Advanced Retention and Drainage Technology Offers Improved Performance and Operational Cost Savings

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ABSTRACT

Papermaking has changed remarkably during the past 20 years, creating huge pressures on retention and drainage programs. During this time, technology has advanced from single PAM flocculants to inorganic microparticle-based programs and then to micropolymer-based programs. In today's evolving fine paper market, retention and drainage programs have to meet increased demands in many areas, such as increased speed, GAP formers, dilution headboxes, higher ash levels, reduced furnish quality, lower cost, and increased machine efficiency.

Hercules recently introduced a new technology that offers performance and stability improvements and operational cost savings as compared to existing advanced technologies. PerForm® SP Advanced Retention and Drainage Technology consists of a family of products based on a structured organic particulate that offers papermakers the ultimate flexibility for management of wet end chemistry.

This paper compares PerForm® SP Advanced Retention and Drainage Technology to inorganic microparticle and micropolymer technologies and provides multiple case histories on machines that demonstrate the benefits of the technology. In these case histories, the PerForm SP is shown to provide improved retention and drainage that results in improved performance and operational cost savings to the mill.

INTRODUCTION

During the past 20 years a series of advanced retention and drainage technologies have been developed to improve fines and filler retention, drainage, and floc type. With the introduction of inorganic microparticles (silica and bentonite), the papermaker gained the ability to consistently develop micro flocs, which in turn improved sheet appearance and drainage. Silica offered the papermaker the first major advancement in performance by using microflocs to achieve high levels of drainage without sacrificing formation. Bentonite clay and cationic polyacrylamide offered the high levels of drainage often experienced with silica but provided retention capabilities that were critical during the North American conversion of fine paper to alkaline conditions. Micropolymer technology provided the high levels of retention and drainage often seen with silica and bentonite but in a typically more controllable, lower cost program.

PerForm® SP Advanced Retention and Drainage Technology is the latest advancement. This technology, which was developed by Hercules and has patents pending, builds on the capabilities of the previous technologies and offers high retention and drainage performance with a controllable, stable response that allows the papermaker to reduce the operating cost of the machine.

ADVANCED RETENTION AND DRAINAGE TECHNOLOGY

PerForm® SP Advanced Retention and Drainage Technology is an innovative technology that provides superior retention, drainage, and formation for a variety of neutral and alkaline paper grades. An overview of the technology, as well as a discussion of its mode of action and application, follows.

Technology Overview

PerForm® SP Advanced Retention and Drainage Technology is a family of products based on an anionic, organic particulate with a three-dimensional structure. The high charge and small size of this uniquely structured particulate make it very efficient at delivering high performance on the machine. Different PerForm® SP products are available for use in a variety of grades, including printing and writing and tissue/towel. The technology also delivers benefits to other grades of paper, including white top board, recycled packaging board, and bleached board.

Mode of Action

The PerForm® SP particulate interacts with the cationic sites on fibers, fines, and fillers to form microflocs. These microflocs provide retention but enable higher

levels of drainage compared to traditional flocculants that create larger, more difficult to dry flocs. Cationic sites are commonly provided by additives such as alum, PAC (polyaluminum chloride), cationic flocculants, cationic starch, and/or polyamide wet strength resins. The sites that have the strongest influence on the PerForm® SP particulate are created by sources of aluminum, such as alum and PAC. Low levels of these additives used in conjunction with the PerForm® SP particulate provide high levels of retention and drainage. In some programs, cationic flocculants are used in addition to or in place of alum or PAC to provide additional cationic sites to boost performance.

Application Technology

Program components that can be used with PerForm® SP products include either alum or PAC and either an anionic polyacrylamide (APAM) flocculant or cationic polyacrylamide (CPAM) flocculant. These components are selected based on the existing system additives and which chemistries are the most effective in that system. The PerForm® SP product is typically the last retention component added to the thin stock and is fed before or after the machine screen, depending on the needs of the system. The alum or PAC is fed prior to the PerForm® SP product and in most cases is added before the machine screen or fan pump. Whenever a flocculant is used, APAM can be fed before the screen or it can be mixed with the PerForm® SP product and fed after the screen; CPAM can be fed before the screen or before the fan pump.

TECHNOLOGY COMPARISON

Since the first product's introduction four years ago, PerForm® SP technology, due to its broad application and effectiveness, has been widely accepted. The knowledge and experience gained from trials and many ongoing applications indicate how the PerForm® SP technology compares to silica-based, bentonite-based, and micropolymer-based programs in general. Examining performance characteristics is helpful when comparing these technologies. The following discusses these characteristics and compares performance.

Effect of Conductivity

The conductivity of the stock system impacts the performance of many types of retention programs. Increasing conductivity and ion content of the water can shield the charge of most polymers, reducing the hydrodynamic volume or effective molecular weight of the polymer, resulting in reduced effectiveness [1]. Experience has shown the PerForm® SP particulate to be more tolerant to variable and higher conductivity levels than either traditional micropolymers (see Figure 1) or inorganic microparticle programs that are dependent on organic polymers for performance. The high tolerance minimizes the negative impact on retention and drainage performance under these conditions.

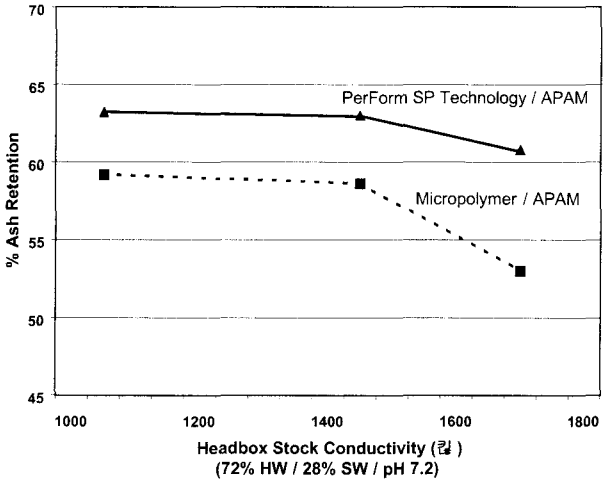

Figure 1 – Effect of conductivity

The mechanism utilized to achieve the unique structure of the PerForm® SP particulate allows the particulate to maintain its structural integrity in variable and higher conductivity systems, which can compress the structure of micropolymers to a greater degree. Bentonite and silica are solid particles that are not compressed under high conductivity, but the polymeric flocculants commonly used in these programs are susceptible to the negative side effects of higher conductivity systems.

Charge Demand Sensitivity

The stable structure and strong reactivity with sources of aluminum or flocculants make the PerForm® SP program more robust and less sensitive to the charge demand of the system. This is particularly evident when compared to the silica-based programs. This allows the PerForm® SP program to be less sensitive to changes in the system charge demand and reduces the need for costly coagulants to adjust the charge of the system.

Dosage Response

Some inorganic microparticle programs have a non-linear dosage response curve and therefore are fed at higher rates than necessary to avoid operating in a range where making small feedrate adjustments cause major, unpredictable changes. The PerForm® SP program has proven its ability to provide retention and drainage with a controllable, linear dosage response curve that benefits the stability of the machine. Variability in the wet end conditions will not dramatically affect drainage, which could impact the sheet quality and machine operation. This controllability has often resulted in comments from machine operators that the PerForm® SP program is easy-to-use compared to the more sensitive, inorganic microparticle programs.

Filler Retention

The performance characteristic that often distinguishes the PerForm® SP program is its high level of filler retention. The filler retention capability exceeds that of micropolymer programs, which is typically superior to inorganic microparticle programs. High filler retention can improve optical properties and yield a cleaner wet end at higher filler levels.

Drainage

PerForm® SP programs provide higher levels of controllable drainage than those seen with inorganic microparticle programs and micropolymer programs. These high levels of drainage can be utilized to reduce headbox consistency for improved formation, to increase refining, and to increase machine speed for greater productivity.

Additive Compatibility

The compatibility of PerForm® SP products with other additives provides flexibility and the ability to optimize many of the other additives in the wet end. The reactivity of PerForm® SP products with alum, PAC, CPAM, and APAM allows customization of the program for each machine system, thereby providing the maximum benefit at the lowest cost.

The broad compatibility of PerForm® SP products has been demonstrated with wet end additives, such as starch and optical brightening agents (OBAs). The products perform well with many types of wet end starch, allowing the papermaker to utilize their current starch or to choose one based on traditional starch criteria, not based on what the retention program requires. This, in many cases, allows for the use of less expensive starches while still maintaining a high performance retention program.

The ability to effectively combine PerForm® SP products with different flocculant types allows the program to be more compatible with OBAs used in the wet end, thereby resulting in lower OBA and retention aid costs. This compatibility is most apparent when compared to a bentonite/CPAM program, in which bentonite can interfere with OBA performance and the OBA can interfere with CPAM performance.

PerForm® SP products are also compatible with polyamide wet strength resins. In grades using these resins, the products enhance their performance, resulting in higher strength tests or reduction in resin usage.

Impact on Operating Cost

Many factors affect a machine's overall operating cost, such as the cost of labor, fiber, additives, and energy. A high performance retention and drainage program can impact some of these areas and should be considered when comparing programs. Compared to inorganic microparticle programs and micropolymer programs, PerForm® SP programs offer the ability to:

- maintain high performance and stability in variable and harsh conditions.
- maintain a clean wet end.
- optimize optical properties through high levels of filler retention.
- work with the other additives to reduce overall wet end chemical costs.

A comparison of these performance characteristics is summarized in Table I.

TABLE I – COMPARISON OF PERFORMANCE CHARACTERISTICS

	Inorganic Microparticle Technology	Micropolymer Technology	PerForm® SP Technology
Effect of Conductivity	Some Tolerance	Least Tolerance	Some Tolerance
Charge Demand Sensitivity	Sensitive to Changes	Robust	Robust
Dosage Response	Not Always Linear	Linear	Linear
Filler Retention	Good	Better	Best
Drainage	Good	Good	Good
Additive Compatibility	Selective	Good	Good
Impact on Operating Cost	Good	Better	Best

CASE HISTORIES

Commercial applications have demonstrated the benefits of PerForm® SP Advanced Retention and Drainage Technology. The following case histories show the ability of the technology to increase filler retention, to improve drainage, to increase retention stability, and to improve machine operating costs.

Mill A

A North American alkaline mill producing offset and copy paper grades at speeds of approximately 920 mpm was interested in upgrading the performance of its retention program.

This mill maintained tight control of the silo consistency to keep the wet end clean and the sheet defects low. The existing APAM/micropolymer program provided good retention but could not always achieve the desired retention. The mill was also looking for increased ash retention on some new, lighter-weight grades that were now being run. Overall, the mill wanted to increase performance without increasing costs.

The mill evaluated two approaches to improve its retention program: APAM with colloidal silica and an extended evaluation using CPAM with colloidal

borosilicate. These approaches resulted in similar drainage but lower ash retention and higher program cost than the micropolymer program. They also were more sensitive to system variations, which made them harder to control.

Hercules conducted lab tests and designed a program using PerForm® SP technology and APAM. A short trial was run to verify the results achieved in the lab and the machine was then converted to this new program, which offered higher ash retention (see Figure 2) at a lower flocculant feedrate with improved stability and better control of the silo consistency. These benefits were all achieved with an easy-to-use, controllable program that responds predictably to adjustments. Due to the high performance of PerForm® SP technology, these improvements were achieved with a lower overall feedrate, thereby providing the mill with a lower-cost, more efficient retention program.

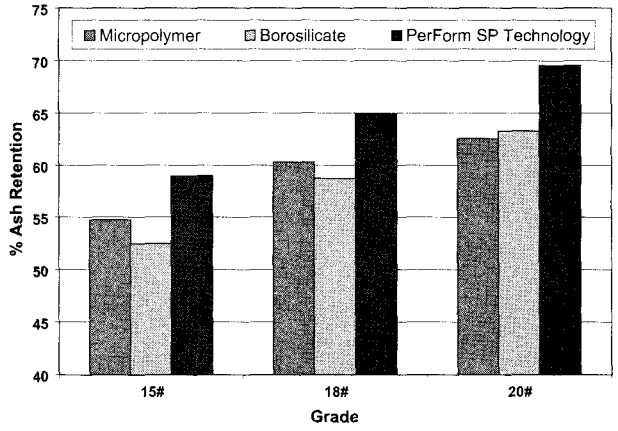

Figure 2 – Comparison of ash retention

Mill B

A Nordic alkaline fine paper machine producing copy paper grades at 1,200 mpm converted from a CPAM/bentonite program to a CPAM/micropolymer program. At that time the mill experienced improved performance and increased first pass retention and first pass ash retention by 5%, improved formation at lower refining levels, and improved drainage at the top wire former by 30%. A positive impact on the OBA performance was also observed, resulting in a significant reduction in OBA and dye usage compared to the CPAM/bentonite program. These improvements resulted in an operating cost savings of more than €1,000 per day.

To further improve program performance, the mill converted to a program using PerForm® SP technology and CPAM. Using closed loop control on the CPAM portion of the program, the conversion to the PerForm® SP product demonstrated improved performance by reducing CPAM usage even when the feedrate of the PerForm® SP product was 10% lower than the micropolymer. In addition to reducing the feedrates, the ash retention improved and the trends monitored on the DCS (distributive control system) showed reduced variability over time due to system changes. Overall, the PerForm® SP program provided better performance and greater stability at a lower operating cost.

Mill C

A North American alkaline fine paper mill producing copy paper on its Gap former machine wanted to improve on its existing APAM and micropolymer program. At speeds greater than 1,190 mpm, the demand on the retention program was higher and the current program was not always responsive enough to control tray solids to the desired targets. The machine also had targeted a higher sheet ash and maintaining a high FPAR was important to achieving the targets while maintaining a clean machine and good runnability.

To address the needs of the mill, Hercules recommended replacing the micropolymer program with PerForm® SP technology. During the trial, the mill achieved the desired control of the tray solids while reducing the cost of the retention program through feedrate reduction. The PerForm® SP trial application also provided a five point increase in CaCO3 retention at the same tray solids target as the old program.

After the machine was permanently converted to the PerForm® SP program, sheet ash increased to the targeted 17%, brightness levels were increased to 92 with the use of an OBA, speed increased to record levels (increasing from 1,220 mpm to 1,340 mpm sustained with a 1,371 mpm maximum), and machine efficiency increased from 86% to 92%. The PerForm® SP program not only delivered better performance at a lower program cost but also helped contribute to a significant reduction in overall operating cost through these major achievements.

Mill D

A North American fine paper mill producing specialty text and opaque grades was having difficulty developing a grade requiring 25% to 27% sheet ash using an APAM/borosilicate program. This program did not provide sufficient ash retention above a 22% sheet ash and resulted in high white water solids and poor clarifier performance.

Hercules recommended a program utilizing APAM and PerForm® SP technology to achieve the higher ash retention levels needed to meet the mill's target ash goal for the new grade. The higher ash retention and resulting lower PCC usage (see Figure 3) was achieved at a lower program cost than the borosilicate program and delivered additional operational cost savings to the mill. These savings include a reduction in fiber costs of $10 per ton, a 50% reduction in clarifier polymer costs, a 20% to 50%

reduction in AKD size usage (see Figure 4), and an improvement in drainage.

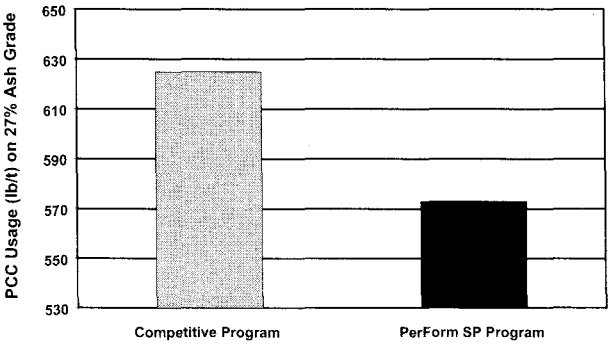

Figure 3 – Comparison of PCC usage

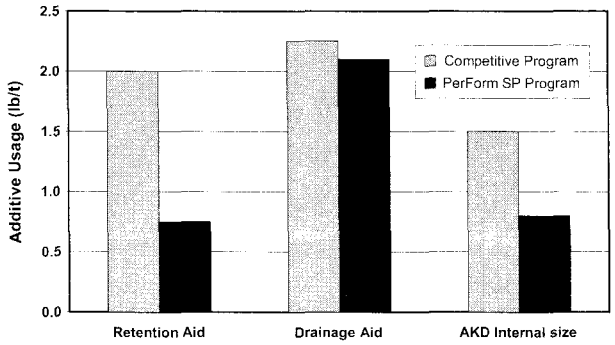

Figure 4 – Comparison of additive usage

CONCLUSION

PerForm® SP Advanced Retention and Drainage Technology provides papermakers with the capability to achieve high filler retention, good drainage, and stable performance. The high performance, flexibility, and ability to reduce the operating cost of the machine have allowed the technology to effectively replace silica, bentonite, and micropolymer programs in many paper grades.

REFERENCES

1. Mike Schuster, "Charge Measurement – What It Means and How to Use It," *TAPPI Wet End Short Course*, 1994.