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Experience of Seventeen Compact Wet End Systems

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ABSTRACT

Ten years ago most papermakers were convinced that a system needs to be voluminous and heavy for controllability and stability. In order to improve grade changing dynamics, the author of this paper began developing a compact papermachine wet end. The results have proven that compactness is beneficial even more broadly. Quoting Voith[1] "the trend is now the opposite - the systematic collecting and direct feeding of the individual water flows back into the system". In its gasless form this is actually covered by a POM Technology patent[2].

The POM System

The POM System Fig 1, aims at fast response and fast equilibrium by minimizing volumes.

The stock is composed in a POMix stock processor, which is a special mixer with about one minute holding time feeding the mixing pump by bone dry (volume x consistency) flow control.

The cleaners, if any, may be coupled as a flexible cascade[3] combining the primary and secondary accepts and allowing for constant operation under all process conditions. The backwater is degassed by means of centrifugal degassers, POMps, immediately at the former and distributed to the dilution points of the core process over a closed hydraulic system without tanks.

Compact POMlocks substitute for the sealing pit and the wet end pulpers (couch- and press pits) can be made as POMit kneaders, feeding the wet broke directly to the POMix. Also other parts of the process, like fibre recovery, may be designed for compactness and fast recycling.

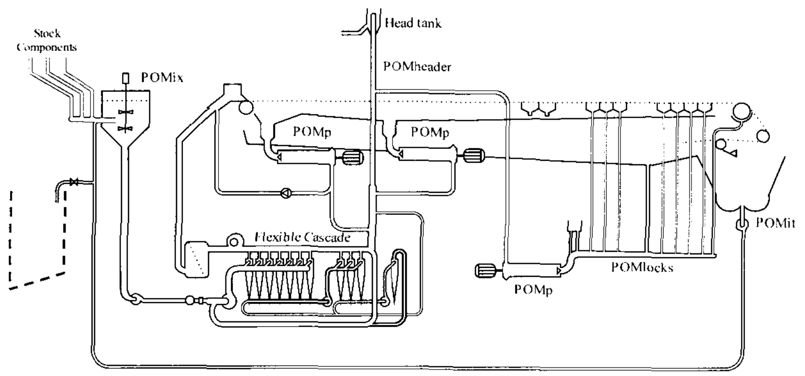

Fig 1, POM System

• POM Technology Oy Ab Helsinki, Finland, www.pom.fi.

Experience of seventeen installations

POM Technology is a small company, without resources for experimental research, and limited ones for process analysis and studies. Most of our knowledge is empiric or based on experience and common sense. The systems operating are for production, not for research. Clients do not always disclose everything and as all of us know, "no news is good news". With sixteen installations we believe to have a good feeling for how compact systems work - and believe to have understood a number of reasons and logic connections.

In the following I will discuss certain aspects of the experience made with the installations.

1. MD-Papier, Albbruck, Germany
- Products: LWC, MWC,HWC
- Production: 90 000 t/a
- Installation 1997: 4 units POMp 415 substitute for Deculator
- Installation 1999: Compact System with POMix and POMlocks

2. International Paper #1, USA
- Products: Uncoated finepaper
- Production: 8 000 t/a
- Installation 1999: 1 unit POMp 415, POMlocks, Flexible Cascade, POMix

3. International Paper # 2, USA
- Products: Uncoated finepaper
- Production: 35 000 t/a
- Installation 1999: 3 units POMp 415, POMix, POMlocks, Flexible Cascade

4. International Paper #3, USA
- Delivered 2000: 3 units POMp 415, POMix POMlocks

5. Ahlstrom Paper, Osnabruck, Germany
- Products: Laminating papers
- Production: 20 000 t/a
- Installation 2000: 1 unit POMp 415, POMlocks and Flexible Cascade

6. Carl Macher Hulsenpapier, Germany
- Products: Core paper, core board
- Production: 100 000 t/a
- Installation 2001: 3 units POMp 415

7. Japan, undisclosed order
- Installation 2001: 6 units POMp 415, POMlocks and Flexible Cascade

8. Neu Kaliss Spezialpapier GmbH, Germany
- Products: Technical specialities
- Production: 15 000 t/a
- Installation 2001: 1 unit POMp 415

9. Japan, undisclosed order
- Products: Colored speciality fine paper
- Installation 2001: 1 unit POMix

10. USA, undisclosed order
- Products: Liner and corrugated medium
- Production: 170 000 t/a
- Installation 2001: 2 units POMp 415

11. Oji Paper, Kasugai Mill, Japan
- Products: WF and mechanical printing papers
- Production: 60 000 t/a
- Installation 2002: 3 units POMp 415, POMlocks

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12. Hansol Patech, Chunan Mill, Korea
- Products: Colored speciality papers
- Production: 20 000 t/a
- Installation 2002: 1 unit POMp 400, 1 unit POMix, POMlocks, Flexible Cascade

13. Moorim Paper, Daegu Mill, Korea
- Products: WF coating base, fine paper, release paper
- Production: 70 000 t/a
- Installation 2002: 2 units POMp 415, 1 unit POMix, POMlocks

14. France, undisclosed order
- Products: Decor paper
- Production: 27 000 t/a
- Installation 2002: 1 unit POMix

15. France, undisclosed order
- Products: Decor paper
- Production: 20 000 t/a
- Installation 2002: 1 unit POMp 415, 1 unit POMix, Cleaner Plant

16. Japan, undisclosed order
- Products: Colored printing paper
- Production: 50 000 t/a
- Installation 2002: 3 units POMp 420, 1 unit POMlocks

17. Spain, undisclosed order
- Products: Colored WF specialities
- Production: 25 000 t/a
- Installation 2002: 1 unit POM 415, 1 unit POMix, 1 unit POMlocks, Cleaners

18. Torraspapel, Motril Mill, Spain
- Products: Coated woodfree printing papers
- Production: 100 000 t/a
- Installation 2002: 3 units POMp 420, 1 unit POMix, 1 unit POMlocks

Stability

Did you ever try to transport a barrel of water on your bicycle? If you did, you will know that weight and volume do not necessarily stabilise, on the contrary, they may even rock your process.

In old times with variable wood quality, poor control over batch digesting and cyclic sharpening of grindstones big volumes in the core process were necessary for being able to control the process by primitive means. This has left papermakers with a mind set requiring volumes for stabilising even if the world has changed.

Volume may still be a means for stabilising component quality. Once that is done, fast and exact response, not slowness and delay, make a well controllable process. This is well confirmed by the results we have from operating POMixes. We do not know about a single case where the small mixing volume would have caused stability problems.

Direct stock feeding

The experience and all data received also confirm the good function of direct stock feeding from the POMix. Gunnar Gavelin4 many years ago explained why the stuff-box and basis weight valve are a poor and instable arrangement. When testing a POMp in Albbruck, we found that this is very true, changes in the silo flow pattern were enough to cause basis weight variations and even web breaks. The POMix with a high feeding leg to the stock pump and high speed differential in the dynamic mixer before the mixing pump yields a stable and uniform flow.

Back water consistency variations

When planning a system for an inclined wire, we very strikingly observed a phenomenon that seems overseen by many papermakers. When different flows flow into a tank or silo with poor mixing - like is the case in backwater silos and many white water or sealing tanks - the fractions will not merge to a homogeneous mix, but will form clouds of variable composition. Fig 2. This will lead to consistency variations at the tank outlet our observation was extreme with a consistency ratio of 1:25! You can well imagine what this can do to basis weight stability - especially if the fractions contain variable amounts of air causing a variable cavitation in the following pump. In a pipe, when velocities are right, there would be an intensive zone of turbulence homogenizing the mixture.

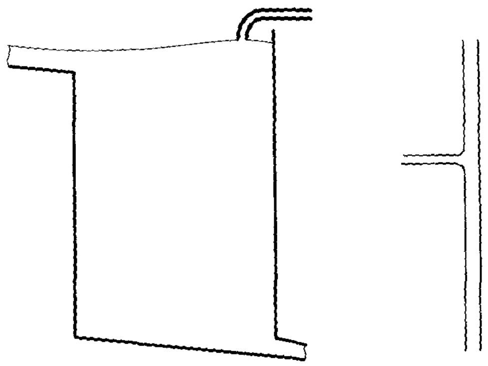

Fig. 2. Scales of turbulence and composition variation.

Pump pulsations are proportional to pumping head

When the inlet pressure is high and the pumped medium is free of gas, cavitation is reduced, which stabilises the pumping. The high inlet pressure also reduces the pumping head required and all these factors reduce pulsations caused by pumping.

Typical for the POM system is the POM Header that gives a higher inlet head on the process pumps

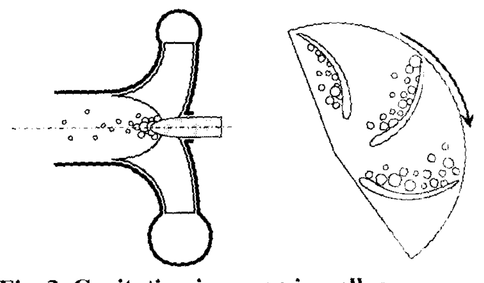

Fig. 3. Cavitation in pump impeller

and provides degassed water. The dimensions of the header is such that it does not give space for disturbing turbulences, but merging flows get efficiently mixed by their own kinetic energy. When also the overflow is such that no rocking waves can emerge we understand why the pressure in the system is very stable.

This explains also why original fears that the system would be vulnerable to pulsations and instabilities due to its small volume did not materialise. On the contrary, we see that the system is very stable and except for the controls required for the POMps can work with even less process control than other systems.

Agility

A light and compact system responds faster than a voluminous one. Fig. 4. Fast and accurate response is always beneficial for process control. This is true for all processes and not only at grade changes. The POM System was originally developed for easy grade changes, but the range of installations have shown that it is good also for papermachines that produce a very narrow product range.

The time to equilibrium after a change is proportional to the holding or cycle time. In the practise a change, however, depends on other factors as well and the full benefit of a volume reduction cannot always be yielded. When tuning a system for fast grade changes we have seen that the digital control systems more often than machine operators set the limits before they are optimised.

Cleanliness

As can be expected, a compact system with less surfaces and shorter dwelling times for debris and detrimental substances will stay cleaner than a voluminous one. We do, however, think that there are certain additional factors keeping the system clean.

Gas dissolves and bubbles collapse, when the pressure of gaseous back-water increases in white water towers and pumps. These bubbles are coated by a film of hydrophobic material collected from the colloids and anionic trash in the water. Upon the collapse these form tiny agglomerates which, for hydrodynamic reasons, more readily reach the surfaces of process equipment than the dispersed colloids would5.

In the compact system there are no volumes of stagnant water where the trash would precipitate. When correctly designed, the compact system has shorter pipe runs and these may be dimensioned for higher flow speeds than is economic in a voluminous system. The higher speeds contribute to self cleaning and polishing of the pipe lines. When designed for speeds over 3 m/s corresponding to a dynamic head of 4,5 kPa (45 cm), pipes will stay clean by themselves.

We think that process designers traditionally are unduely afraid of the high flow speeds and rather tend to over-dimension pipes. We have seen even polished head box approach pipes building thick deposits due to low flow speed - and then polishing is certainly poorly spent money. A cheaper and more efficient way would be to secure appropriate speeds.

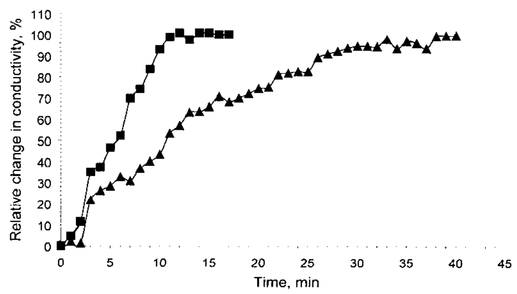

Fig. 4. Response time Conventional Albbruck PM 6 vs. POM System, PM 7 Change in conductivity upon changing Alum metering.

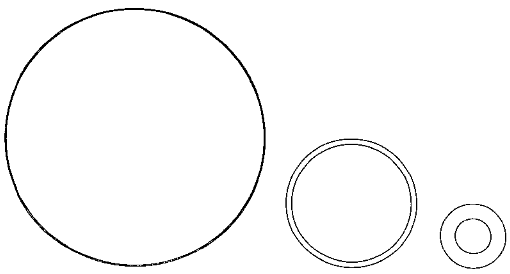

Fig. 5. Forming of an agglomerate at the collapse of a bubble.

Centrifugal Degassing

There are many opinions on what the acceptable gas content for good papermaking would be. Certainly gas in the process water or the stock is seldom beneficial - even if we met cases where a client needed some gas for making bulk or porosity. Voith and Metso seem to be of the opinion that no mechanical degassing is needed at speeds lower than 1000 m/min. Voith1 tells that above that total full flow degassing by vacuum would be necessary. On the other hand, I have heard knowledgeable people tell that a high speed gap former would not be disturbed by gas up to 1,5%.

Gas in the process water disturbs forming and dewatering. It also influences process stability and cleanliness. Our experience shows that for various reasons and independent of papermachine speed the gas content should be kept low. The content of dissolved gas does not need to be zero, but should be low enough to avoid forming of free gas during paper forming.

The POMp centrifugal degasser removes gas bubbles. With a degassing surface of about 1.5 m^2 and a centrifugal force of 150 g, it would correspond to a flume with a surface of 225 m^2. The degassing can be improved by applying vacuum to the POMp, which expands the bubbles and accelerates their rising to the surface.

We did initially underestimate the effect of dissolving gas under pressure. An installation where the inlet pressure to the POMp was about 70 kPa, showed us that a lot of gas was dissolved before centrifuging and we had to apply 70 kPa vacuum for reasonable degassing. This dissolving was enhanced by over-dimensioned pipes extending the time before degassing. The same phenomenon, but to a lesser extent we saw in an installation with three POMps in the paper machine basement. The two ones taking water from the table left more gas in the water than the one of the sealing pit, with lower inlet pressure.

The conclusion of this is that the degassing shall be done as early as possible after dewatering, before the water is pressurized. When applying vacuum assisted degassing before pressurizing we comfortably achieve a gas content that is so low that the water stays hungry for gas. That is it is under saturated and has capacity to dissolve the gas entering with the thick stock. An example of this is a 100% brown recycled paper machine where we reduced the gas content in the head-box from 4...6% to 0,2...0,3%, a reduction by 95%. In this case the thick stock share of the whole flow was as high as 30%. The client then by reducing defoamer dosage has optimised the gas at about 0,5%, which seems good enough for his needs.

A further advantage of the early degassing is that collapsing air bubbles are avoided. This reduces forming of secondary stickies and small agglomerates and improves cleanliness of the system.

When talking of gas content, it may be good to note that we have found measuring of the gas content in the process to be particularly tricky. The manual methods are very sensitive to how the sample is handled and during measuring gas transits from dissolved to free gas and vice versa. This in certain cases leads to systematic errors up to 300%.

Also the on-line gas meters are sensitive to sampling flow rates. One must therefore be cautious when comparing data and well aware of how the samples are handled and the measurement is done.

Quality

It is well known that reducing the gas content in the thin stock improves paper quality. Also we have seen this very clearly in many installations. In the recycled brown paper case mentioned above, the Scott bond improved so that the client could reduce refining and even use a lower grade raw material. In another case the burst strength increased significantly even if only the top layer of a liner board was degassed. Main reason for the strength improvement seems to be a better dewatering, where we have seen improvements up to 20% of draining capacity on the wire.

The sheet formation similarly improves by better dewatering and the defects caused by air bubbles, i.e. thin spots or pinholes disappear. When testing the high capacity (600 l/s) POMp 700 we have seen that when the POMp is running, the coater backing roll stays clean whereas without POMp it gets white of penetrating coating colour. At the same time defoamer is minimised.

These effects can, of course, be obtained also by full flow vacuum degassing. The point is that in our opinion the centrifugal degassing is efficient enough for yielding the same quality benefits.

Cleanliness, basis weight stability and less breaks are specific quality influences by the compact system. One client noted that there were less dark spots in their coloured paper after installing the degasser.

It is, however, clear that degassing cannot solve all problems. For instance we did not achieve a significant improvement of STFI-crush test for linerboard when degassing the <40% top layer only. There was, probably, gas in the base disturbing couching and decreased bulk may have offset the improved bond.

Materials efficiency

That faster grade changes, smaller volume to dump and so on save material is self evident.

Purposeful selection of the back-water, as mentioned in the ingress, not only improves process performance, but also total retention of the short circuit. An extreme of this was a mill where a new save-all filter was left unstarted because the excess back water was enough efficiently filtered through the wire at the flat boxes. In another case, involving waste paper, the amount of sludge brought to landfill could be reduced by about 100 to/month (wet).

Energy efficiency

One would suspect that adding degassers to the system would increase energy consumption. The system is, however, so much simpler, has less pumps and agitators that the energy consumption, as far as we know, has not increased. On the contrary a full POM System consumes less than a traditional one.

Especially the flexible cascade with natural counter pressure and no throttling typically saves a lot. Another energy saving feature is that once the water is pressurized in a POMp it will retain its potential energy. In a traditional system much gets lost by throttling for flow or level control.

Less expected was that improved forming should save refining power.

Reliability

A papermaking process is made of thousands of small element, which all must be absolutely reliable for the process to work. The POM System brings a few new components to the process and their dependability is critical.

We have seen that the installations, up till now, have started up extremely smoothly. At the first start, in May 1997, we had full width paper on the reel less than half an hour after starting the stock pump and no web break within 24 hours. In another typical start up we started the stock pump at 11 AM one Friday and at 1 PM the mill supervisors left for the weekend. When there have been delays, they depended on DCS or other reasons.

Of course, we have also had some teething problems, mainly mechanical ones. We have, however, purposefully resolved those and after that the POMps work very reliably. They, actually, rotate at a speed around 10 revolutions per second and are heavily built which makes them mechanically very robust. We hade some issues about sealing the bearings for avoiding water to get in, but now consider those as resolved.

In some instances there has been disturbances in the automatic control of the POMps. The POMp however is inherently stable and can also be operated manually, so even these have not caused production losses.

Summary

The compact systems have fulfilled expectations and even brought some unexpected benefits. We have seen that centrifugal degassing, when correctly implemented, is efficient enough for high quality papermaking. Compared to traditional full flow vacuum degassing it offers some additional advantages regarding cleanliness and process stability.

The process, after some mechanical teething problems, is very robust. Starts of new installations have been smooth and unproblematic. Less time losses for cleaning, grade changes and web breaks have improved machine availability. Where machine efficiency has been reported, improvement has ranged from 3% to 10%.

Contrary to what was expected, we have seen that compactness in the wet end and papermachine approach system also improves stability. In hindsight the reasons are obvious, but according last century conventional wisdom this was not obvious.

The original objective of compactness, i.e. process agility has been reached. There are, however, new bottle necks which retard results. We are convinced that these are rather easy to overcome and that the full potential of improved system agility will be reached by a normal learning curve.

Final note

We have had the privilege to work with the most open and progressive papermakers, ready to try a new approach. Even these are cautious and soundly conservative, which has led to compromises, to some extent compromising the results of the installations. It is still difficult to overcome some old habits in designing the process.

Many papermakers still stick to the stuff box and basis weight valve combination with fundamentalistic conviction. From understanding that tanks are detrimental to really eliminating them seems to be a long step and pipes are regularly over-dimensioned causing risks for dirt build-up. Open reject tanks bring dirt and air into the system and a poor level control may even disturb the system balance.

Discussing these compromises with one client, she said: "Even if you are unhappy with the compromises, consider that we are happy with the system." I would, however, like to build a system living up to our motto, "Simplify without Compromizing".

REFERENCES

1 Michael Schwarz & Al, Pulp and Paper Europe March/April 2002, p 36.

2 Paul Olof Meinander, Patents based on WO 93/23612 (25.11.1993 Gazette 1993/28): Process and apparatus for circulating backwater in a papermachine.

3 Paul Olof Meinander, Juha Lahti, Risto Nykanen, Patent application FI 20000940 and related patents.

4 Gunnar Gavelin, Malddosering med Nivalada, Svensk Papperstidning 68 (1965): 5, 150.

5 A. Esser & al, Physicochemical Mechanisms in the Treatment of Detrimental Substances - Evaluation of Treatment Efficiencies, IPW / Das Papier 1.2002, pp. 40-47.