GRI’s Fibrous Filler Technology

April 5th, 2006

Presented by:
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AGENDA
April 5th, 2006

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Background and Acknowledgements

- **Project Title:** Fibrous Fillers to Manufacture Ultra-High Ash / Performance Paper
- **Project Number:** DE-FC07-0131D14439
- **Principal Investigator:** Dr. Vijay K. Mathur
- **Industrial Partners:**
  - Weyerhaeuser Company
  - Grays Harbor Paper Company
  - Lawrence Livermore National Laboratories
  - Pennsylvania State University
  - University of Washington
Statement of Problem
Statement of Problem

- The Paper Industry currently uses fillers to reduce manufacturing cost and energy consumption.
- The problem is that the current fillers cause a **Loss in Paper Strength**
  - This is due to their size, shape, and aspect ratio.
- This strength loss limits the amount of filler added into paper to ~15% to 18%.
GRI Technology Solutions and Innovations
I. “Fibrous Fillers:” Patented Calcium Silicate Products
   - Silicate nano-fibers (SNF / Tech-8) - ultra-high opaque pigment
   - Silicate macro-particle (SMP / Tech-4) - ultra-high bulk pigment
   - Silicate macro-particle low-drying demand (SMF-LDD / Tech-6) – lower drying demand and ultra-high stiffness (intrinsic stiffness)

II. “Super” PCC / Tech-2: Patented High Pressure Process

III. Chemical Pretreatment for Fillers (Licensed from Weyerhaeuser)
Silicate Nano-Fibers (SNF)

Products
Tech-8 SEMs

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Silicate Macro-Particle (SMP)

10 µm

1 µm

Confidential
Proprietary
“Fibrous Fillers”

“Super” PCC for Fillers

Nano-Clustered PCC

Scalenohedral
G.R. International
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GRI Technology Solutions

Brightness

Normalized Opacity
(to 74 gsm)

Filler (%)

Filler (%)

PCC (HO)  SNF  SMP

PCC (HO)  SNF  SMP

Calendared
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GRI Technology Solutions

Bulk

Smoothness (Felt-Side)

Calendared
Multifunctionality of SNF

- Caliper
- Sheffield Smoothness
- Filler Scattering Coefficient
- Sheet Scattering Coefficient
- ISO Opacity
- ISO Brightness
- Tensile Index
- Stiffness
- Porosity
- Bulk

Calendared
Multifunctionality of SNF

- Caliper
- Sheffield Smoothness
- Filler Scattering Coefficient
- Sheet Scattering Coefficient
- ISO Opacity
- ISO Brightness
- Tensile Index
- Porosity
- Stiffness

PCC

PCC + 7% TiO2

Calendared
Multifunctionality of SNF

- Caliper
- Sheffield Smoothness
- Bulk
- Filler Scattering Coefficient
- ISO Opacity
- Porosity
- Sheet Scattering Coefficient
- ISO Brightness
- Stiffness
- Tensile Index

Legend:
- Blue: PCC
- Green: PCC + 7% TiO2
- Red: SNF

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Calendared
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GRI Technology Solutions

Basis Weight Reduction Economics

Filler Savings Per Ton (OD)

$0 $10 $20 $30 $40 $50 $60

Basis Weight (lb/3300ft2)

- 12% PCC/0% SMP
- 7% PCC/13% SMP
Integrated Mills

TiO₂ Reduction Economics
(Total Ash: 20%)

Filler Savings Per Ton (OD)

$150
$125
$100
$75
$50
$25
$0

Percent TiO₂ Replaced by SNF

0 2 4 6 8 10
The Key Innovations are:

- **Fiberous Crystals from Inorganic Materials (Calcium Oxide and Silica)**
  - US Patent #: 6,726,807B1

- **Multifunctional Performance of “Fibrous Fillers”**
  - Improves Sheet Bulk, Porosity, Smoothness, Optical, and Strength Properties Simultaneously

- **Pressure Carbonation System to Produce Super Precipitated Calcium Carbonate at 400% to 600% Higher Reaction Rates**
  - US Patent #: 6,251,356

- **Producing Multiple Pigments, “Fibrous Fillers” and Calcium Carbonates, From a Common Reactor**
  - US Patent Allowed, Serial # 09/797,173
Project Objectives and Schedule
Project Objectives and Schedule

◆ Objectives:
  • Techno-Economic Viability of Manufacturing “Fiberous Filler”
  • Low Cost Super Precipitated Calcium Carbonates (S-PCC) or Tech-2
  • Prototype Plant for Scale-Up of Fiberous Filler Technology

◆ Schedule
  • Initiation Date: 4/14/03
  • Original Expected Completion Date: 9/30/06
  • Revised Expected Completion Date: 4/13/06
Status of Milestones

/ Key Issues
The Key Issues are:

- **Could Not Complete the Work on Interfacial Interaction, Paper Structure, and Paper Properties**
  - Task I: University of Washington

- **Partially Completed the Mechanism of Formation of “Fiberous Fillers”**
  - Task II: Lawrence Livermore National Laboratories

- **Partial Completion of Application of “Fiberous Filler” in Surface Treatment Formulations**
  - Task V: Western Michigan University
Projects Output / Key Accomplishments
Objective I Accomplishments:
- Development and Validation of Techno-Economic Viability
- Techno-Economic Viability Manufacturing Demonstration of:
  - Silicate Nano-Fibers (SNF) or Tech-8
  - Silicate Micro-Fibers (SMF-LDD) or Tech-6
  - Silicate Micro-Particles (SMP) or Tech-4

Objective II Accomplishments:
- Development and Validation of S-PCC or Tech-2

Objective III Accomplishments:
- Designed, Engineered, and Erected the Prototype Plant to Produce Multiple Pigments
  - Tech-6, Tech-4, and Tech-2
Commercialization
Barriers / Economics
Barriers to Commercialization

- Market Resistance to New Silicate Technology
- 1st Commercial Validation of Technology

Economics of a Typical Multiple Pigment Plant

- Capital (millions): ~7.0
- Revenue (millions): ~13.5
- ROI(%): ~31.0
Commercialization Plan and Strategy
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Commercialization Plan

R&D Stage

1997: Concept
2000: Lab Reactor
2001: Bench Reactor
2002: Commercial Scale-up
2003: DOE Funding

Commercialization

2005: Prototype Plant
2006: First Commercial Plant
2007: Commercialization
2011: Commercialization
Financing Strategy

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Pigment/Chemical Manufacturers

GRI

Licensing

Strategic Partners/Customer

Debt/Equity Partners

Debt

Equity
Energy Efficiency
Papermachine Dryer Steam Consumption As A Function Of Press Solids
*Steam Temperature 230 - 266 °F

Range for 230 - 266 °F (steam 21- 39 psia)
## Energy Savings (Trillions BTU/yr)

<table>
<thead>
<tr>
<th>Mill Type</th>
<th>Savings (Trillions BTU/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulp Mill*</td>
<td>31.5</td>
</tr>
<tr>
<td>Paper Mill**</td>
<td>11.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>43.0</td>
</tr>
</tbody>
</table>

* 1000 ton pulp mill vs. 600 ton pulp mill and 400 ton "Fiberous Filler" mill

** Press Solids increased from 45% to 55%
### Potential Savings To U.S. Industry

<table>
<thead>
<tr>
<th>Product</th>
<th>Attainable Savings $/ton</th>
<th>Industry Usage (tons)</th>
<th>Total Attainable Savings (per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNF (TiO₂ Reduction)</td>
<td>$900</td>
<td>90,000</td>
<td>$81 million</td>
</tr>
<tr>
<td>SMP (Bulk, Stiffness, Basis Weight Reduction)</td>
<td>$15</td>
<td>20,000,000</td>
<td>$300 million</td>
</tr>
<tr>
<td>Energy Savings (Paper Mill)</td>
<td>$12</td>
<td>20,000,000</td>
<td>$240 million</td>
</tr>
<tr>
<td>Incremental Pulp Profits (10% Filler Increase)</td>
<td>$200</td>
<td>1,000,000</td>
<td>$200 million</td>
</tr>
<tr>
<td>PCC (Lower Cost)</td>
<td>$20</td>
<td>1,000,000</td>
<td>$20 million</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>$841 million / Year</strong></td>
</tr>
</tbody>
</table>
Current Status

- Building The Prototype / Commercial Plant
"Fibrous Fillers"

**Pigment Mill**
- SiO₂
- Ca(OH)
- SMP
- SNF
- Lime Slaking

**Pulp Mill**
- Ca(OH)₂ + SiO₂ → CaSiO₃·H₂O
- Ca(OH)₂ + CO₂ → CaCO₃ + H₂O
- Precipitated Calcium Carbonate

**Paper Mill**
- Fibrous Fillers
- Paper Mill

- Recovery (Lime Kiln)
- Power

Boiler
50# GH Offset HiBright SM PM#1
Grays Harbor Paper - March 28th, 2006

Brightness (ISO)

Pretrial          Trial
50# GH Offset HiBright SM PM#1
Grays Harbor Paper Trial - March 28th, 2006

Smoothness Felt Side (Sheffield)

Pretrial

Trial

Pre-Trial

Trial
50# GH Offset HiBright SM PM#1
Grays Harbor Paper Trial - March 28th, 2006

Pretrial
Trial
50# GH Offset HiBright SM PM#1
Grays Harbor Paper Trial - March 28th, 2006

Steam Pressure (Main Dryer Section)

- Pre-Trial: Very High Pressure
- Trial: Moderate Pressure

Pretrial
Trial
Date: April 4, 2006  
From: Bob Brennand  
To: Operations  
Subject: Preliminary GRI S-PCC Trial Results  

Summary  
Though we have not trialed the S-PCC on a wide variety of products yet, the following properties improved on both machines during the second (March 28th) trial: Steam Usage, Brightness, HST, and Sheffield Smoothness. Several other properties (CD Stretch, CD & MD Tensile Energy Absorption, Burst, and Porosity) improved on one of the two machines, and some properties deteriorated on one of the two machines (Caliper/Bulk, Porosity, and MD & CD Stiffness). Considering the short time the GRI reactor has been operating, the results to date are very encouraging, and I think there is room left for fine tuning the S-PCC manufacturing process. Further trials in the future should be performed on a wider variety of paper products, but the data so far indicates the S-PCC is very close to being “qualified” at GHP.
Path Forward

GRI and our industry partners are requesting an extension of the project by one year, so that we can:
1. run extended trials
2. continue research on energy savings
3. continue research on cost reduction
4. meet original program objectives