New Technology for Increased Filler Use and Fiber Savings in Graphic Grades

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ABSTRACT

Virgin fiber is an expensive raw material in the paper making process. There are continual efforts to replace it with less costly materials, such as calcium carbonate. While increased filler usage has long been sought after by the paper industry, technical limitations have precluded the practice. A novel solution to this problem will be presented. The approach involves the preparation of filler designed to be incorporated at higher levels in papermaking operations without compromising the performance of the final product. In particular, the critical dry strength and optical properties of the sheet are preserved at the higher filler level. Results from commercial applications of this technology in the uncoated and coated wood-free grades will be presented.

INTRODUCTION

It has long been a goal of the paper industry to increase the filler content of graphic papers. The cost of filler is approximately four to seven times less than the price of market kraft pulp. A 1% increase in filler content is estimated to save $6/ton raw material cost, assuming the price of market kraft pulp and filler is $700 and $100, respectively. Sheets with higher filler content are easier to dry, resulting in reduced steam consumption. Increasing filler content also has the potential to improve sheet optical properties, surface smoothness and printability.

Significant challenges exist for utilizing more filler in terms of both end product quality and machine runnability. The largest technical challenge is the loss in strength as filler disrupts the fiber-fiber bonding network of the sheet by reducing the number of fibers and preventing effective contact of the fibrils. The increased total surface area of the papermaking stock due to higher filler levels reduces the efficiency of conventional dry-strength agents. Loss in strength is detrimental in printing operations; for example, low internal strength can cause sheet delamination and low surface strength results in picking, linting and dusting. Another issue with higher ash content is that fillers are harder to retain. This often leads to elevated retention aid use, poor sheet formation and increased difficulty of maintaining an even distribution of fillers across the z-direction of the sheet. Operational instabilities due to dusting or center roll picking are other potentially negative consequences of higher ash levels.

FILLER TREATMENT TECHNOLOGY

Various approaches to circumvent the challenges with higher filler usage have been pursued over the years. One approach is to preflocculate fillers prior to their addition to the wet end approach system. Preflocculation means the modification of filler particles into agglomerates through proper chemical treatment. Preflocculation effectively increases the size of the filler, and reduces the filler surface area. Therefore, disruption of fiber-fiber bonding from fillers becomes less. The high fluid shear rates present in modern high-speed papermaking demand stable and shear resistant filler flocs. Furthermore, the size distribution and surface properties of filler flocs must be controlled in order to meet the following requirements: allow high and uniform filler retention, minimize reduction in sheet strength with increased ash content, minimize the loss of light scattering efficiency from the filler particles, and minimize negative impacts on sheet uniformity and printability. Patent-pending FillerTEK technology from Nalco utilizes a combined chemical and mechanical approach to deliver these attributes.

FillerTEK technology is a fit for customers utilizing precipitated or ground calcium carbonate (PCC or GCC), or a blend of PCC and GCC as their filler source. The chemical treatment is carried out on-site with a mill's existing filler slurry. This can be accomplished in-line or the treated filler slurry can be stored in a run tank; no residence or aging time is required before use. The program is economical, even for paper producers targeting the relatively low increase in sheet ash of 3 to 5 percentage points.

This paper presents two case studies of commercial applications of filler preflocculation technology. The first is for an uncoated woodfree sheet, and the second is for a coated woodfree sheet.

COMMERCIAL APPLICATION IN UNCOATED WOODFREE SHEET

The FillerTEK program has been run in one North American fine paper machine for about two years and has helped the mill increase sheet ash from 18% to 23%. The mill produces 400 tons/day of copy paper and offset grades in the basis weight range of 75 – 105 g/m^2. The majority of the mill's production is 75 gsm copy paper using a blend of PCC and GCC as the filler source. Previous attempts to increase the ash level were unsuccessful due to limitations in sheet strength, as well as machine operational issues like dusting, deposits and poor retention. FillerTEK technology was implemented across all grades and has been utilized continuously for over a two year period. As a result, the mill has achieved a 5 percentage point increase in the ash content of their sheet while maintaining machine runnability.

Sheets made before and after implementation of the FillerTEK program were collected and analyzed in the lab. Results represent the average of 10 samples randomly selected from 10,000 sheets. The major sheet properties were listed in Table 1. The results showed that filler preflocculation enabled the filler content of the sheet to be increased by 4.5% without the loss of internal strength, tensile strength, optical properties, and bulk. Bulk was maintained because the mill incorporated BCTMP into the furnish mixture. Sheets with preflocculated filler at higher ash were significantly smoother. This smoothness gain can be transferred into bulk improvement by reducing calendering load.

The sheets described in Table 1 were subjected to a converting study to monitor dust formation. It was found that sheets produced using FillerTEK technology at 4.5 percent higher filler content generated 47% less dust than the sheets containing untreated filler.

Z-directional ash distribution in the sheet was also measured using a tape-peeling method. As shown in Figure 1, the distribution of preflocculated filler at the elevated content is similar to that of untreated filler.

COMMERCIAL APPLICATION IN COATED WOODFREE SHEET

The FillerTEK program was successfully implemented on a world class machine in Asia producing coated woodfree paper and has been utilized across all grades for about one year. The preflocculation technology enabled the mill to increase the base sheet ash level about 3 to 5 percentage points. The critical sheet properties, including internal bond strength, tensile strength, stiffness, optical properties, porosity and roughness, were maintained. Table 2 compares the properties of sheets with 17% untreated filler and 22% treated filler. The data was obtained from one of the FillerTEK trials on this paper machine.

Because of elevated filler content in the sheet, steam consumption in the dryer section was reduced by over 20% since the implementation of this technology, as shown in Figure 2

CONCLUSIONS

FillerTEK technology delivers cost-efficiency to paper producers by allowing them to utilize less expensive raw materials without compromising product quality. This patent-pending technology is based on a unique filler preflocculation approach that produces flocs with a narrow particle size distribution and high shear stability. The technology has been demonstrated on both uncoated and coated woodfree commercial paper machines.

Table 1. Summary of sheet properties produced during the commercial production of uncoated woodfree paper using a blend of PCC and GCC with and without FillerTEK technology. Results represent the average of 10 samples randomly selected from 10,000 sheets.

Sheet Property	**Untreated Filler**		**Pretreated Filler**		**Impact of Filler Treatment**
	Value	**Std. Dev.**	**Value**	**Std. Dev.**	
Sheet ash (%)	17.7	0.50	22.2	0.50	+4.5 pt ash increase
Basis Weight (gsm)	76.33	1.17	74.87	0.92	Lower
Bulk (cm^3/g)	1.38	0.02	1.38	0.01	Equal
Internal bond (ZDT, kPa)	571.7	18.0	574.0	10.6	Equal
Tensile index (Nm/g)	54.32	2.97	52.73	2.73	Equal, within std dev
Bending resistance (mN)	103.5	9.3	91.1	8.6	Reduced
Porosity (ml/min)	1157	87	1198	66	Equal, within std dev
PPS Roughness (μm)	6.43	0.32	6.01	0.11	Smoother sheet
Sizing, HST (sec)	69.15	25.3	61.43	25.4	Equal, within std dev
Opacity at 75 gsm (%)	94.43	0.76	94.63	0.52	Equal
Brightness (%)	91.20	0.08	91.09	0.20	Equal

Table 2. Summary of sheet properties from FillerTEK technology trial in a world class reference machine in Asia producing coated woodfree paper.

Sheet Property		**Untreated Filler**		**Pretreated Filler**	
		Ave.	**Std. Dev.**	**Ave.**	**Std. Dev.**
Ash Content (%)		17.1	0.2	22.0	0.2
Basis Weight(gsm)		105.7	0.6	104.8	0.4
Internal Strength (kg.cm)		1.03	0.02	1.04	0.02
Caliper (μm)		140.6	0.8	137.0	0.4
Bulk (cm^3/g)		1.33	0.01	1.31	0.01
Formation		39.3	3.4	32.7	1.5
Porosity (ml/min)		621	46	648	17
Opacity (%, ISO)		96.5	0.1	97.0	0.1
Roughness (ml/min)	BWS	141.0	6.8	131.0	9.2
	TWS	186	11	179	12
Tensile Strength (kg_f/15mm)	MD	10.8	0.3	10.7	0.1
	CD	3.3	0.1	3.3	0.1
Stiffness (mN·m)	MD	1.3	0.1	1.3	0.1
	CD	0.41	0.02	0.39	0.04

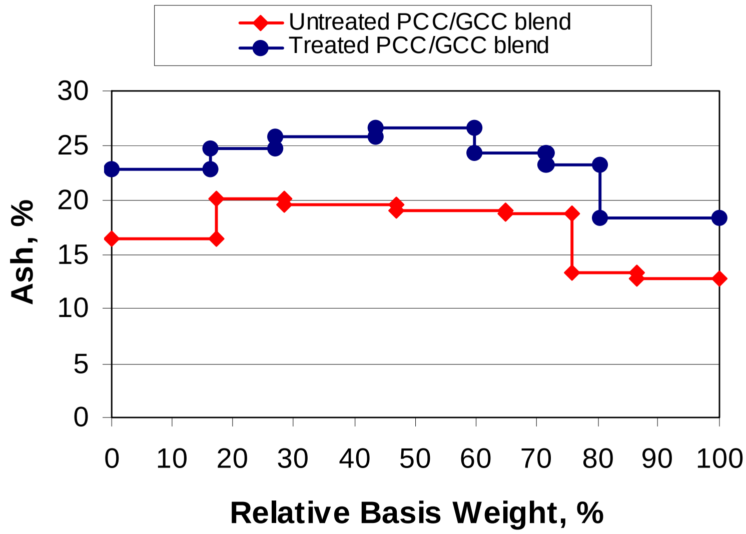

Figure 1. Z-directional ash distribution for commercial sheets produced with and without filler treatment. A similar profile is maintained at the higher ash level.

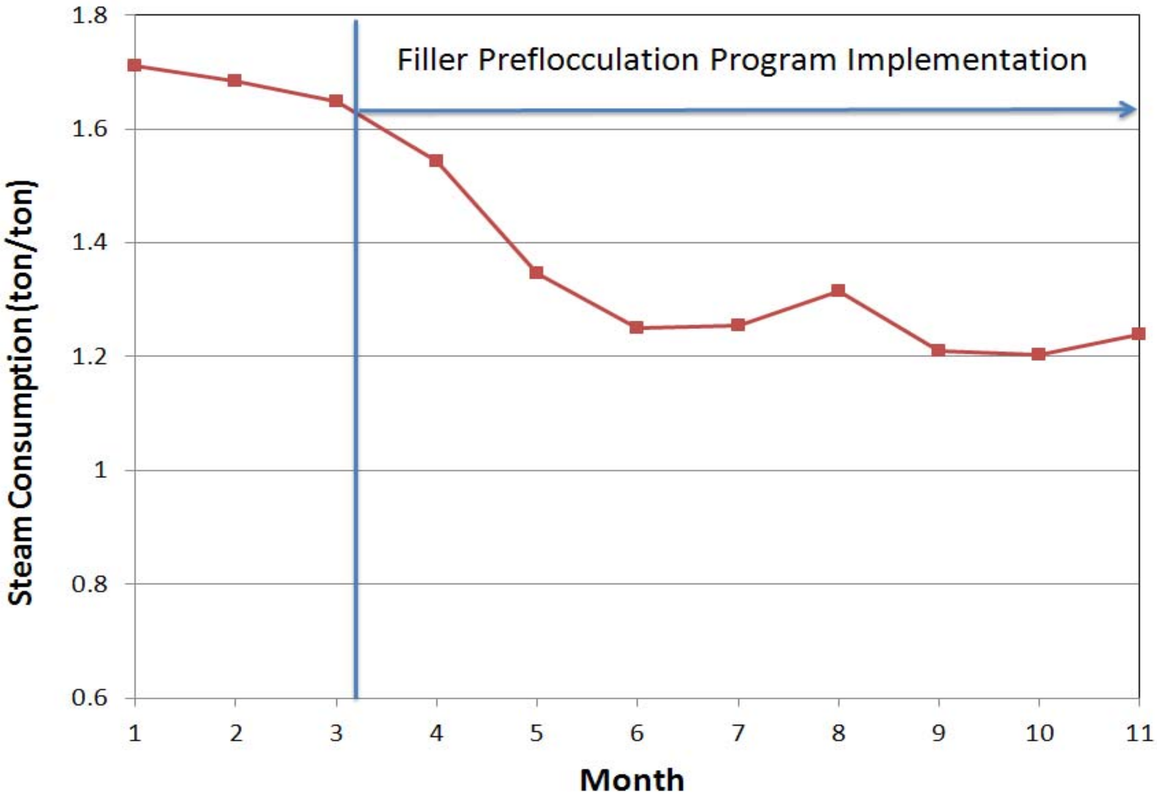

Figure 2. Average steam consumption per ton of base paper. The FillerTEK technology was started to be fully implemented across all grades in May, 2010.