Compact wet end systems for superior papermaking

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Abstract: Compact Wet End Systems have contributed to improving paper machine operating efficiencies by up to 10%. With Compact Wet End Systems, wire pits, silos and mechanical deaeration systems are eliminated as well as thick stock blend and machine chests. Wet end process volume reductions of up to 90% have been implemented. This paper will discuss the principles and operation of Compact Wet End Systems. Specific applications will be reviewed and discussed.

Paper machine designs have historically included large volume wet end processes as a necessary part of an efficient and productive papermaking facility. The conventional large volume processes, as shown in Figure 1, provide mixing and blending of thick stock components and control of entrained air from the forming section white waters.

When designed properly, these systems initially perform to an acceptable level. However, as production rates, operating speeds or grade structures change, performance can deteriorate. Results can include poor stock blending and increased levels of entrained air in the headbox white waters, which can negatively impact machine efficiency, productivity and quality.

Other problems associated with large volume wet end systems include:

- Low operating efficiencies with frequent grade change
- Poor attenuation of low frequency variations
- Accelerated bacteria and scale growth
- Process variability from compression of entrained air

Compact wet end systems, as shown in Figure 2, have been developed to address these operating issues and to improve wet end performance over what is available with conventional systems.

DEVELOPMENT

The principle of compact wet end systems was first introduced to the paper industry by Paul Olof Meinander at the TAPPI Papermakers Conference in 1993 [1]. As entrepreneur and founder of POM Technology, Meinander received mixed reviews of his compact wet end system concept. However, Meinander proceeded with his development work and in 1997 the first full scale system was placed in service at MD Papier, Albruck, Germany [2]. Currently, 25 systems have been delivered worldwide.

Compact wet end systems focus on reducing the volumes of conventional wet end processes to provide significant improvements in overall paper machine performance. System volume reductions based on the POM principle utilize compact stock mixing systems to replace conventional blend and machine chest and dry stock flow control technology to eliminate the stuff box. Centrifugal deaeration, cleaner systems based on the flexible cascade concept and presurized white water distribution systems minimize short circulation volumes by eliminating the wire pit, silo and vacuum deaeration system. Total wet end volume reductions of up to 90% have been implemented with compact wet end systems.

Meinander’s development and progress with compact wet end systems has not gone unnoticed in the paper industry. Today, all major manufacturers of paper machinery equipment and systems offer compact wet end systems as an effective tool for improving paper machine performance.

COMPONENTS AND PRINCIPLES OF OPERATION

Contrary to historical beliefs, large volume stock chest, machine silos and wire pits are not mandatory requirements for an efficient high speed, high quality paper machine operation. In many cases these large volume systems contribute to instability, variability and overall reduced efficiencies in the papermaking process.

Compact wet end systems employing proven components and process applications have significantly reduced process volumes and exceed the performance of conventional wet end systems. The principles employed apply to both the thick stock and white water systems as described below.

Thick stock system

Mixing and blending of single and multiple thick stock components, including associated wet end additives, is often inefficient with large volume systems. Poor agitation, flow channeling and air introduction can contribute to poor wet end performance.

Compact stock mixer

A compact wet end system solution for a poor mixing and blending problem, which maximizes system volume reductions, is the compact stock mixer [3] as shown below in Figure 3. The compact stock mixer will replace the blend and machine chest and provides significant improvements in thick stock system stability.

Multiple furnish components and appropriate wet end additives can be successfully mixed and blended in this unit. One to three minutes retention is provided to suit process needs related to chemistry, color or other process requirements. The compact stock mixer is located as close to the
headbox as practical, on the operation floor, to minimize process volumes. Where frequent grade change is an issue, the compact stock mixer will allow plug-flow operation for fast and efficient changes. Some color operations utilize the plug-flow opportunity for “on-the-fly” changes not possible with conventional systems.

**Dry stock flow control**
To insure thick stock flow stability from the compact stock mixer, dry stock flow control technologies are incorporated. Here, consistency and flow measurements are used to control the thick stock pump speed for accurate dry fiber flow to the machine. Process stability is such that the stuff box can be eliminated for direct fiber delivery to the fan or cleaner pump suction.

The compact stock mixer operates at 4% to 5% consistency and eliminates one consistency control point to the machine. With increased consistency, excess water from the machine in reduced.

**White water and thin stock system**
The short circulation loop of the paper machine wet end process must efficiently remove entrained air for recirculation to the headbox. The large volume wire pits and silos are designed with very low flow velocities to provide retention time needed for atmospheric deaeration. Often these units are ineffective in reducing the entrained air content of the white waters to acceptable levels. For many high quality, fine and newprint grades, mechanical systems must be used to achieve the required level of deaeration.

In additional to being inefficient deaerators, wire pits and silos are breeding grounds for bacteria growth with their low flow velocity designs. To maintain control, expensive biocides, slimicides and defoamers are required including regular system boilouts. The large volume systems also contribute to low frequency variations that are difficult if not impossible to effectively manage. These variations can contribute to significant MD basis weight swings on the paper machine.

Compact wet end systems address these problems and effect significant volume reductions using centrifugal deaeration, pressurized white water distribution systems and selective reuse of white water. See Figure 2.

**Centrifugal deaeration**
White water deaeration in a compact wet end system is accomplished through a centrifugal deaerator [4] shown in Figure 4.

Forming section white waters are deaerated through this unit immediately on exiting the forming section allowing the wire pit to be eliminated. The deaerated quality of the white water from the centrifugal deaerator is sufficient to replace mechanical deaerators, further reducing system volumes and providing significant energy reductions. For paper machines currently operating without deaerated white waters, compact wet end systems with the centrifugal deaerator will provide the valued benefits of improved formation and quality.

**Pressurized white water distribution**
The virtual “air free” white water is delivered by the centrifugal deaerator, under pressure, to the enclosed white water distribution system. This pressurized header transfers the deaerated white water to the respective fan and cleaner pumps and other system white water users. A stable pressure is maintained on the total system by means of an elevated overflow head tank incorporated at the top of the distribution header.

**White water segregation**
Rich and lean waters are processed separately by individual centrifugal deaerators and delivered under pressure to the distribution header. Rich waters enter the header such that they are consumed first and lean waters last. This insures lean water only flows to excess contributing significantly to reduced system losses.

The white water header is a closed, air free hydraulic system...
with higher flow velocities than a conventional white water system. Therefore, bacteria growth and scale build-up are minimized.

**Flexible cleaner arrangement**

As an additional volume reduction opportunity, compact wet end systems can incorporate a cleaner arrangement that reduces equipment sizing and energy cost while further reducing system volume. This system is shown in Figure 5.

The primary cleaners of the flexible cascade arrangement are sized for minimum headbox flow or optimum cleaning efficiency. Here, secondary accepts are recirculated in a full cascade arrangement. As headbox flow increases, secondary accepts feed forward automatically for an open cascade operation to satisfy the higher flow requirement. When flow requirements exceed the combined primary and secondary accepts flow, additional white water dilution flow is drawn from the distribution header.

Cleaners of the "Flexible Cascade" arrangement operate at optimum flow or cleaning efficiency throughout a broader range of the headbox flow. Equipment selections are minimized, horsepower requirements are reduced and control and piping systems are simplified.

**Compact seal pit**

The flat box or vacuum leg seal pit is often overlooked as an area of the papermaking process requiring improvements or upgrade. For compact wet end systems, it provides another opportunity to reduce system volume and improve paper machine performance.

Typical, seal pit operations are dirty, turbulent, large volume chest that can generate vacuum variations at the forming section. In addition, slime buildup can be difficult to manage leading to increased frequency of required thermal, mechanical and/or chemical cleaning. With the compact wet end system approach, a compact, pre-fabricated seal pit is provided. See Figure 6.

This unit allows each vacuum leg to be sealed individually and operators can view the performance of each table element and make adjustments as may be necessary. The individual seal chambers can be easily fitted with a “V-notch weir” to allow direct and simple flow measure and sampling from each vacuum device. Figure 7, is an operating compact seal pit unit.

**RESULTS**

After the first compact wet end system startup in 1997, it became quickly apparent that performance and additional opportunities for improvement would be much greater than anticipated. Benefits that have been reported to date include:

- 60% reduction in grade change time
- 75% reduction in wet end breaks
- 50% reduction in wash-up frequency
- 25% reduction in energy consumption
- 20% improvement in sheet formation
- 99.5+% "air-free" white water
- 10% operating efficiency improvement

A discussion of these improvements and opportunities [5] include:

**Reduced grade change time**

Paper machines incorporating compact wet end systems have reduced grade change time on average by 60%. Reduced process volumes allow thick stock and white water systems to purge quickly, minimizing off-quality production and transition time.

The improvements in change time apply to simple basis weight changes or complete color and/or wet end chemistry changes. One installation reported simple basis weight changes were improved by 65% where a color producer reduced grade-to-grade change time by greater than 80%. Many specialty machines find downtime for wash-up between grade changes are no longer required and major production changes are now made on the fly.

**Reduced wet end breaks**

Compact wet end systems have disproved the age-old assumption that large volume processes are required for maintaining a stable system. Whether in thick stock or white water systems, large volume systems can generate low frequency variations that are difficult if not impossible to attenuate. These variations usually contribute to significant MD weight swings.

With the minimum retention time in a compact stock mixer and the higher flow velocities of the hydraulic white water distribution system, low frequency variations are avoided. The elevated overflow head tank further enhances the white water system stability with the optimum in pressure control for minimizing variability.

Stable white water systems are the key to a stable wet end. One
Compact wet end system installation reported an 80% reduction in wet end breaks due to improved stability. Other users note MD variation reduced significantly with two sigma reductions of up to 50%.

**Reduced wash-up frequency**
White water system cleanliness is affected by flow velocities and entrained air content. Wire pits and silos maintain low flow rates by design, allowing stagnant areas to exist which support bacteria growth. Air in the white waters further enhances bacteria growth requiring use of biocides, slimicides and defoamers for control.

Compact wet end systems remove entrained air immediately on exiting the forming section; therefore air is not introduced to the downstream system. Also, high flow velocities in the hydraulic white water system prevent stagnate areas and dirt accumulation. Each of these contributes to improved system cleanliness with a compact wet end system.

The improved cleanliness reduces boil out frequency and chemical additions needed for bacteria and slime control. The boil out frequency on one machine improved by 50%; 6 week cycles for system boil outs was increased to 12 weeks with a compact wet end system. Chemical usage was also reduced with defoamer consumption down by 50% and biocide reductions of 75%. Boil out chemical requirements are less with the reduced volumes and boil outs are more effective.

**Reduced energy consumption**
Many components of conventional wet end systems can be eliminated with a compact system. Blend and machine chests, white water wire pits, silos, vacuum deaeration systems and water storage tanks have been deleted.

The elimination of these components has resulted in energy savings of up to 25%. Combined with these savings is the increased efficiencies gained from the pressurized white water distribution system. Here, the distribution system supplies white water to all system users at higher suction pressures for increased pump performance and improved pumping stability.

**Improved sheet formation**
Removing air from the short circulation white waters increases drainage in the forming section. With increased drainage, lower headbox consistencies can be obtained. Lower headbox consistencies will improve formation and therefore quality. All compact wet end system users report improved formation and in one case slice flows were increased by 20%.

**Air-free white water**
The management of entrained air in the wet end white waters is critical with compact wet end systems. Centrifugal deaeration has proven to be effective in removing entrained air from the short circulation waters. The virtually air free white waters produced by these centrifugal deaeration units rival more expensive vacuum systems.

One compact wet end installation replaced their vacuum deaeration system with centrifugal deaeration for equal to better results. Other installations report entrained air levels as low as 0.1%.

**Improved operating efficiency**
Each of the above results from currently operating compact wet end systems improve paper machine operating efficiency. Combined, they can significantly reduce bottom line cost. To date, compact wet end system users have reported overall efficiency improvements of 2.5% up to more than 10% as compared to earlier operation with conventional systems.

**CONCLUSION**
Of the many compact wet end systems in operation to day, no installation has elected to go back to the old (conventional) way of operating the wet end of their paper machine. Once the magnitude of the benefits has been realized, the operating units only look forward to additional opportunities.

Many different grades employ compact wet end systems including coating base stock, specialty fine papers, decorative laminates, core stock, photographic paper, recycled linerboard and medium.

Compact wet end systems improve paper machine wet end operation as compared to conventional large volume systems. Utilizing compact stock mixing, white water centrifugal deaeration and pressurized white water distribution systems, wet end processes are extremely responsive to operational demands while maintaining stable operations.

With deaeration of white waters immediately off the forming section, systems operate much cleaner than conventional ones and pulsations from air in the process are avoided. The pressurized hydraulic white water distribution system provides segregation of rich verses lean white waters for 100% recycle of rich waters. Only the leanest white waters to excess significantly reducing system loses to sewer.

Compact wet end systems have been successfully applied for new greenfield installations as well as cost-effective alternatives to conventional upgrade options. When considering your next upgrade or a new installation, compact wet end systems should not be overlooked. This proven, reduced volume approach has established itself as the future in paper machine wet end technology.

**LITERATURE**

**Résumé**:
Les systèmes compacts pour la partie humide ont permis d’améliorer de jusqu’à 10 % le gain de rendement de la machine. Grâce aux systèmes compacts pour la partie humide, les fosses sous toile, les silos et les systèmes de désaération mécanique sont éliminés, ainsi que les cuviers de machine et de mélange de la pâte épaisse. Une réduction de jusqu’à 90 % du volume à la partie humide a été obtenue. La présente communication discute des principes et de l’exploitation des systèmes compacts à la partie humide. Des applications particulières sont évaluées et font l’objet de discussion.


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