Final Technical Report

Project Title:	New Manufacturing Method for Paper Filler and Fiber Material
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Partners:	**Participating Organization:** Empire State Paper Research Association **Cost Share Partner:** Lhoist North America Specialty Minerals Inc. International Paper NewPage

Executive Summary:

The use of fillers in printing and writing papers has become a prerequisite for competing in a global market to reduce the cost of materials. Use of calcium carbonates (ranging from 18% to 30%) as filler is a common practice in the paper industry but the choices of fillers for each type of papers vary widely according to its use. The market for uncoated digital printing paper is one that continues to introduce exciting growth projections. and it is important to understand the effect that new manufacturing methods of calcium carbonates have on the energy efficiency and paper production.

Research conducted under this award showed that the new fiber filler composite material has the potential to increase the paper filler content by up to 5% without losing mechanical properties. Benefits of the technology can be summarized as follows for a 1% filler increase per metric ton of paper produced: **(i)** production cost savings over $12, **(ii)** Energy savings of 100,900 btu, **(iii)** CO_2 emission savings of 33 lbs, and additional savings for wood preparation, pulping, recovery of 203593 btu with a 46lbs of CO_2 emission savings per 1% filler increase.

In addition the technology has the potential to save: **(i)** additional $3 per ton of bleached pulp produced, **(ii)** bleaching energy savings of 170,000 btu, **(iii)** bleaching CO_2 emission savings of 39 lbs, and **(iv)** additional savings for replacing conventional bleaching chemicals with a sustainable bleaching chemical is estimated to be 900,000 btu with a 205 lbs of CO_2 emission savings per ton of bleached pulp produced.

All the above translates to a estimated annual savings for a 12% filler increase of 296 trillion buts' or 51 million barrel of oil equivalent (BOE) or 13.7% of the industries energy demand. This can lead to a increase of renewable energy usage from 56% to close to 70% for the industry sector. CO_2 emission of the industry at a 12% filler increase could be lowered by over 39 million tons annually. If the new technology could be implemented for bleaching process a total annual estimated energy savings potential of 64 trillion buts' or 11 million barrel of oil equivalent (BOE) equal to 3% of the paper industries energy demand could be realized. This could lead to a increase of renewable energy usage from 56% to close to 60% for the industry. CO_2 emissions could be lowered by over 7.4 million tons annually. It is estimated that an installed system could also yield a 75 to 100% return of investment (ROI) rate for the capital equipment that need to be installed for the fiber filler composite manufacturing process.

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Introduction:

The paper industry in North America produces over 90 million tons of paper and paperboard annually. According to the American Forest & Paper Association, the paper industry creates more than $200 billion annually in financial revenue, employs over 1 million people and is in the top 10 list of manufacturing employers in 48 states [1].

The produced paper products require the use of approximately 3.5 million tons of filler material, with an estimated 5% annual increase [2, 3]. The major paper fillers used in papermaking are ground calcium carbonate (GCC) and precipitated calcium carbonate (PCC). PCC is the largest category of filler in North America, with nearly 70% of the market share. The second most common filler type, with a market share of 15%, is Kaolin, followed by ground calcium carbonate (GCC) with 13%. Titan dioxide's estimated market share is about 2%. The use of Silica / Silicates accounts for 0.3% and Talc and Aluminum Trihydrate together account for approximately 0.1% [3].

Paper fillers materials are less expensive than fiber, allowing reduced production costs, improved optical paper properties, dimensional stability, and better sheet formation and printability. The use of fillers, especially PCC, is mainly driven by production cost issues and the printing industry's need for higher quality, brightness and improved printability as well as increased machine speed on the paper machine and coating application side.

Today, the paper industry around the world is experiencing significant challenges due to stringent environmental laws; globalization, high competitiveness and substantial pressures on profit margins. The number of U.S. pulp and paper mills (integrated and non-integrated) decreased from 1,095 to 375 (216 paper only, 137 integrated, and 22 pulp only) in between 1975 and 2009 [4]**.** Despite this, our society is far from being paperless. Although increasing use of digital media is threatening to decline paper consumption, there are remarkably similar consumption patterns in the main cut-size applications (work-in-progress, reading, distributing, and archives) across a range of countries, with no substitution of digital media expected in work-in-progress or reading, even though a moderate substitution is expected in distribution and archiving applications [5]**.** The main demand drivers are the increasing numbers of users of cut-size paper and the amount of cut-size paper used per personal computer (PC) in developing countries. The expected demand growth per year for the 2003-2015 period is +1% in North

America, +4% in Western Europe, +9% in Eastern Europe, +12% in the Asia-Pacific region, and +7% in Latin America [4].

Optimizing the production cost in the manufacturing of digital paper is vital for any manufacturer to stay competitive in the global market. The price of uncoated digital paper, a commodity product, is determined as a function of its market as a whole, indicating that the only way to be competitive is having a low cost product.

The addition of fillers, at either the wet-end or surface application in the production of traditional printing/writing paper grades, is an attractive option to the paper industry for cost and energy savings, and is a very common practice [6]. Calcium carbonate (CaCO3) has been intensively used for the last three decades as a substitute for part of the virgin fibers used in papermaking, and has become the dominant filler in the production of uncoated digital printing paper [7]. It improves many paper properties, such as opacity, brightness, sheet formation, dimensional stability, printability, write ability, etc [8] and helps in increased furnish drainage rate, machine speed, productivity, etc [9, 10, 11]. However, increasing the level of fillers beyond certain limits can reduce paper strength, increase the need for sizing agents, and produce dusting problems [10]. The filler content limit is mainly related to the type of virgin fiber used, and ranges from 10% to 30%. It is possible to save about US$1.5 to US$4.0/ton for each 1% increase of calcium carbonate in the paper, depending on the fiber cost [12]**.** Thus, application of $CaCO_3$ fillers (usually 20%) to replace fibers in the uncoated digital printing papers is an attractive option for the industry because of both the benefits obtained in optical and printing properties and higher economic benefits. Hence, producing PCC for digital printing papers is an attractive option for the paper manufacturer to increase the profitability of the individual paper mill. Therefore, identifying a new filler manufacturing method for calcium carbonate for digital printing paper, considering all the properties needed for excellent performance, requires a study of the impact of using different types of calcium carbonate on paper properties and an adequate comprehension of the most important variables involved. This forms the basis for the current study.

Background:

Present and Past:

In the US, approximately 21.7 million metric tons of printing and writing paper grades are produced each year, incorporating most of the 3.5 million tons of filler material used annually in the US [2, 3].The filler level of printing and writing paper is limited to approximately 25%, depending on the paper grade produced. Increasing the filler level further, decreases necessary paper properties for printing and processing paper.

The knowledge of how to manufacture PCC dates back to the 1920's when the first United States patents on grinding and precipitation of calcium carbonate were granted [13, 14]

The current, most efficient practice for manufacturing PCC as papermaking filler is to produce it in a satellite plant, adjacent to the paper mill. Satellite plants often exist near large-scale paper mills which produce mostly graphic printing and writing paper grades. Only paper mills producing 700 tons per day have sufficient demand to justify the capital investment of over $20 million for a satellite plant [15]. Therefore, the most common applications for calcium carbonate in the U.S. are coated papers (e.g. wood-free 135 g/m^2 with a filler level of up to 50%), and copy and office papers (e. g. 75-80 g/m^2 with up to 30% filler level reported) [15].

Another application for calcium carbonate fillers is lightweight, high-opacity copy and printing paper, a subsection of uncoated fine paper. Different paper grades for lightweight printing and low weight offset papers can be either surface-sized using a size press and starch, or pigmented with a coating pigment containing PCC. The basis weight can range between 35-80 g/m^2 and the filler content can range from 10 to 30% based on the geographic location. For example, in North America, filler levels of 15% are common for many basis weight levels of up to 75 g/m^2

Other user applications in North America include paper mills specializing in light weight coated (LWC) papers with a basis weight of 35 to 80 g/m^2 and a coating pigment level as high as 30% of the basis weight. These LWC papers are "fiber-limited", which means that the paper mills are trying to reduce the Kraft fiber content in the base sheet by increasing filler levels.

All these applications have made PCC the primary filler and coating pigment for today's coated and uncoated papers in North America, while in Europe GCC from marble or limestone and chalk is the primary filler material. In order to compete with the existing filler technology, a new filler type must show equal or better results in paper performance and process. However, the PCC filler level is limited to a maximum of 20 to 25% depending on the paper grade used.

Fillers today are normally incorporated into the paper web during its formation on the papermaking wire. Filler particles are typically designed to accommodate the individual customer needs. This is achieved by having the filler suspended in the pulp, prepared in the stock preparation process, in either a mixing chest or directly in front of the headbox fan pump. The pulp is then drained onto the wire while suspended filler particles are retained in the formed fibrous web. A common problem of both filler types is that a high portion of the filler particles is not retained in the fibrous web with a retention rate of approximately 30% [16]. The filler particles entrained in the water create wire wear and are essentially lost. In addition, filler levels are limited due to mechanical restrictions of the paper produced. Another serious problem with an increase in filler levels is the loss of bulk and an increasing density of the paper product because paper is sold in reams and pounds, meaning customers would get less paper product for the same price.

Today, filler and coating manufacturers use batch process tower reactors in their satellite plants to produce PCC in various forms and shapes, such as scalenohedral and rhombohedral shapes, with mean particle diameters between approximately 0.50μm and 2.5μm. However, in most cases the filler and coating particles are designed to accommodate the customer needs. The typical manufacturing process includes two main steps. First, calcium oxides are added to water to produce calcium hydroxide. This process is called lime slaking. The prepared mixture is then pumped into a second tank. Next, carbon dioxide, purchased from a gas manufacturer or reused from a mill site combustion process is bubbled through the mixture to precipitate calcium carbonate. After precipitation, the PCC is screened, thickened and pumped to an intermediate storage vessel for further use in the paper manufacturing process. The PCC slurry can also be filtered, dried, bagged and then shipped to a paper mill that does not have the size to justify an on-site PCC manufacturing plant.

Another option to the PCC satellite plant operation is wet and dry ground calcium carbonate (GCC). GCC can be manufactured by a mining operation, followed by a combination of washing and grinding to achieve an approximate particle diameter of 0.40μm for wet ground and 1.50μm for dry ground particles. The particles are then slurried in water, using a dispersion agent to achieve a consistency of approximately 75%. The produced filler and coating particles are then shipped for further use in the paper manufacturing process. GCC filler and coating particles can also be filtered, dried and bagged, like PCC, and shipped as bulk to the end user.

Discussion of the "State of the Art"

In the recent past, new processes for the manufacture of filler material have been developed by major filler producers, new process ventures and supplier companies.

One approach is shown by G.R. International, investigating a silicate and calcium based filler for paper manufacturing suitable for ash contents over 40% using a pressurized carbonation system. Results publicized show some improvements, but do not reveal the needed breakthrough for commercializing. [17, 18, 19, 20].

Another approach that was developed started with mixing and soaking the fibers in a sodium sulfate, sodium carbonate, barium chloride and calcium chloride soluble salt solution. The fiber-salt suspension is then added to a barium chloride, calcium chloride and sodium carbonate solution. Through chemical reactions, the pigment particles are precipitated inside the fiber pores. Upon examination, the barium sulfate, barium carbonate and calcium carbonate particles were found to be precipitated and present within the fiber pores [21, 22]. The filler level achieved was reported between 2% and 5%, depending on the reactants used.

A multi-pigment strategy was being investigated by most of the filler producing companies with different pigments, e.g. kaolin that has a fine plate shape in combination with GCC particles. It is anticipated that these new designed filler materials will increase mechanical and optical paper properties and that in the future, current GCC filler materials can be replaced at a higher filler level. [23]. Another process called Lumen Loading retains colloidal particles in the porous structure of cellulosic fibers. The resulting fiber slurry has an average of 3 to 8% solid fiber content in the solution. This method uses mechanical, high shear and centrifugal forces to load the fiber pores. In various research reports, the loading process of titanium dioxide under acidic conditions was reported as an absorption process, with the time rate of loading determining the resulting particle concentration [24, 25, 26, 27, 28].

A combination of the mechanical and chemical method was first developed at the United States Department of Agriculture (USDA) Forest Products Laboratory (FPL). In this method, hydrated lime is added to fibrous materials at a level of up to 50%. The hydrated lime is deposited in both the water and the fibrous material. Carbon dioxide (CO_2) gas at a level sufficient for chemical reaction is added to the solution of the fibrous material. Under high shear mixing, the gas reacts with the slurry to precipitate calcium carbonate ($CaCO_3$) in the fiber walls and in-between the fibers. The produced pulp slurry is then forwarded to the paper manufacturing process [29 -35].

At the Helsinki University of Technology, research was conducted on the precipitation of filler material to the pulp fines which are actually of the same size as the filler material itself. In addition, Fiber Loading research was performed, showing the feasibility of using an aluminum compound to replace GCC. In this process, pulp fibers with approximately 15% consistency were mixed with a solution of alum. Sodium silicate and sodium hydroxide were added to the slurry by mixing over time [36].

All research on various in situ precipitation processes showed improvements for the paper manufacturing process in regards to physical and mechanical handsheet paper properties. However, no commercial applications of this process have been found. However, mixing the filler particles with the pulp suspension and storing this suspension in the head box feed chest, for a specific time, applies indirectly many Lumen Loading principles to today's paper making processes.

Project Objective:

The main objective of this research project is to improve paper manufacturing in regards to energy and raw material savings by implementing a filler increase of at least 5% without losing important paper properties necessary for the production of printing and writing paper grades.

Principal Investigator's Experience:

The principal investigator **Dr. Klaus Doelle**, assistant professor at State University of New York's College of Environmental Science and Forestry (SUNY-ESF), joint the Department of Paper and Bioprocess Engineering (PBE) has over 20 years of work experience in the paper manufacturing segemtn in various capacities, both in the US and in Germany. Due to his long industry experience ranging from basic design issues to complete process and reactor design and conducting rather large research projects on a national and international level is uniquely applicable in that it encompasses both academic and industrial arenas.

Accomplishments:

The projects laboratory investigation and laboratory paper machine trials were performed in the Department of Paper and Bioprocess Engineering (PBE) laboratories and its associated pilot plant at SUNY-ESF. The 12” PBE pilot paper machine is capable of producing paper and non woven products utilizing various fiber raw materials with a basis weight range from 20 g/m² up to 750 g/m² and a production speed of up to 12m/min. The stock preparation system of the 12” laboratory paper machine can be adjusted individually to trial specific needs.

Testing of paper handsheets and pilot paper machine samples methods were carried out in accordance to the Technical Association of the Pulp and Paper Industry (TAPPI) testing methods such as:

- Grammage, TAPPI (T 410 om-08)
- Thickness, TAPPI(T 411 0m-05)
- Taber stiffness of paper, TAPPI (T 489 om-08)
- Air resistance of paper, Tappi (T 460 om-06)
- Brightness of paper, Tappi (T 452 om-08)
- Opacity of paper, Tappi (T 425 om-06)
- Tensile strength of paper, Tappi (T 494 om-06)
- Internal tearing resistance of paper, Tappi (T414 om-04)
- Ash in paper @ 525oC, Tappi (T 211 om-07)

Accomplishments achieved for the award period 08-16-2010 to 09-30-2012 are as follow:

All major project tasks described below were completed. The project showed that a fiber filler composite material can increase the filler content in paper without loosing needed properties and therefore saving energy and manufacturing costs.

During the research project the following was produced:

(i) approximately 1,500 paper handsheets,

(ii) approximately 3.2 linear miles of paper with the 12” pilot paper machine and

(iii) approximately 10,000 data points.

1. **<u>Progress by Task and Milestone</u>:**

Task 1.0 Potential Environmental Benefits Assessment

For the potential environmental benefit assessment the below listed energy data from the 2005 DOE Energy and Environmental profile of the U.S. Pulp and Paper industry will serve as a base line [37].

Papermaking energy average up to 6.26 mkJ/ton (5.93mbtu/ton)

Stock Preparation energy average (SP) up to 0.80 mkJ/ton (0.76mbtu/ton)

Forming, Pressing & Finishing energy average (FPF) up to 1.44 mkJ/ton (1.33mbtu/ton)

Drying energy average (D)up to 5.00 mkJ/ton (4.74mbtu/ton)

Table 1 shows the accumulated estimated energy savings in tbtu/year, total CO_2 emissions saved in mlb/year and estimated economic benefits in m$/year.

The shown values in the benefit table are based on the following assumptions:

i. Assuming a successful pilot plant study and successful mill trial which will lead to a first industrial commercial implementation.

ii. Energy savings are estimated with 10%in SP, FPF and D for a unit size of 500t/day of paper.

iii. Energy production using lignite coal at a rate of 215 lbs of CO_2 emitted per million btu of energy produced. Many paper mills have coal fired power plants.

iv. Market pulp price of $600/ton (please note: market pulp price varies due to international trading)

v. Filler increase of 5% at filer price of $150/ton and a filler base level of 20%

vi. Economic benefit based on iv and v of $22.5/ton of paper produced if a 5% filler increase can be achieved.

vii. Energy cost of $5 per mbtu

viii. $ 15 per ton of CO_2 emitted

Table 1: Benefit Table:

Year	*Installed Systems*	*SP (tbtu)*	*FPF (tbtu)*	*D (tbtu)*	*Total (tbtu)*	*CO2 (mlb)*	*Saving (m$)*
2014	***1***	***0.014***	***0.024***	***0.086***	***0.124***	***26.66***	***4.908***
2015	***4***	***0.056***	***0.096***	***0.344***	***0.496***	***106.64***	***19.632***
2016	***10***	***0.140***	***0.240***	***0.860***	***1.240***	***266.6***	***49.080***
2017	***19***	***0.266***	***0.456***	***1.634***	***2.356***	***506.54***	***93.252***
2018	***31***	***0.434***	***0.744***	***2.666***	***3.844***	***826.46***	***152.148***
2019	***46***	***0.644***	***1.104***	***3.956***	***5.704***	***1226.36***	***225.768***
2020	***64***	***0.896***	***1.536***	***5.504***	***7.936***	***1706.24***	***314.112***

a) A performed evaluation of 14 commercially produced papers revealed that the actual filler level of industrial manufactured paper is closer to 15%+-3%. Therefore, a significant potential for improvement in the North Americas paper industry is possible.

b) Research trials showed that new fiber filler material could be produced with a filler level of over 100%. However, manufacturing a paper with such a filler content would not allow to achieve the needed paper properties. However, mixing a high filler content fiber solution with the base fibers might reveal improved paper properties.

c) Laboratory trials indicate that a filler level in the paper product can be increased from 7.9% to 14% or by 6.1% representing a 70% increase of total filler material I n the paper product.

d) Composite fiber filler material achieves up to 60% higher tensile strength than commercial available filler at same filler level.

e) A performed life cycle analyses predicts that up to $45,000,000/year in savings for a 1000 tons/day paper production facility including al associated equipment costs and depreciation might be possible.

f) Return of Investment (ROI) of the equipment used to produce the new fiber filler material including depreciation and interest is estimated to be 1.5 years or viewer for a 50 ton/day operation and below 1 years for a 1000 ton/day operation.

Task 2.0: Establish a Base Line

This task involved the analysis of 13 different commercial copy papers. From the selected copy papers physical, strength and optical paper properties were tested to establish a base line for comparison with the Fiber Filler Composite Material. This study resulted in over 1000 individual analyzed samples.

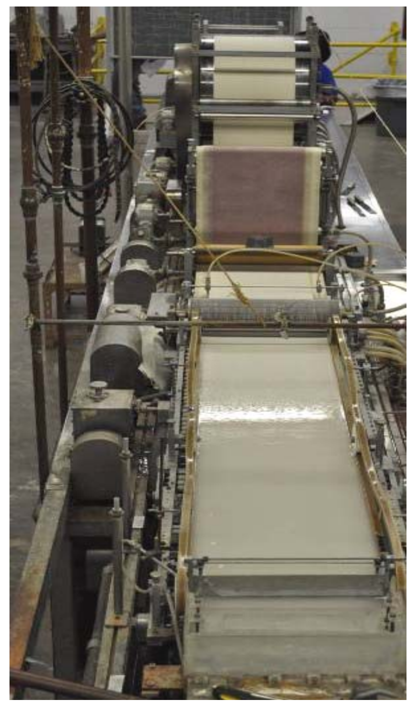

Figure 1:
Pilot Paper Machine

Second, this task involve production of copy paper with an 80% hardwood (HW) and 20% softwood (SW) split using northern US softwood and hardwood materials as well as eucalyptus market pulp and incorporating a target filler content of 0%, 10%, 20%, 30% and 40% with a 12" laboratory paper machine. The results served as a base line for the 12" paper machine testing. This study resulted in over 3000 individual analyzed samples. This study included a refining investigation that produced over 200 made handsheets and over 100 analyzed individual samples.

Task 3.0: Generate Fiber-Filler Composite Material:

Fiber-Filler Composite material (Picture 2) was generated with a designed precipitation unit located at the Environmental Laboratory at the SUNY-ESF PBE

Pilot Plant. The precipitation unit could produce a filler content of over 100% in the pulp suspension.

During the course of the research a smaller system needed to be designed to accomplish the smaller amount of material needed for trials and therefore, generate a substantial savings in raw material and time needed and therefore cut cost for the research project. The small laboratory unit started up in July 2011 allowing to produce a Fiber-Filler Composite material with up 60% filler content. Research trials also showed that a filler content over 100% can be achieved based on fiber material in the pulp suspension.

Task 4.0: Determine Best Fiber-Filler Composite Process: (completed)

This part of the research project implementing gained knowledge from Tasks 2, 3, 5, and 6 in planning trials in for the 12" pilot paper machine. This task was interrupted by a severe summer rain storm that damaged the pilot plants power supply this resulted that no work could be performed till end of May 2011. After the repairs the study continued investigating the effect of the fiber filler material on paper properties with various paper machine runs under different conditions.

Task 5.0: Compare different Fiber-Filler Composite Materials: (completed)

This task included knowledge gained from previous task s 2 to 4 incorporating conventional filler material with the fiber filler composite material. Work was started by executing first Fiber-filler Material trials with the new designed small laboratory unit and

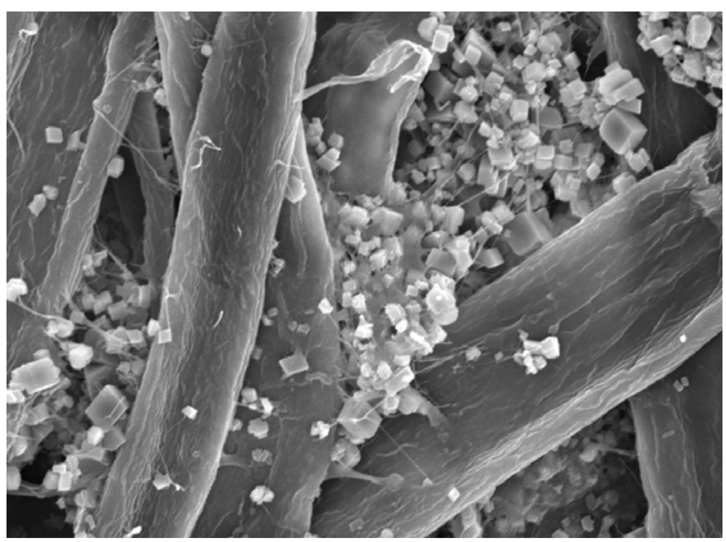

Figure 2: SEM Picture of Fiber Filler Material SEM

preparing paper products with a 12” laboratory paper machine. Results revealed that conventional filler material can be used to offset some optical deficiencies the fiber filler composite material has due to the usage of the low grade lime that was used to produce the fiber filler composite material. However, a high grade optical fiber filler composite material could be produced if filler grade lime would be available. For this research project we did not have this lime material available.

Task 6.0: Evaluate Lowest Basis Weight for Paper Production:

Work was started by gathering basic information and analyzing commercial paper properties. Results show that it is possible to decrease the basis weight of paper by 5 g/m^2 due to the higher strength properties the paper product with the Fiber Filler Composite material.

Task 7.0: Compare Fiber-Filler Composite Copy Paper to Commercial Copy Paper:

Based on 12” laboratory paper machine trial results the new Fiber –Filler Composite material can in some instances yield an up to 60% higher breaking length at same filler level. This will allow an estimated filler increase in the paper product of over 5%.

Task 8.0: Life cycle Analyses of the Process:

Today’s paper making operations are very dependant on energy and raw material resources. Incorporating higher filler content and repurposing raw material can have a significant impact on a paper mills operational cost.

The assumptions for a fiber filler material system shown in Figure 1 and its estimated cost savings for the production of a 100% hardwood digital printing paper product are based on hypothetical digital printing paper mills with a production range of 100 to 1000 metric tons shown in Figure 1. It was assumed that the paper mill is using:

(i) 20% softwood and 80% hardwood pulp for the production of digital printing paper,

(ii) Operating on 350 days/year,

(iii) Softwood and hardwood pulp cost of $980 and $880 per ton,

(iv) Paper drying cost of 1,700,000btu/ton,

(v) Estimated system cost for the fiber filler composite material production of $1,800,000 for a 50 ton/day to $8,000,000 for a system size of 1,000 ton/day including machinery and depreciation,

(vi) Eestimated system cost for CO2 recovery equipment of $620,000 for a 0.3 ton /hour to $6,000,000 for a system size of 10 ton/hour including machinery and depreciation,

(vii) Commercial filler cost of PCC $175 per ton and,

(viii) Estimated filler production cost of $127 per ton for a system capacity of 50 ton/day to $78 for a system capacity of 1000 ton/day,

(ix) Commercial CO_2 price of $110 per ton if CO_2 recovery is not feasible.

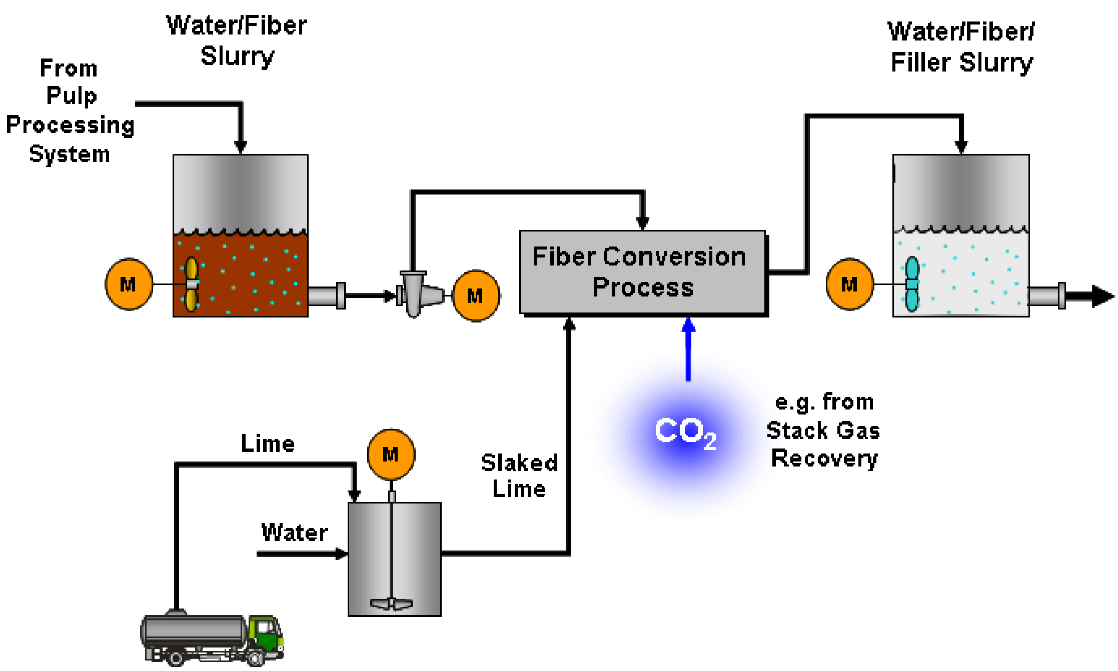

Figure 3: Fiber Filler Manufacturing System

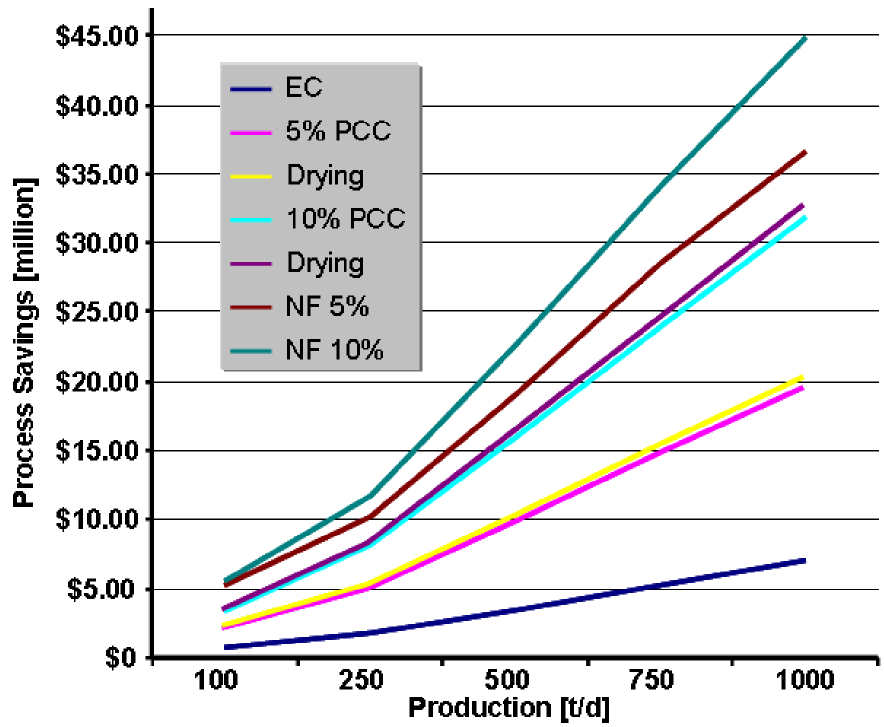

Figure 4: Savings potential using 100% hardwood, PCC and fiber filler material

Estimated cost savings, shown in Figure 2, for the assumed digital printing paper mill with a production range of 100 tons to 1000 tons per day can be in the range of: **(i)** $700,000 to $7,000,000 by replacing softwood/hardwood mix with 100%hardwood pulp , **(ii)** if a filler increase of 5% or 10 % with commercial PCC can be achieved a cumulative savings of $1,996,000 to $19,960,000 for the 5% filler increase and $3,253,000 to $32,530,000 for the 10% increase is possible and, **(iii)** cost saving for applying the fiber filler composite material can be in the range of $5,600,000 to $44,900,000. The mill is assumed to use 100% eucalyptus fiber material.

Task 9.0: Preliminary Design of a Laboratory and Pilot Fiber-Filler Composite System:

Small Fiber-Filler Composite research and development runs were completed. Small laboratory units for the PBE Environmental Laboratory was designed, build, and stated up in July 2011. Preliminary process design of a versatile laboratory unit, able to supply the SUNY-ESF Paper Engineering Departments 48” paper machine was completed and could be built if further funding would be available.

2. Scope issues:

A no cost extension was filed to bring the project back on track due to the following:

i. Availability of the pilot plant due to customer trial and teaching use
ii. Main power supply damage through severe rain storm on 4/26/2011 resulting in a 8 week unavailability.
iii. New fiber-filler preparation systems was designed and build to produce fiber filler material in smaller batches for the 12” laboratory paper machine.
iv. A no cost extension was granted till 08/15/2012. Table 1a-Task Schedule, Table 1b-Milestone Schedule and Milestone chart were updated based on the granted extension.

3. Patents:

During the project report the two patent invention disclosures listed below were filed:

One patents disclosure was filed during the award period from 10-01-2010 to 12-31-2010
Title: filler Process to “Fiber-Filler Composite Calcium Carbonate (FFC^3) Material”
Date of Conception 11-22-2010
File date with SUNY-ESF Research Foundation 12-06-2010
Informed DOE Golden Field Office, Project Monitor, DOE Case No. S-126,496

A second patents disclosure was filed during the award period from 01-01-2011 to 03-31-2011
Title: filler Process to “Paper Making Process for Fiber-Filler Composite Calcium Carbonate (FFC^3) Material”
Date of Conception 02-15-2011
File date with SUNY-ESF Research Foundation 02-15-2010
Informed DOE Golden Field Office, Project Monitor, DOE Case No: S-126,679

4. Publications / Presentations:

The following papers were presented:

Doelle K., Bajrami B., Ali M., Mahmud S., (2011), “Optimum Calcium Carbonate for Uncoated Digital Printing Paper“, 106th Zellcheming Annual Meeting and Expo, June 26th to 30th, 2011, Rhein-Main Hallen, Wiesbaden, Germany

Doelle K., (2011), “Ein neuer Hybridverbundwerkstoff aus Fasern und Füllstoff: Vergleichende Pilotuntersuchung verschiedener Füllstoffe zur Eigenschaftsentwicklung von Digitaldruckpapieren “, PTS Pulp Technology Symposium – Pulps for the Future, Nov. 22nd to 23rd, 2011, art’hotel Dresden, Dresden, Germany

5. Commercialization Status:

The Research project was presented and promoted to eight international paper companies the companies that expressed interest in the research. No commercial application or further research was conducted.

Conclusion:

The main objective of this study was to investigate how a new fiber filler material can save production cost for the copy paper manufacturing process. Results show that the new fiber filler material has the potential to improvement tensile strength values. This reveals that the new fiber filler material has the potential to either fully or partially substitute commercial filler material and achieve a possible higher filler level for digital printing paper.

12” pilot machine trials confirmed that the new fiber filler material can outperform conventional filler materials.

The new fiber filler material can enhance filler level as stand alone filler material.

The mew fiber filler material can enhance filler level if combined with conventional filler materials.

Using PCC grade lime has the potential to increase optical properties.

Filler level increase of up to 12% is might be possible.

The new fiber filler material can achieve a filler level of >60% in fiber suspension.

The new Fiber Filler Material has a 50% retention value w/o using retention aids.

Return of Investment in the range of 1.5 years to .5 years for production size of 100 ton/day to 1000 ton/day. However, return of investment values are very dependant on paper mill set up and size. Each fiber filler system needs to be designed for the individual mill application and therefore it is expected that return of investment values are mostly in the 1 to 2 year range.

The study showed that not only filler material can help to save cost in the paper production. It is also possible to produce copy paper with 100% hardwood content. This could lead to significant savings in fiber material cost.

Recommendations and Outlook:

Outlook:

The past research project will help to:

(i) Apply for future funding in the advanced manufacturing field,

(ii) Provide topics for further graduate research on process and paper properties if funding becomes available and,

(iii) Provide publishable material with other research projects for technical publications in journals such as the TAPPI solutions magazine.

Recommendation:

If future funding should become available it is suggested to carry out the following tasks and investigations:

(i) Design and build a pilot scale fiber filler material unit large enough to run pilot paper machine trials at a 48” (1219 mm) wide pilot paper machine at the pilot plant at SUNY-ESF Department of Paper and Bioprocess Engineering.

(ii) Full scale 48” (1219 mm) paper machine trials at the SUNY-ESF Department of Paper and Bioprocess Engineering pilot plant to prove the concept in a semi commercial scale and attract paper mills attention for the project,

(iii) In depth investigation of Fiber Filler Composite Material in regards to: **a)** perform a laboratory paper machine study to investigate interaction of the fiber filler composite material with commercial filler material, **b)** laboratory paper machine study to compare different commercial available fiber and filler materials , **c)** pilot paper machine and process trials with full scale 48” (1219mm) paper machine run at SUNY-ESF Department of Paper and Bioprocess Engineering in conjunction with paper manufacturers producing an actual commercial grade copy paper with the fiber filler composite material,

(iv) Update Life Cycle Analyses based on 48” pilot paper machine results.

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