New Cationic Microparticle System Improves Retention, Quality on Latest Generation Paper Machines

System combines advanced properties and cost-efficiency for fine paper retention on machines running at high speeds incorporating twin wire and gap former technology. by Kimmo Strengell

The conversion of most fine paper machines to calcium carbonate loading is now almost complete. A major driving force behind this trend has been the demand for brighter, whiter neutral papers. However, the envisioned increase in loading levels in excess of 30% has not yet been realized. Despite escalating costs, paper machine runnability and quality issues have outweighed the economic advantages of increased filler levels.

Furthermore, the speed of modern paper machines has increased dramatically. The higher shear forces now encountered have placed increasing importance on the retention system. These forces make more demands on the wet web. Maintaining good retention in this extreme environment is difficult, placing great demands on retention systems and control of wet end chemistry.

Obviously there must be a balance between the sheet properties required and the type and quantity of filler used. Higher filler content can only be achieved if paper quality and machine runnability are satisfactory (see Wet End Filler Content side box). In this regard, a new cationic microparticle retention system has been designed to not only improve retention but also formation and paper quality.

Wet End Filler Content

Key factors when choosing filler include:
- Particle size
- Surface chemistry
- Ash content required.

A mill must balance these requirements with the effects on paper quality, including:
- Formation
- Surface properties
- Printability
- Smoothness
- Opacity
- Brightness
- Porosity
- Strength (tear, tensile, burst)
- Handle

… and the effects on wet end chemistry, which include:
- Runnability
- Retention
- Dewatering/ drying
- Sizing
- System Charge
- IPPC environmental discharge
Filler and Fines Retention Mechanisms

The mechanism for filler and fines retention depends on mechanical entrapment and colloidal aggregation. The relative contribution of these two mechanisms depends on many factors, such as:

- Basis weight
- Machine speed
- Headbox consistency
- Forming section configuration
- Wire type, etc.

Mechanical entrapment involves catching the filler in the matrix of fibers as the web forms on the wire. As the fiber mat builds, more filler is caught in the denser network, which provides more available points of entrapment.

In modern high-speed paper machines, such as twin-wire gap formers, for example, the contribution of mechanical entrapment for filler retention is significantly reduced. The importance of colloidal aggregation therefore increases. Both coagulation and flocculation processes are involved. Figure 1 depicts the hard floc reversion mechanism.

Dewatering in this stationary element is due to pressure created by fabric tension as the forming fabrics pass over the elements. A pressure pulse is created each time the mat passes over a blade.

After each pressure pulse, the forming mat expands and absorbs water and fines/fillers from the furnish suspension. Then, when the next vacuum pulse occurs, the mat is compressed quickly and the fines/fillers move in the direction of water flow. The net result is reduced retention in the web. The greater the pressure and the lower the consistency, the lower will be the ultimate retention.

Over the years, many companies have tried to modify their microparticle retention systems to accommodate these high shear and turbulent conditions as described in the above gap former system.

New Retention System

Fennosil A is a new retention system developed and evaluated extensively by Kemira Chemicals in laboratory studies as well as pilot machine and full scale trials, especially for the latest generation of paper machines. This system is particularly suited to retention on fine paper machines producing both uncoated and coated fine papers.

The system is comprised of two components—cationic Fennosil FS 158 microparticles and Fennopol retention polymer. Kemira Chemicals produces both components, which means that the properties of either component can be tailored to specific customer needs.

Compared with other microparticle retention systems, the mechanism of this system is extremely different, in terms of chemicals used, dosing order, and floc formation.

Although Fennosil FS 158 solution has a net cationic charge, this low-molecular-weight polymer has two-charge characteristics (amphoteric). Fennosil FS 158 is added first, before the shear point. The anionic microparticles are strongly attached to the polymer structure, which is carrying the cationic charge.

Adding this product to the papermaking system will form small and soft flocs through the patching model of coagulation mechanism. The positive sites are attached and adsorbed to fine and fiber surfaces by electrostatic bonding, while the anionic microparticles can interact with the positively charged
(by cationic starch or FS 158) adjacent fines or fibers.

Formation of soft flocs with this retention system is done before the shear point, and can be adjusted by altering Fennosil FS 158 dosages. Other microparticle retention systems, using cationic PAM before the shear point, rely on the hard floc reversion mechanism (Figure 1) to form soft flocs.

A Fennosil A program can be fitted for the need of a specific paper machine construction, furnish, and speed to finally run with acceptable retention level and superior formation. Matching of the Fennosil A program is done by the selection of chemicals applied. Obviously, the higher the shear, the more resistance against shear is needed.

Anionic PAM polymer is added after the shear point to form denser and stronger flocs. The cationic sites on soft flocs will serve as anchor points for the bridging flocculation mechanism. Fennosil A flocs are irreversible, unlike the conventional anionic microparticle retention systems. Conventional anionic microparticle systems re-form the flocs immediately upon reduction of the shear level. This is the main reason Fennosil A results in improved sheet formation over traditional microparticle systems.

![Figure 2. Fennosil retention mechanism for soft floc formation (Ref: Leo Neimo, Papermaking Science and Technology, Book 4, 1999).](image)

Figure 2 depicts the Fennosil retention mechanism for soft floc formation.

Fines or filler flocculation occurs in stock preparation, the approach flow system, and the headbox. Once formed, a floc's ability to resist disruption by shear and turbulence in a paper machine headbox and forming section is a determining factor in its retention. If flocs are sensitive to these hydrodynamic forces, they will break down, pass through the forming fabrics, and accumulate in the white water.

Laboratory study, prior to a full-scale machine trial, is carried out to evaluate various retention systems in a Britt Dynamic Drainage Jar (DDJ), Dynamic Drainage Analyzer (DDA), and Moving Belt Former (MBF) unit (see Moving Belt Former sidebox). The MBF unit is a useful tool for direct measurement of retention under turbulent conditions without interference from filtration or the fiber mat formation mechanism. It provides turbulence and shear forces (via the stirrer) that are always present during the papermaking process.

**The Moving Belt Former (MBF)**

Helsinki University of Technology developed the Moving Belt Former (previously known as the moving belt drainage tester). MBF is designed to simulate dewatering over the suction boxes up to the couch roll. It can be used to compare various retention systems. MBF operates with a batch principle. In the “closing the water cycle” test, the degree of backwater closure can be precisely regulated by recycling the filtrate of a previous test into the next test. Each test yields a sheet, thus allowing the opportunity to measure paper technical properties such as formation.

Solids content of the sheet in the MBF device ranges from 10%-25%, which corresponds to the solids content at the end of the wire section on a paper machine. General characteristics of an MBF operation include:

- Computer controlled
- High speed machine
- Suction box simulation
- Frequency replication
- Recycled backwater
- Sheet 10%-25% consistency
- Formation measurement
Case Studies

The following case studies outline the application and results of Fennosil programs at two separate paper mills:

MILL NO. 1

Paper Machine: Valmet Speedformer M B (twin-wire gap former). Operating speed of 1,150 m/min (design 1,200 m/min)

Paper products: Copy paper

Furnish: 65% HW, 35% SW, PCC filler, starch 8 kg/ton

Targets maintained:

- Total retention: 65%
- Filler retention: 30-35%
- Ash content: 20% minimum

Objective:

Maintain retention but improve paper properties

Benefits of Fennosil program:

- Improved formation (Beta Ambertech and CTP)
- Lower porosity
- More uniform filler distribution
- Improved smoothness
- Improved runnability
- Better release from center press roll to first drier
- Increased vacuum at suction boxes
- Reduced COD (improved starch retention reduced COD by 5-20%).

MILL NO. 2

Paper machine: Valmet hybrid former (Sym former R). Operating speed of 700-900 m/min (1,000 m/min maximum)

Paper products:

Copy paper, specialities, envelope, ream paper

Furnish:

65% HW, 35% SW, PCC filler, starch 10 kg/ton

Targets maintained:

- Total retention: 70%
- Filler retention: 40-45%
- Paper ash content: 20% minimum

Objectives:

- Soft floc formation
- Formation improvement

Benefits of Fennosil program:

- Soft floc formation
- Improved formation (Beta Ambertech and CTP 10%-15% better).

Conclusions

Filler can only be retained by chemical means. Papemaker’s require higher filler retentions without compromising paper quality. In fact, formation and smoothness must be improved to meet the demands of new high speed printing processes.

Kemira Chemicals’ new Fennosil A retention program provides:

- Adjustable soft floc formation
- Dense and stronger flocs
- Adjustable drainage and formation
- Lowering of initial dewatering
- Excellent runnability
- Excellent formation

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References: