**Increasing ash without compromise – A comprehensive approach**


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## Abstract

Papermaking fillers are generally much less expensive than fiber. Therefore, by increasing sheet filler content, papermakers can reduce manufacturing costs. During the past decade, the global average filler content for copy paper increased from 15 to 20%; however, further improvements are desired. Historically, trial efforts to significantly increase sheet filler content typically resulted in some combination of lack of sheet bulk and stiffness, inadequate sheet strength, or paper machine runnability problems. Following several years of collaborative research, Ashland Inc. researchers have developed a new technology that is currently being commercialized.

This paper describes this new approach to significantly increase filler content in freesheet grades. The comprehensive approach consists of a novel dry strength additive to improve bonding of carbonate filler particles into the sheet, the modification of the carbonate filler to maintain sheet bulk and stiffness at high filler loading, and the use of an advanced retention/drainage system to maintain paper machine performance as filler content increases.

This paper also reviews commercial trial data from world class paper machines. The data demonstrates that by using this comprehensive approach, sheet filler content can be increased by up to eight percent while maintaining critical sheet quality parameters and paper machine runnability.


## Introduction

To be more competitive in the global market, papermakers are constantly seeking new methods to reduce manufacturing costs, improve quality and/or minimize the impact of high market pulp prices. Substituting expensive fiber with lower cost fillers can significantly drive the cost down. As an example, if a mill's filler cost is $130/ton and its incremental fiber supply cost is $780/ton, then every percentage point filler increase will reduce manufacturing costs by $6.50/ton of finished paper production. This represents a high savings potential for mills that are net buyers or net sellers of pulp. In addition, energy savings may also be realized since higher filler loadings will reduce paper drying cost.

However, increasing filler content has always been limited by wet- and dry-end productivity and/or paper quality issues. Paper quality complaints have often been related to lack of stiffness and/or internal bond.

A new approach has been developed by Ashland Hercules Water Technologies to allow papermakers to overcome these technical barriers. This program has commercially demonstrated significantly reduced costs by increasing filler content in paper without compromising quality or productivity. This paper introduces the key components of the program and presents the results achieved on world class machines.

**Program Description**

Based on several years of collaborative research, a three-component program consisting of a novel dry strength additive, a modified carbonate filler and the utilization of an advanced retention/drainage system yields the most comprehensive program to increase filler while maintaining paper machine runnability and paper properties. Each of the program components are described below.

The function of the first component, a novel, patent-pending product designated Hercobond® HA5305 strength additive, is to build a polymeric network between fillers and fibers to maintain sheet strength both in the finished paper and in the wet-end. This chemistry has a unique affinity for calcium carbonate fillers. Developed to be compatible with the wet-end chemistry of paper machines producing freesheet grades, this water-soluble polymer will not quench whiteners. As a result, a filler increase will maximize brightness without the need for additional whiteners.

In typical dry strength applications the product is added to the machine furnish to enhance paper strength. However, for this application the polymer is added directly into the filler slurry (prior to the contact with the fibers) allowing the polymer to coat the surface of the filler to enhance bonding interaction with pulp fibers.

It is recognized that increasing filler in paper tends to decrease bulk which reduces stiffness. Therefore, the second component, a modified calcium carbonate filler, is required to maintain bulk and stiffness as filler is increased in the sheet. For this application, the papermaker will work with their current filler manufacturer to modify the filler morphology. The modified filler particles can then maintain bulk and stiffness while meeting optical requirements.

As filler is increased, the need for a high performance retention and drainage program is necessary during high ash papermaking. As such, the third component’s function is to maintain first pass ash retention, to control z-direction filler distribution in the sheet, and to maximize drainage without damaging sheet formation. This retention program utilizes an industry leading structured organic polymer, PerForm® SP retention additive, modest amounts of polyacrylamide flocculant, and an aluminum source.

Once the paper is formed with the program components, a polymeric network is created between fibers and fillers. This is presented in Figure 1 with a scanning electron microscopic view of the surface for paper containing 26% PCC filler that was treated with the new approach.

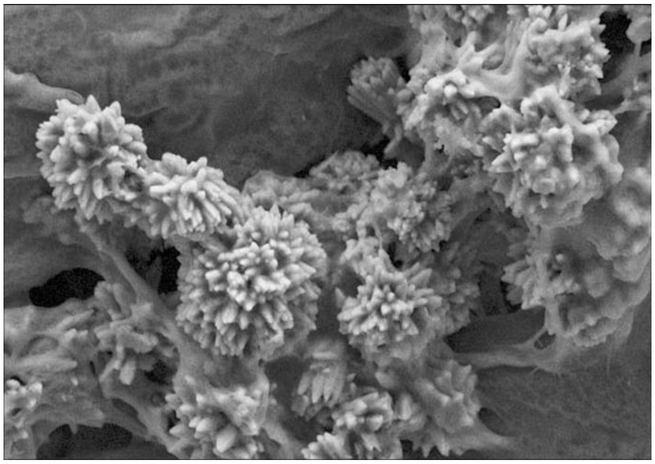

**Figure 1. The sheet surface, with embedded filler particles at 26% ash, demonstrates the polymeric network created by the new technology. Picture courtesy of Specialty Minerals Inc.**

This new approach includes three distinctive components that offer papermakers the tools to gradually increase filler content while minimizing risks. Furthermore, if excess filler capacity is readily available, the program can be implemented with low capital cost.

## Wet Web Strength Improvement

During the development of this new approach, a procedure was developed to aid in understanding how the program impacts wet web strength. This is a key parameter to maintain paper machine productivity while producing high ash paper. Because of the limited bonding between filler and fiber, an increase in filler could lead to a reduction in wet web strength. In some cases, this reduction translates into increase in breaks in the wet-end of the paper machine.

Lab work was performed, using this new technique, to evaluate the impact of the new approach on wet web strength by measuring never-dried tensile; these results are presented in Figure 2. Without treatment with the new approach, an 8% filler increase resulted in significant loss (about 50%) in never-dried tensile strength at constant press solids. However, with the use of the new approach nearly 70% of the loss was recovered at the higher polymer dose.

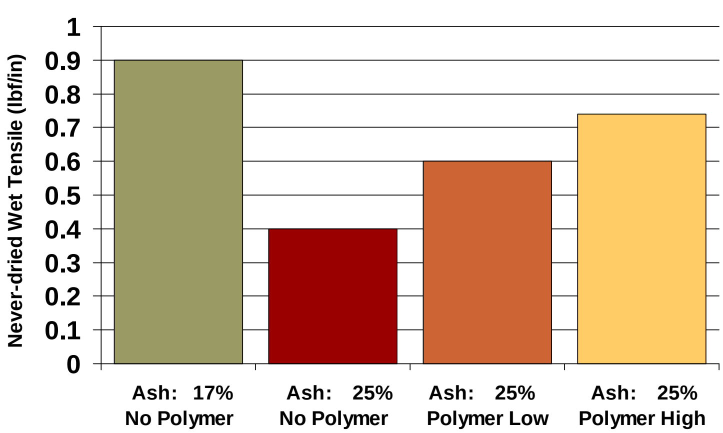


**Figure 2. Recovering Lost Wet Web Tensile Strength.**

**Case Histories**

With an understanding of this program's impact on wet web strength and completing extensive laboratory testing, the next step was to run commercial trials on world class coated and uncoated paper machines. The first case history is more extensive while the subsequent cases focus on the key paper characteristics for the production of these grades.

**Case History 1 – North American Copy Paper**

Several 24-hr evaluations were run on a 1,000 tpd North American paper machine producing 75 $g/m^2$ copy paper. Using PCC, filler content was increased from a baseline of 18% to 24% and then to 26%. This required a strength additive dosage of 2 -3 lb/T (dry basis). Machine Direction (MD) tensile was monitored as a criteria to maintain paper machine runnability through the drying and calendering process. Figure 3 shows that MD tensile was maintained and as a result good paper machine productivity was observed.

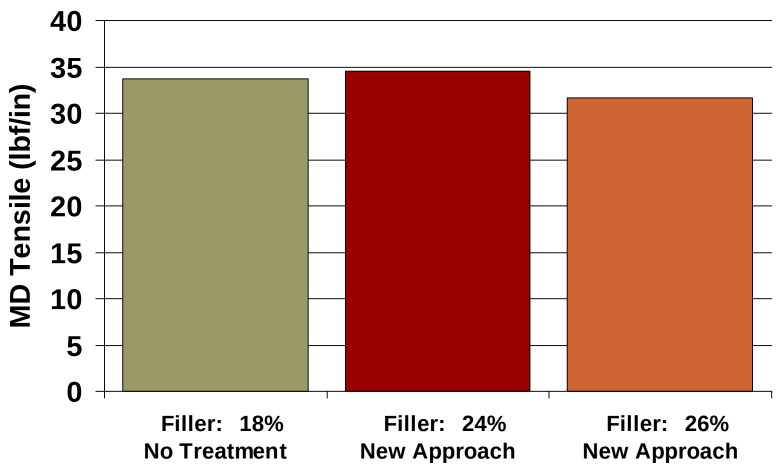


**Figure 3. MD Tensile Maintained at High Filler Loadings.**

For copy paper, stiffness is often a limiting factor to filler increase. With this new approach, the function of the modified filler is to maximize bulk and thus help maintain stiffness when filler is increased. During these evaluations, bulk and stiffness were measured comparing baseline paper made with regular filler (18% ash) with paper produced using the new approach including the modified filler. Figure 4 shows that both bulk and stiffness were maintained with 6% and 8% filler increases.

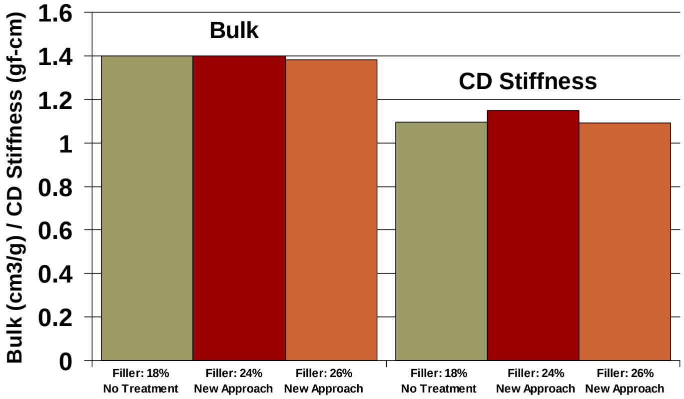


**Figure 4. Bulk and Cross Direction (CD) Stiffness Maintained at High Filler Loadings.**

Z-direction tensile (ZDT) strength was also monitored during commercial production as a measurement of internal bond strength and dusting potential. Figure 5 demonstrates that the treatment program maintained ZDT under high filler loading conditions.

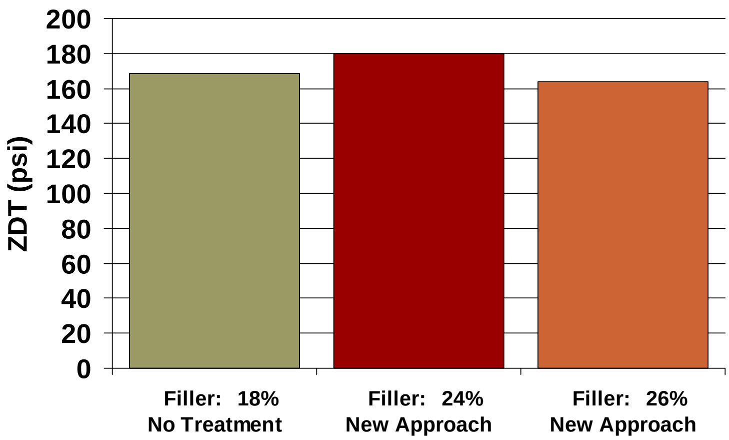


**Figure 5. Internal Bond Strength Maintained at High Filler Loadings.**

Other interesting commercial benefits were also realized during this evaluation. As the amount of filler increases, other quality parameters such as smoothness, brightness, and opacity, are expected to improve.

- Sheffield smoothness improvements of 20–30 points were confirmed during the trial. Such gains can, in some cases, enable calendering to be reduced to further maximize bulk. However, constant calender pressure was maintained during this trial.
- The modified filler provided lower opacity at the baseline ash level. This loss in opacity was recovered with increased filler loading and ultimately resulted in 0.4 point increased opacity at 8% filler above baseline.
- With an 8% increase in filler, 1.0 point in TAPPI brightness increase was realized. No attempts were made to reduce whitener usage during this trial.

When annualized the net savings documented during these trials were in excess of $4 million.

**Case History 2 – Asian Copy Paper**

Outside North America copy paper tends to be produced at higher filler content. In this case a trial was conducted on an Asian paper machine producing 1,400 tpd of 80 $g/m^2$ copy paper with the goal to increase filler from 25 to 30% while maintaining sheet properties. Strength polymer doses of 0.6–1.5 lb/T dry basis were used to treat ground calcium carbonate (GCC) and PCC going to the paper machine. Paper properties including bulk and tensile were maintained within specifications as presented in Figures 6 and 7. These results are encouraging for the production of copy paper at 30% filler content; well above industry average. Evaluations continue at this location.

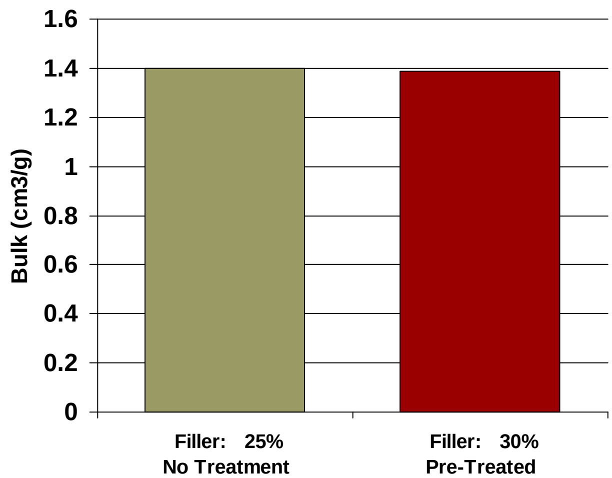


**Figure 6. Bulk Maintained at Higher Filler Load.**

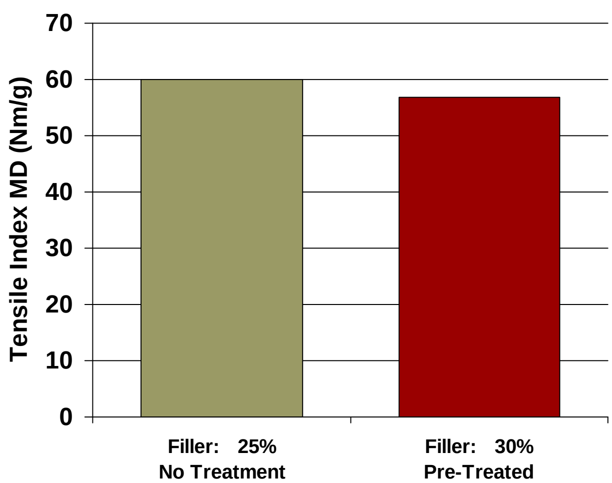


**Figure 7. Tensile Strength Maintained at Higher Filler Load.**

**Case History 3 – Asia Base Paper for Coated Fine Paper**
This Asian paper machine produces 1,400 tpd of base paper at a speed of 1300m/min. Three paper machine trials were conducted to increase filler from 9 to 17% on 54 g/m$^2$ coated basestock paper, while maintaining sheet properties with a focus on internal-bonding and bulk. The GCC was treated with the strength polymer at a rate of 0.75 lb/ton dry and the recommended retention program. In this case, the filler was not modified. The high ash results are compared against pre-trial data in Figures 8 and 9. The primary sheet properties, such as internal bond, tensile strength, stiffness, bulk, and Cobb values, all were maintained within specification. Given the success of the trial and the net savings achieved by the mill, this new approach was commercialized in this mill.

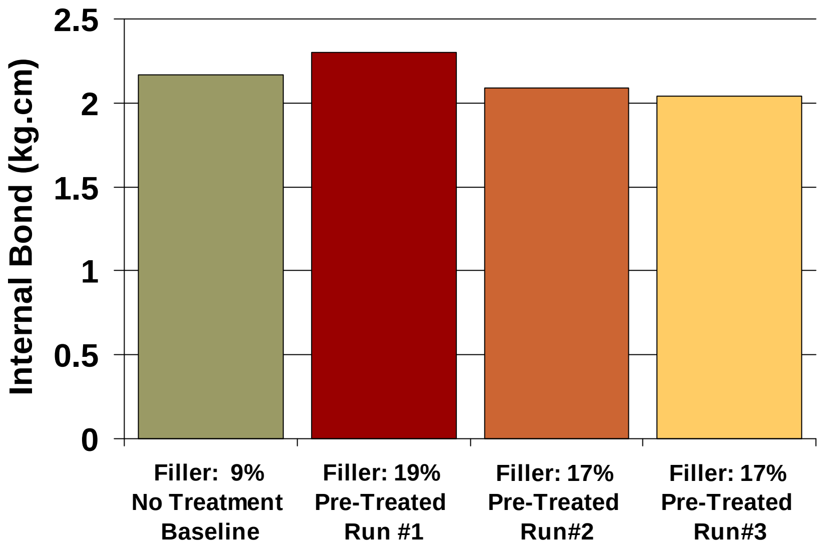


**Figure 8. Internal Bond Maintained; A Key Success Criteria for This Paper Grade.**

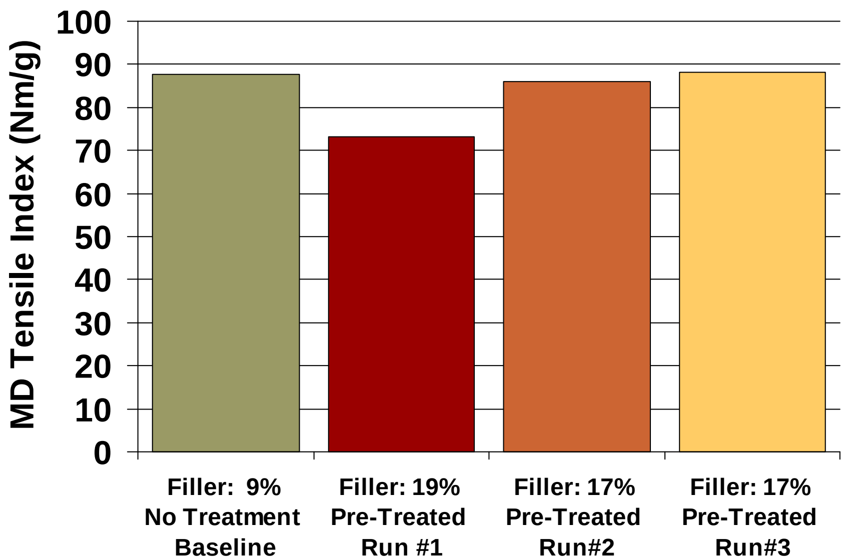


**Figure 9 –Tensile Strength Maintained.**

## Conclusion

This new program developed by Ashland Inc. is designed to provide papermakers with a comprehensive set of tools to successfully increase filler in paper. This program is currently being validated on a variety of world-class paper machines globally. Trial results are very encouraging, delivering up to 8% in filler increase helping papermakers to set new standards in the freesheet market. Significant cost savings have been successfully demonstrated while maintaining both paper machine runnability and finished sheet quality including stiffness and bulk.