CORE SHELL™: THE LATEST INNOVATION IN POLYMER TECHNOLOGY FOR THE PAPER INDUSTRY

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INTRODUCTION

A wide range of chemicals is currently being used as wet-end additives in papermaking to efficiently enhance the retention of fines and filler and to improve the removal of water from the papermaking stock.

The first retention and drainage programs were based on a single polymeric flocculant component. Early in the 1970s, Nalco pioneered the use of emulsion polymers in papermaking applications [1]. Dual polymer programs utilizing cationic coagulants with either anionic or cationic flocculants were introduced later. However, many of the original single flocculant programs were actually dual polymer programs, because of the presence of other cationic additives such as alum, cationic starches, and wet-end strength agents in papermaking systems.

Retention and drainage programs that utilize an inorganic microparticle component such as colloidal silica and bentonite were first described in the 1980s [2,3], although their use in papermaking applications became more widespread in the 1990s. Microparticle programs allow the papermaker to achieve a balance between retention, drainage, and sheet formation. This is why, in the last decade, most specialty chemical companies have focused their developments on these multi-component systems.

Ondeo Nalco was among the first to recognize that the efficiency of the microparticle program depends not only on the microparticle component, but also on the type of flocculant used in combination [4-6]. Based on this knowledge, Ondeo Nalco has continued to focus the development on both new microparticle technologies and new flocculant chemistries. In 1998, Ondeo Nalco launched *Ultra* POSITEK®, a microparticle program utilizing a colloidal borosilicate microparticle [7-9]. Examples of new flocculant technologies developed in the last five years include the ULTIMER® product line of oil-free flocculants that can be dosed on-line and trash resistant polymers, designed for some of the more contaminated systems.

CORE SHELL™ POLYMER TECHNOLOGY

Core Shell™ is the newest liquid polymer technology developed by Ondeo Nalco. "Core Shell" refers to the patented reaction and manufacturing process used to produce the polymer. The new manufacturing process and polymer chemistry allows for unprecedented and simultaneous achievement of higher molecular weight and solids level.

The unique chemistry of the polymer obtained from this manufacturing process allows for fast dissolution and a higher degree of polymer extension, thus improving both process and polymer application effectiveness and efficiency. Core Shell liquid polymers also demonstrate unique performance capabilities when used in papermaking systems as a single component or in combination with microparticles.

Laboratory data, and the first results from commercial paper machine applications, have demonstrated significant performance advantages of the new polymer technology compared to conventional emulsion and dry polymers. The present paper summarizes the results of these studies with emphasis on the key benefits derived by implementation of Core Shell polymers in paper and board applications:

- Improved on-machine retention of fines and fillers compared to conventional dry and emulsion polymers
- Higher floc-shear resistance without large floc formation – superior performance on faster paper machines
- Enhanced performance of borosilicate microparticle programs
- Ability to perform as a single flocculant program
- Drainage and formation improvements
- Suitability for on-line applications

LABORATORY EVALUATIONS

Improved On-Machine Retention of Fines and Fillers Compared to Conventional Dry and Emulsion Polymers

Core Shell high performance polymers produce improved fine and filler retention compared to conventional dry and emulsion polymers. The ash retention values presented in Figure 1 were collected in a fine paper furnish by using Dynamic Drainage Jar (DDJ) testing techniques. For all the data reported in the graph, the retention program was a combination of a flocculant with a fixed dose of colloidal borosilicate nanoparticle (0.5 kg/T). Addition of Core Shell polymer to the furnish improved the ash retention by 34 %, compared to the one obtained with the dry polymer used in the mill. The retention produced with Core Shell polymer was also significantly higher than the one obtained with a series of emulsion polymers with cationic charge density over the 10-30 mol % range.

Additional retention data were collected in a coated fine paper furnish, by using Scanning Laser Microscopy (SLM). The SLM instrument is a flocculation analyzer that uses a highly focused laser beam and back-scattered geometry as a principle of operation. One of the instrument outputs, the Mean Chord Length (MCL, or mean particle size), is a parameter that can be monitored with time and can be used to compare the ability of retention programs in promoting particle aggregation [10-11]. The maximum Mean Chord Length achieved after flocculant addition or Change in Mean Chord Length is proportional to first pass retention data obtained by using the DDJ. As shown in Figure 2, retention could significantly be improved by using the Core Shell technology compared to the dry polymer used in this mill. In addition, the graph shows that the performance of the dry polymer reaches a plateau at 0.25 kg/T, whereas for Core Shell technology, retention significantly increases upon increasing the dose from 0.25 to 0.5 kg/T.

Higher Floc Shear Resistance – Superior Performance on Faster Paper Machines

In modern papermaking, the introduction of high turbulence hydraulic headboxes, different types of twin-wire formers, and the trend towards higher speed paper machines, have increased the need for retention chemicals able to produce shear resistance flocs. A retention program increasing floc shear resistance when applied under high turbulence conditions would still be able to efficiently enhance fines and filler retention.

The shear resistance of flocs produced by Core Shell polymers was investigated by SLM. Figure 3 shows changes with time in Mean Chord Length of a papermaking furnish treated with Core Shell vs. changes produced upon addition of a dry polymer. The furnish was an acid LWC furnish from a mill producing paper of over the grammage range of 48-65 g/m^2.

By adding 0.25 kg/T of Core Shell or dry polymer, a comparable initial increase of floc size (Change in Mean Chord Length) was obtained (Figure 3). However, the initial floc size produced by the dry polymer decayed much more rapidly than in the case of the Core Shell polymer. These data show that Core Shell polymers produce a floc having a higher floc shear resistance. The floc shear resistance decreases further for the dry polymer upon increasing its dose to 0.5 kg/T, whereas the flocs created with Core Shell become even more shear-stable at this higher dose.

Ability to Perform as a Single Flocculant Program

Core Shell polymers increase the floc shear resistance, which is typically a characteristic of microparticle systems. As a result, the new polymer technology can be used to replace a flocculant-microparticle program in cases where a single flocculant program is preferred for simplicity. The Core Shell SLM data of Figure 3 are compared in Figure 4 to the ones collected in the same furnish with addition of a combination of a dry polymer plus bentonite microparticle. As evident in Figure 4, the Core Shell polymer produces a higher floc-shear resistance than the bentonite-based microparticle program.

In addition, drainage data were collected in the same furnish using a vacuum drainage apparatus. The drainage produced by Core Shell alone (volume drained in three-second time) was significantly higher than the one produced by the microparticle program (Figure 5).

Enhanced Performance of a Borosilicate Microparticle Program

The performance of a microparticle program is strongly linked to the flocculant performance. Figure 6 clearly illustrates this point. SLM data were collected in an acid GW furnish with addition of a flocculant, followed by two different types of microparticles. It appears that in this system, the flocculant must induce a chord length change of 30-40 microns before the microparticle starts to show a response. As shown by the next example, the microparticle activity can be significantly improved by using a flocculation program with enhanced performance such as Core Shell polymers.

Figure 7 shows the Mean Chord Length vs. time profile obtained after addition of a flocculant and borosilicate microparticle to a LWC furnish from another mill, producing paper over the grammage range of 51-70 g/m^2. Different flocculants were added to the furnish at a fixed dose of 0.25 kg/T in combination with borosilicate microparticle at a dose of 0.45 or 0.7 kg/T. Change in mean chord length values for the microparticle peak

(Figure 8) were used to evaluate the reflocculation ability by the microparticle. The data in Figure 8 show that the reflocculation ability of borosilicate was higher when the microparticle was used in combination with Core Shell polymers, rather than with conventional low or medium charged emulsion polymers. In other words, Core Shell boosts the performance of the borosilicate microparticle program.

ON-LINE FEEDING

Due to their high and fast solubility, Core Shell polymers can be applied on-line, directly from the preparation unit, with no need for aging and storage tanks for the intermediate solution. A special feeder has been designed for this type of application, with extra security and flow measurement tools for automation purposes. Core Shell polymers have already been fed on-line to different paper machines producing recycled board and printing paper.

CASE STUDIES

Case Study 1 – Recycled board

Overall first pass retention level and retention stability are two parameters that have important influence on the cleanliness and runnability of the board machine. Any new technology should address the importance of having a robust response to variations in furnish quality.

Situation

Core Shell polymer was applied in a South European recycled linerboard machine, replacing a dual polymer program – coagulant and flocculant. The role of the coagulant was to enhance the performance of the flocculant, given the quite high levels of anionic trash present in the system. The machine is a two-ply configuration with a highly closed water system, producing basis weight over the range of 105 to 175 g/m^2.

Program

Core Shell polymer was applied as a single flocculant program, replacing the dual system. Core Shell flocculant was added after the screen at a dosage of 0.9 kg/T based on product in the top layer, and 0.45 kg/T based on product in the bottom layer.

Results

The higher efficiency and flexibility of the Core Shell polymer allowed application of a single product with improved results. The solids content of headbox and white water were considerably reduced in both plies. White water consistency decreased in average from 0.27 to 0.16% in the top layer, and from 0.25 to 0.16% in the bottom layer. Drainage on the wire improved, which allowed headbox consistency to be reduced by 20 %. Due to a less loaded white water system, the machine runnability improved from an average of 2.5 to 1.3 breaks/day.

Case Study 2 – Uncoated Free Sheet

In this type of grade, attention should be paid to the impact of the retention program on ash distribution, sheet formation, porosity, and roughness. All these properties affect printability.

Situation

A mill located in Northern Mexico producing uncoated fine paper wanted to improve formation while maintaining their first pass ash retention level. The machine is a top-wire design operating at 850 m/min, producing basis weights over the range of 56 to 90 g/m^2.

The filler content in the finished paper is moderate (18 - 20 % PCC) and the sheet is sized with ASA. Their previous retention program was based on dry cationic polymer added before the screen at 0.5 kg/T, in combination with a bentonite microparticle at 3.0 kg/T, added after the screen.

Program

A borosilicate microparticle was added before the pressure screen at a dosage of 1.5 kg/T and Core Shell polymer added at 0.7 kg/T after the pressure screen.

Results

The new program produced a stronger, more compact floc, which resulted in better press dewatering. For the standard 75 g/m^2 offset grade, first pass filler retention was maintained at 60%, however, headbox (0.60 to 0.55%) and whitewater consistencies were reduced, which resulted in superior formation. The online formation sensor measured an improvement in formation index from 18 to 20.

Case Study 3 - Newsprint

In all papermaking processes, stability is a required factor before any improvement project can be established. Wet-end chemistry stability plays an important role in the overall process stability, and this is particularly relevant for newsprint machines. A flexible and robust retention program is key to cope with the variability of the newsprint process associated with the quality of the raw materials.

Situation

A producer of standard and improved newsprint (top-wire machine) had problems obtaining stable retention, under the variable conditions of the incoming furnish, based on

100 % deinked pulp. The ash content in the paper is 11-13 % for the standard grade. Particularly in the high brightness grade (higher filler content), the white water consistency was difficult to control, and achieved values that impacted the runnability of the paper machine. In the standard grade, white water consistency fluctuated around 0.5 to 0.7%, with high variability, making it difficult to find the right operating conditions for the machine, and affecting the sheet quality control parameters.

Program

A new multi-component treatment was implemented, replacing the previous bentonite-based microparticle program. A coagulant was applied to the DIP chests for contaminant control. The coagulant dose was controlled using an on-line turbidity sensor. As a retention program, Core Shell polymer was fed after the screen, in combination with a cationic microparticle. Dose of each product was between 0.3 and 0.6 kg/T.

Results

The program was optimized during a two-month trial period. The results were improved control of the white water consistency, improved process stability – determined through statistical process control tools – and improved paper machine runnability.

The stability comes from the good performance of the chemical treatment and from understanding how to manage the program. The coagulant is used to fix the colloidal materials in the back system, and the control parameters are charge and turbidity. Core Shell is the product used to control retention and maintain the desired white water consistency. The microparticle component provides drainage and filler retention and helps the flocculant on buffering the effect of high filler loading.

SUMMARY

A new polymer technology commercialized with the name of Core Shell has been developed by Ondeo Nalco Company.

Laboratory evaluations have demonstrated that Core Shell polymers produce a floc with high shear resistance, making them the flocculants of choice for modern high-speed paper machines. Core Shell polymers provide significant papermaking benefits, when used as single component or in combination with microparticles. At this time, the new program has been successfully applied on more than 60 paper and board machines across the world. Implementation of Core Shell polymers with or without a microparticle provided better and more stable retention values and improvements in paper quality, system cleanliness and machine runnability.

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Core Shell, *Ultra* POSITEK and ULTIMER are trademarks of Ondeo Nalco Company
Borosilicate microparticle is known commercially as NALCO® 8692

APPENDIX

Figure 1: Ash retention data for: Core Shell polymer, a dry polymer, and various cationic emulsion polymers. All the polymers were used in combination with 0.5 kg/T of a borosilicate microparticle.

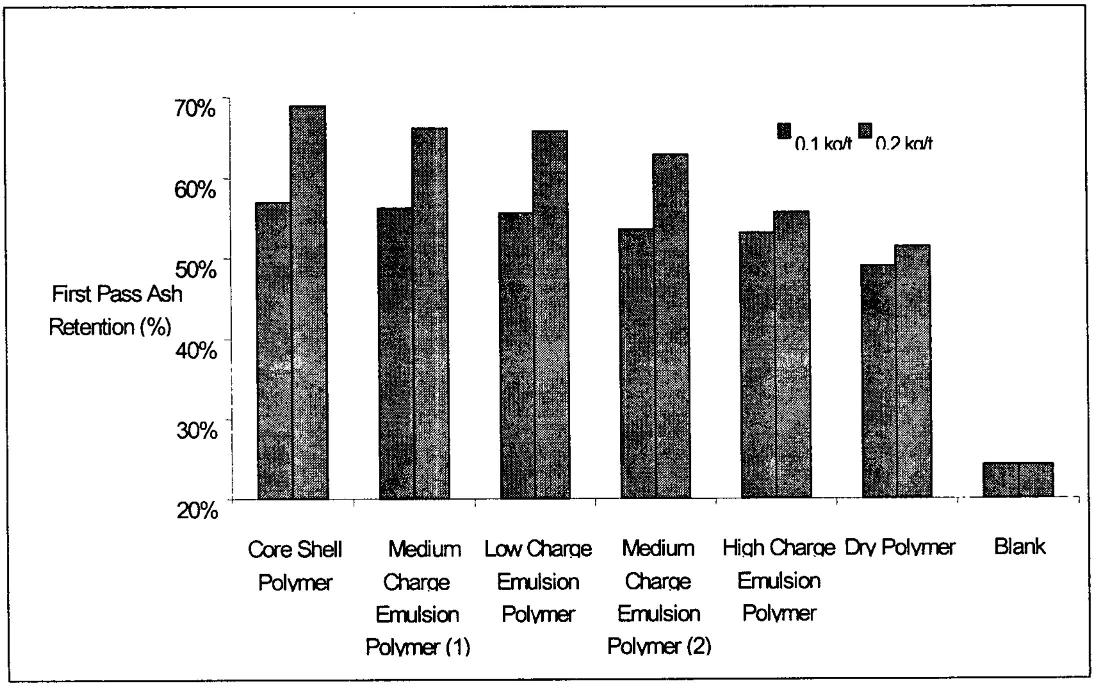

Figure 2: Comparison of the Change in Mean Chord Length obtained after addition of Core Shell polymer and a dry polymer to a coated fine paper furnish.

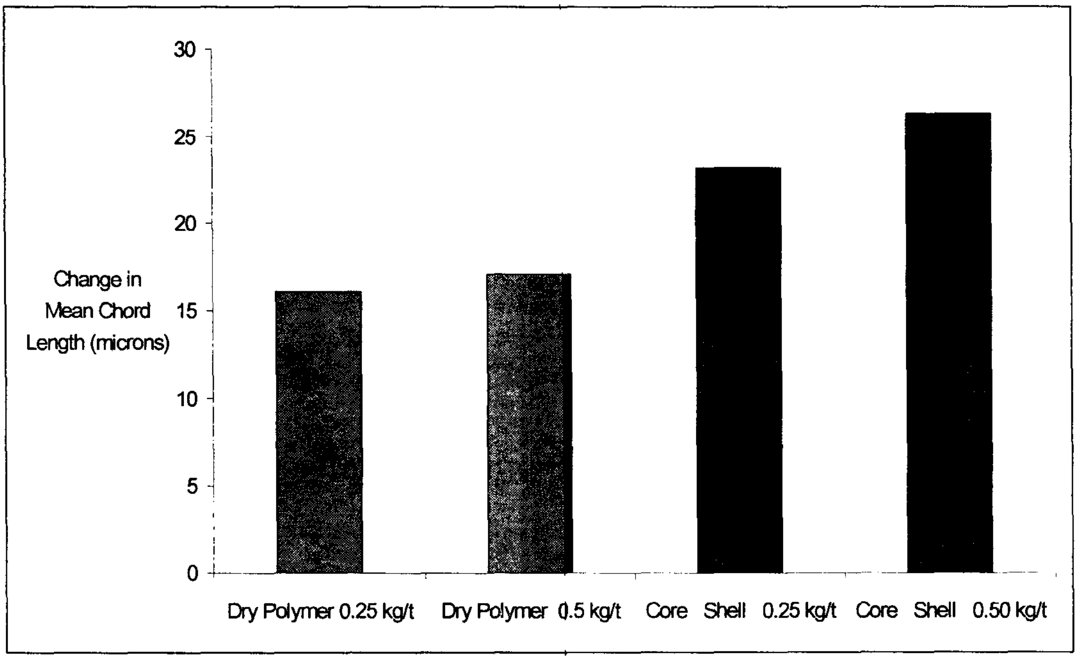

Figure 3: Comparison of Mean Chord Length data obtained after addition of Core Shell or dry polymer to an acid LWC furnish.

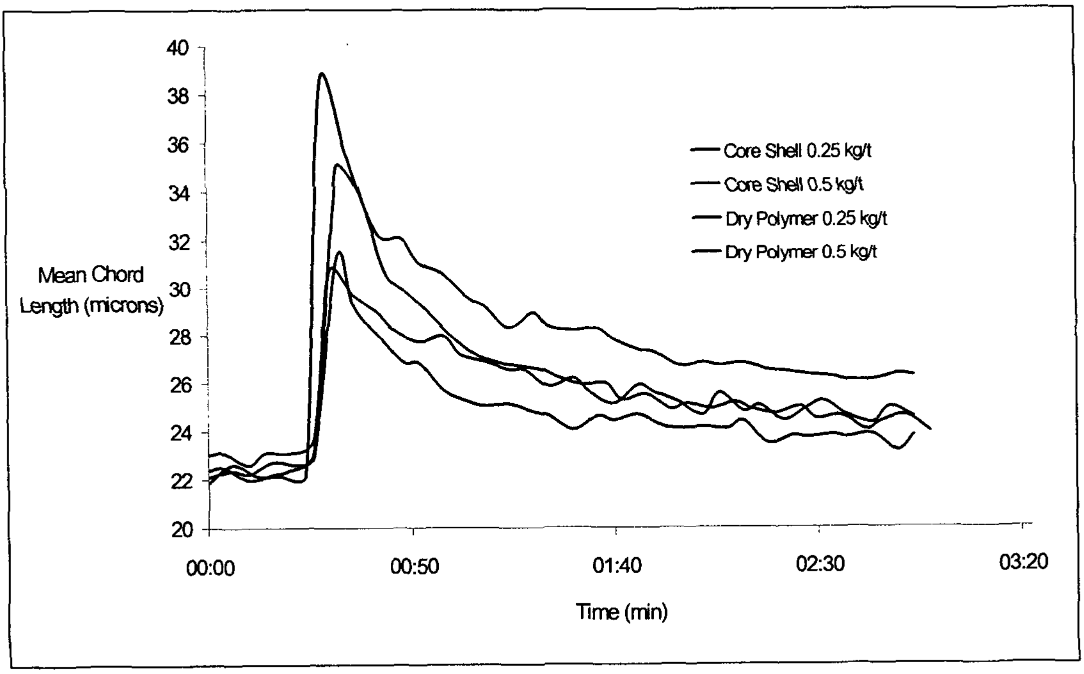

Figure 4: Comparison of Mean Chord Length data obtained after addition of Core Shell only, and a program consisting of a combination of dry polymer plus bentonite. Bentonite was added 5 seconds after the dry polymer.

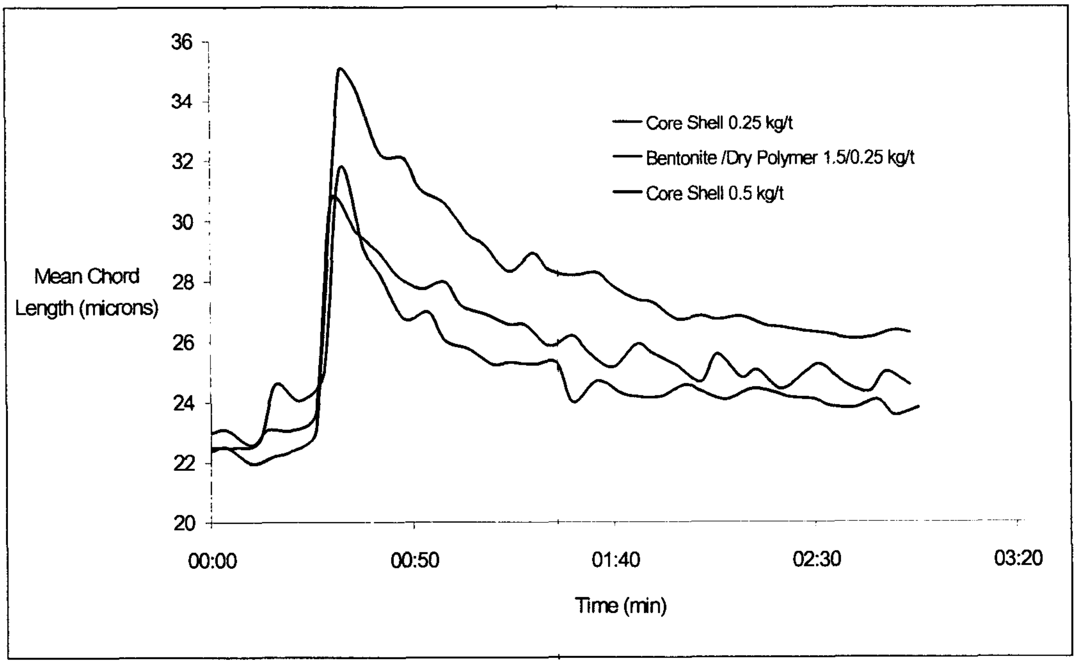

Figure 5: Drainage evaluation in an acid furnish by using a vacuum drainage tester. The volume of filtrate collected in 3 seconds was used as an indication of the furnish drainability.

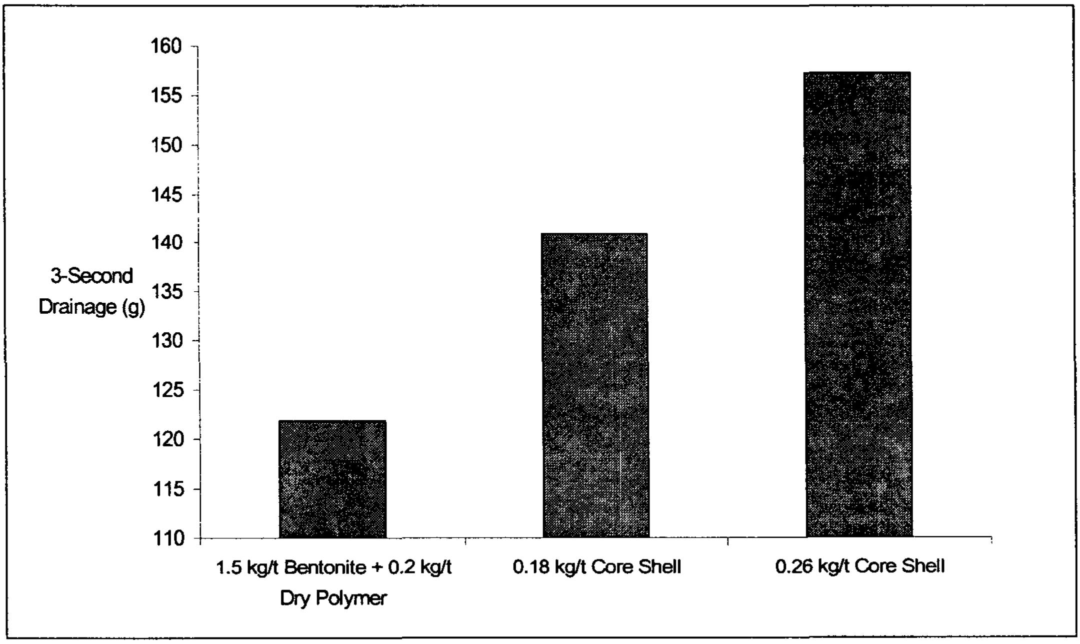

Figure 6: Relationship between flocculant and microparticle activity in an acid groundwood furnish at various anionic trash and coagulant levels. In all the cases, 1.0 kg/T of a cationic flocculant was used in combination with 2.0 kg/T of microparticle.

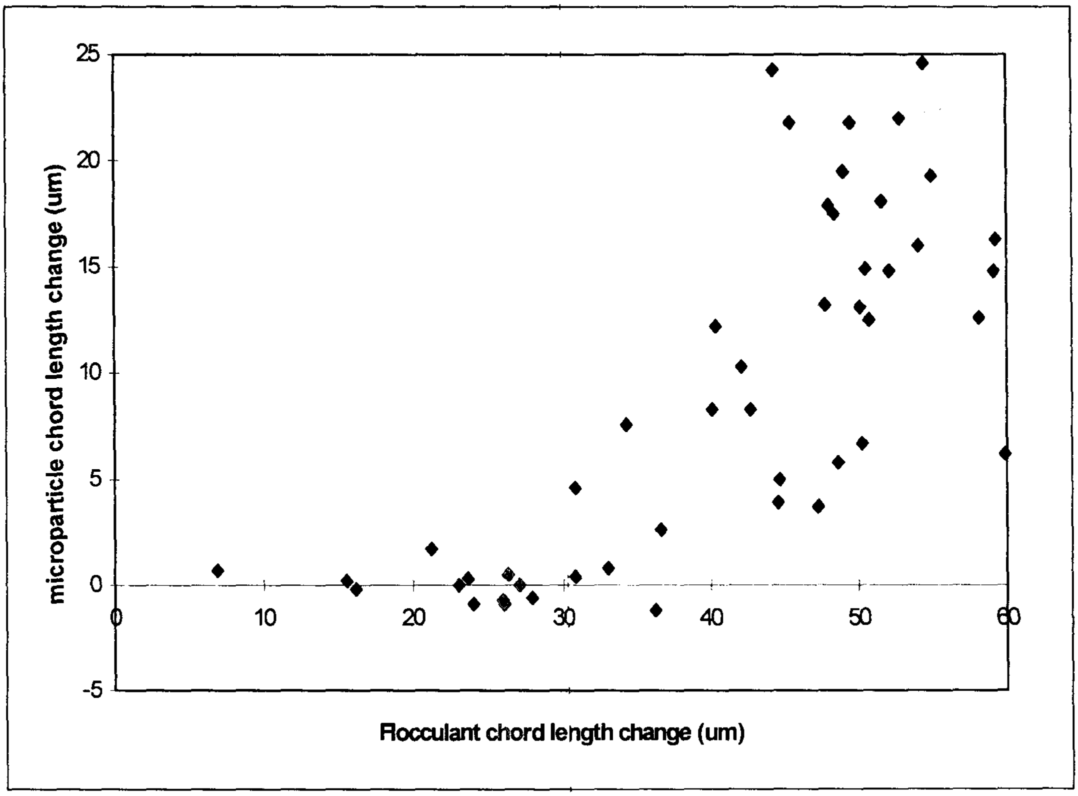

Figure 7: Re-flocculation of a LWC furnish by borosilicate microparticle added 80 seconds after flocculant addition.

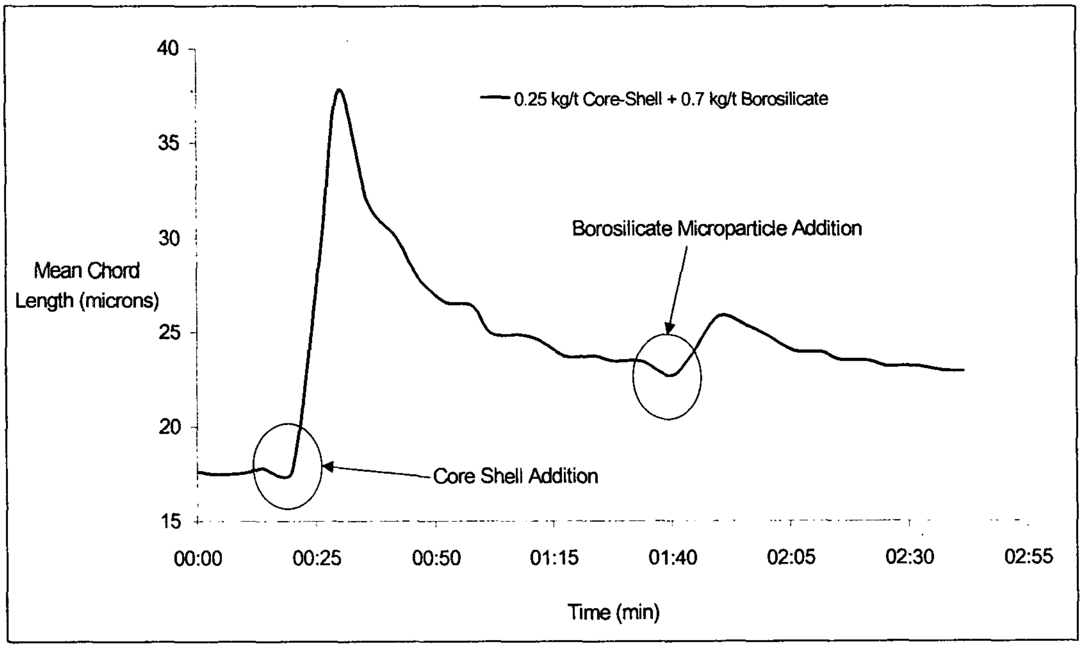

Figure 8: Comparison of the *Change in Mean Chord Length* after addition of borosilicate microparticle for different flocculants added at 0.25 kg/T.