch
Liquid packaging board	Deinking chemical CaOH <sub>2</sub>
Liner board	Sludge dewatering polymer
Folding box board	Microflotation polymer
White chipboard	Microflotation bentonite
Wall paper	Biocide
Corrugated Medium	Size resin
Coarse board	Dry strength agent
	Defoaming agent
	PAC

Table 3: Paper grades and different additives of TrumpJet applications

#### **Environmental benefits:**

The advanced mixer installations supplied this far are together saving a total of approximately 17 - 18 million m<sup>3</sup> of fresh water per annum. Through savings in energy (to heat the fresh water) there is an annual reduction potential of approximately 150.000 -200.000 tons of CO<sub>2</sub> emission.

#### Example 1

A fine paper mill in USA has applied the technology. The mill installed TrumpJet chemical mixing stations in 2004 and mixing and injection are made with stock. Fresh water consumption was reduced by 300.000 million gallons or 1 million m<sup>3</sup> per year through this technology and resulting process optimization. The use of heating energy for fresh water was eliminated. Energy saving was 125 billion Btu's or 36.600 MWH per year. This correspond approx 20.000 barrels of oil and 10.000 tons of CO<sub>2</sub> emission. Process chemical usage was reduced 22%.

The mill received "2005 Governors Award for Environmental Excellence" award in Maine based on the results.

#### Example 2

A large SC paper machine in USA installed a single TrumpJet mixing station for polymer. Mixing media is circulated stock. Fresh water savings were 95 million gallons or 0,35 million m<sup>3</sup> per annum. The saving resulted to 4.400 tons reduction of CO<sub>2</sub> emission.

#### **Conclusions**

The developed TrumpJet mixing technology makes it possible to inject and mix wet end additives into headbox feed stock with help of circulated stock. The innovation eliminates completely fresh water consumption in post-dilution of chemicals. It also brings savings in energy consumption to heat the fresh water and can reduce CO<sub>2</sub> emission. The system improves mixing with lower chemical consumption and better sheet quality and machine runnability. The concept has been proven with numerous mixing systems in different types of paper mills with several years of operation.

References: 1. Manner, H., Ryösö, K., Harju, E., Viik, H., Töyry, M., Kiertovesien käyttömahdollisuudet kemikaalien syöttövesinä - MPKT07 (The feasibilities to use circulation water as feed water of the paper chemicals), CACTUS -teknologiaohjelman vuosikirja 1998 (CACTUS Technology Programme - Yearbook 1998), editor Alakangas, E., VTT Energia, Jyväskylä, 1998, pp. 171...178.