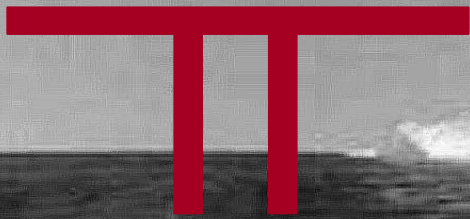


DYADIC<sup>®</sup>

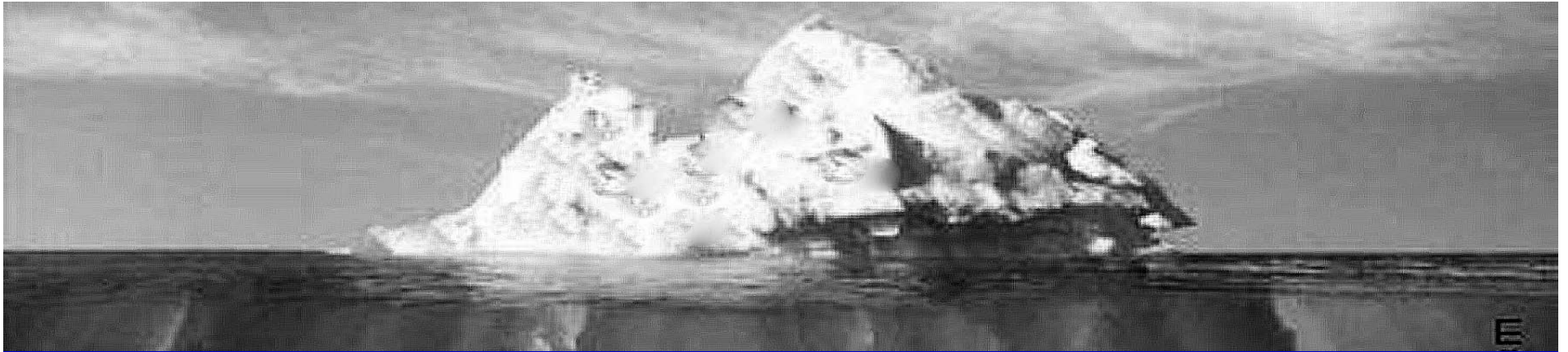


Dyadic International (USA), Inc.

“Enhancement of Wood Pulps by Cellulase Treatment”

August 30, 2005





# Enzymatic Biorefining Overview



# Mechanical Refining of Pulp

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- **Fibrillation**
- **Hydration**
- **Cutting**
- **Brushing of Fiber**
- **Fines Formation**
- **Colloidal Debris Formation**

# Effects of Excessive Fines/Colloidal Material in Paper Making

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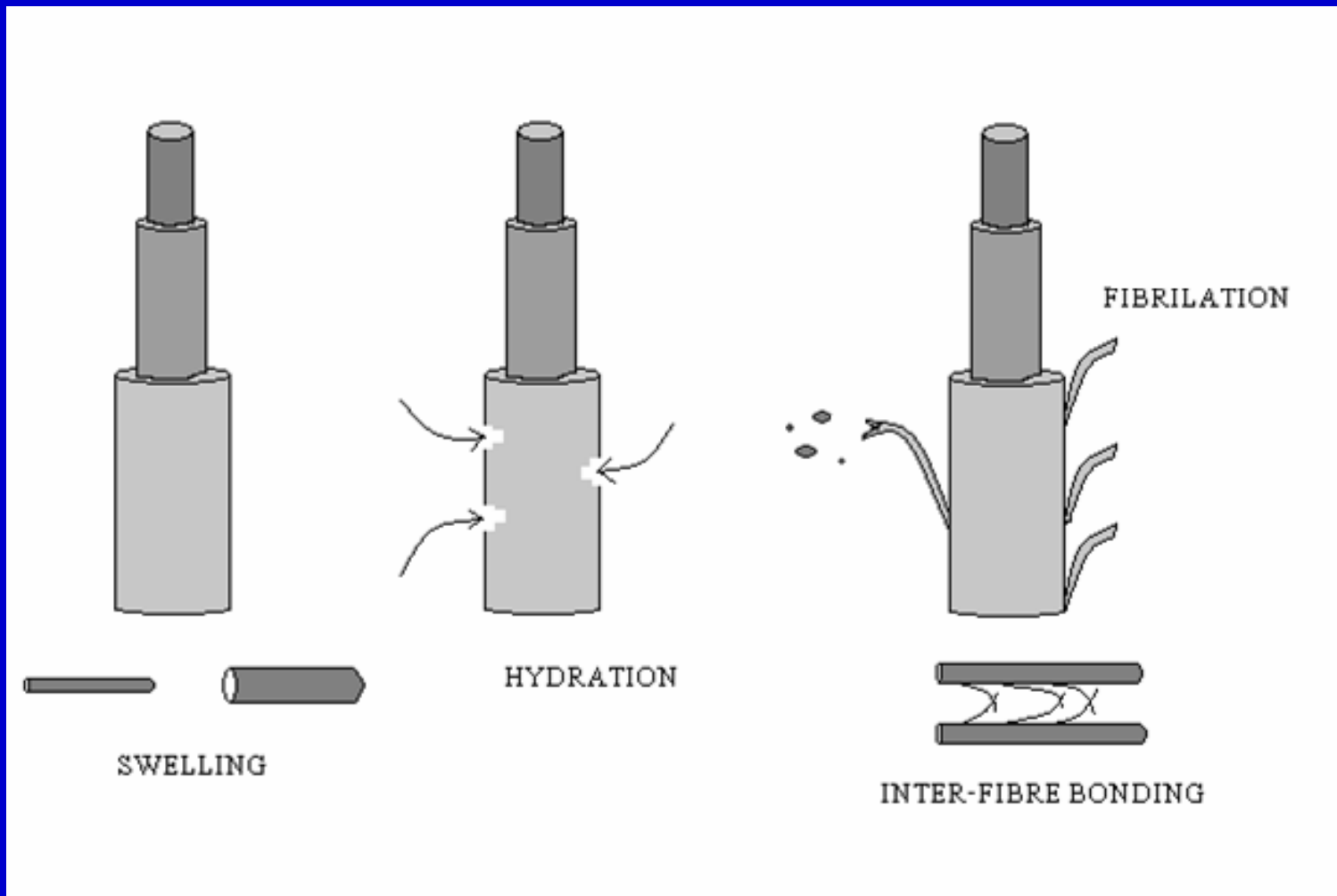
- Reduce paper strength
- Fines build-up in closed water loops
- Reduce drainage rate
- Increase steam load
- Increase linting/dusting
- Reduce PM speed/production

# Biorefining Enzyme Actions

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- **Mild, non-aggressive enzyme activities from *Chrysosporium lucknowense* (C1)**
- **Multi-Component Enzyme Complexes**
  - » **Enhanced activity within complex, variable furnishes**
  - » **Beneficial fiber modification**
    - **Good quality fiber with lower colloid levels**
    - **High quality paper plus enhanced paper making**
    - **Refiner optimization possible**

# Proposed Biorefining Mechanisms

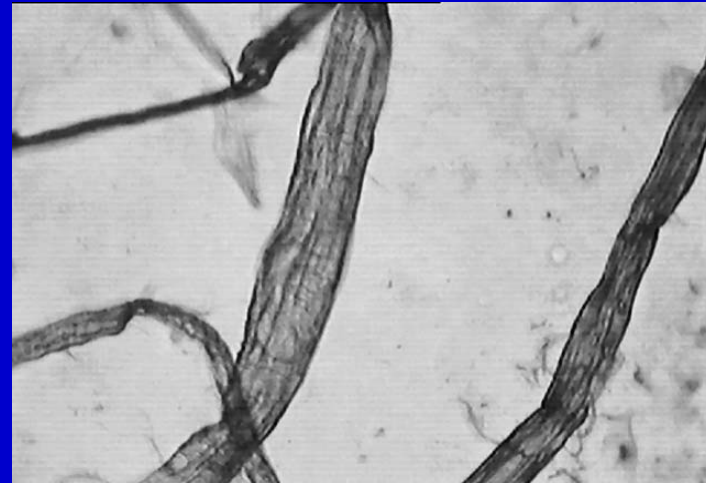


# Biorefining of Eucalyptus Fibers

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Control



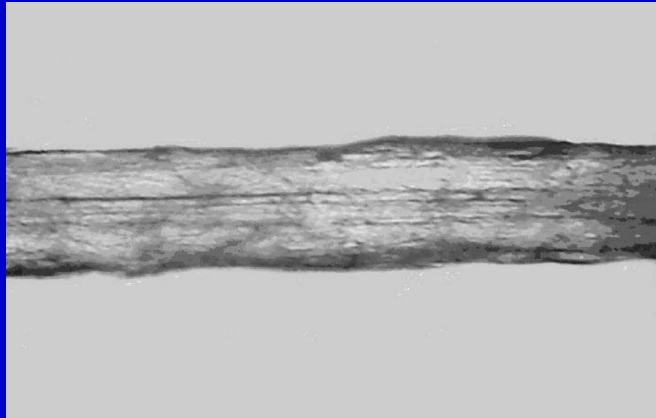
Mechanically Refined



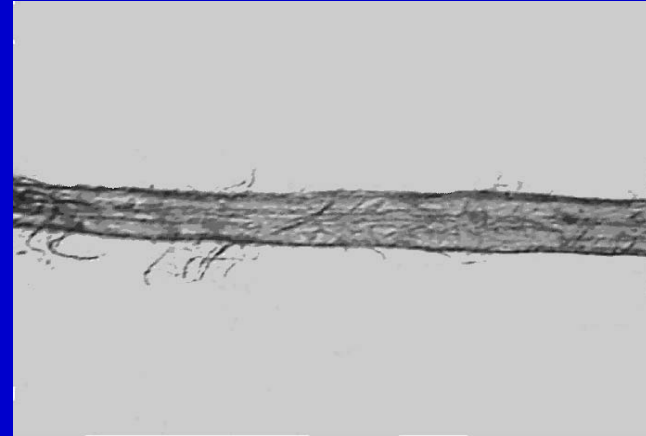
Biorefining + Refining

# Biorefining of Softwood Fibers

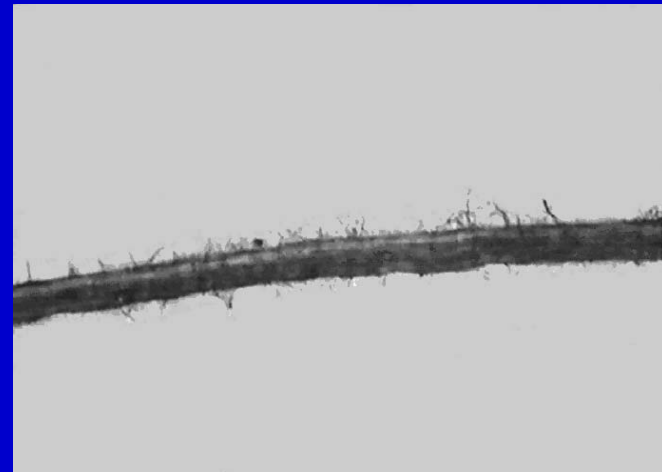
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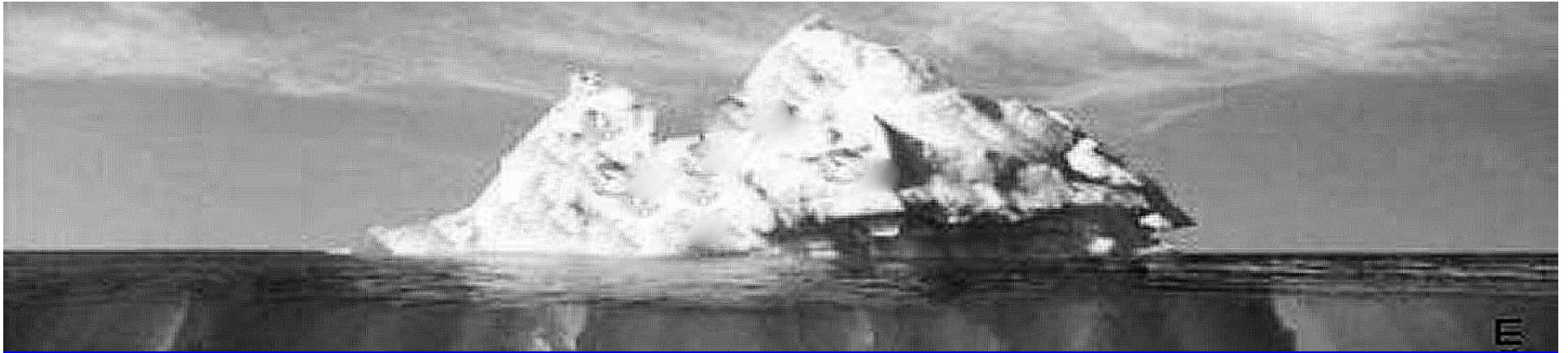
Control



Mechanically Refined



Biorefining + Refining



# Enzymatic Biorefining Mill Results



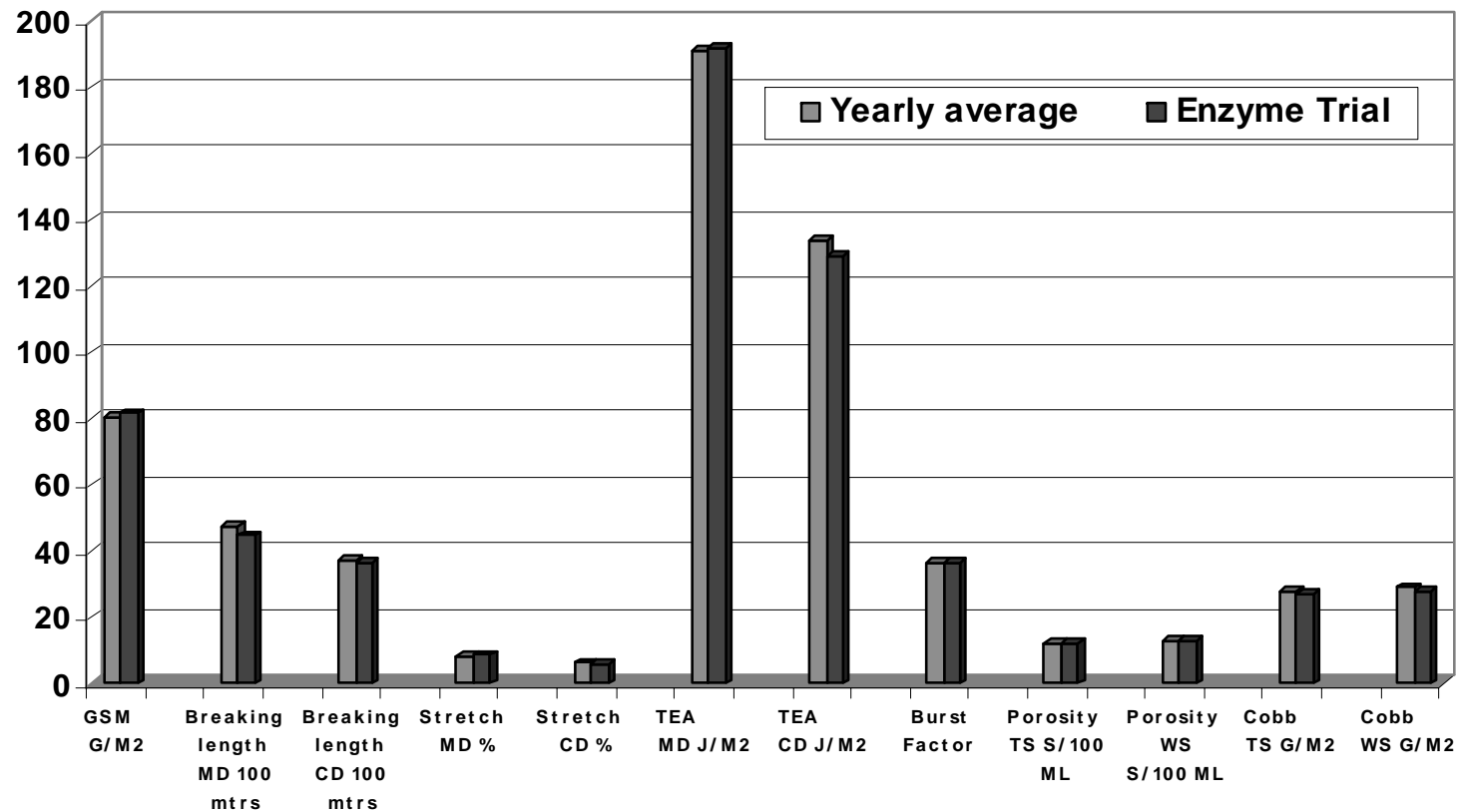
# Mill Example #1 – Packaging Paper

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<b>Mill Location:</b>	<b>India</b>
<b>Paper Produced:</b>	<b>Extensible Sack Paper</b>
<b>Furnish:</b>	<b>Bamboo, waste paper</b>
<b>Enzyme dose:</b>	<b>0.160kg enzyme/ton dry pulp</b>
<b>Enzyme addition place:</b>	<b>Pulpers</b>
<b>Pulp processing temperature:</b>	<b>50°C, 122°F</b>
<b>Pulp pH:</b>	<b>7.0</b>

# Refining Energy Savings & Strength Properties - Mill #1

Energy Savings of \$2.80 per ton

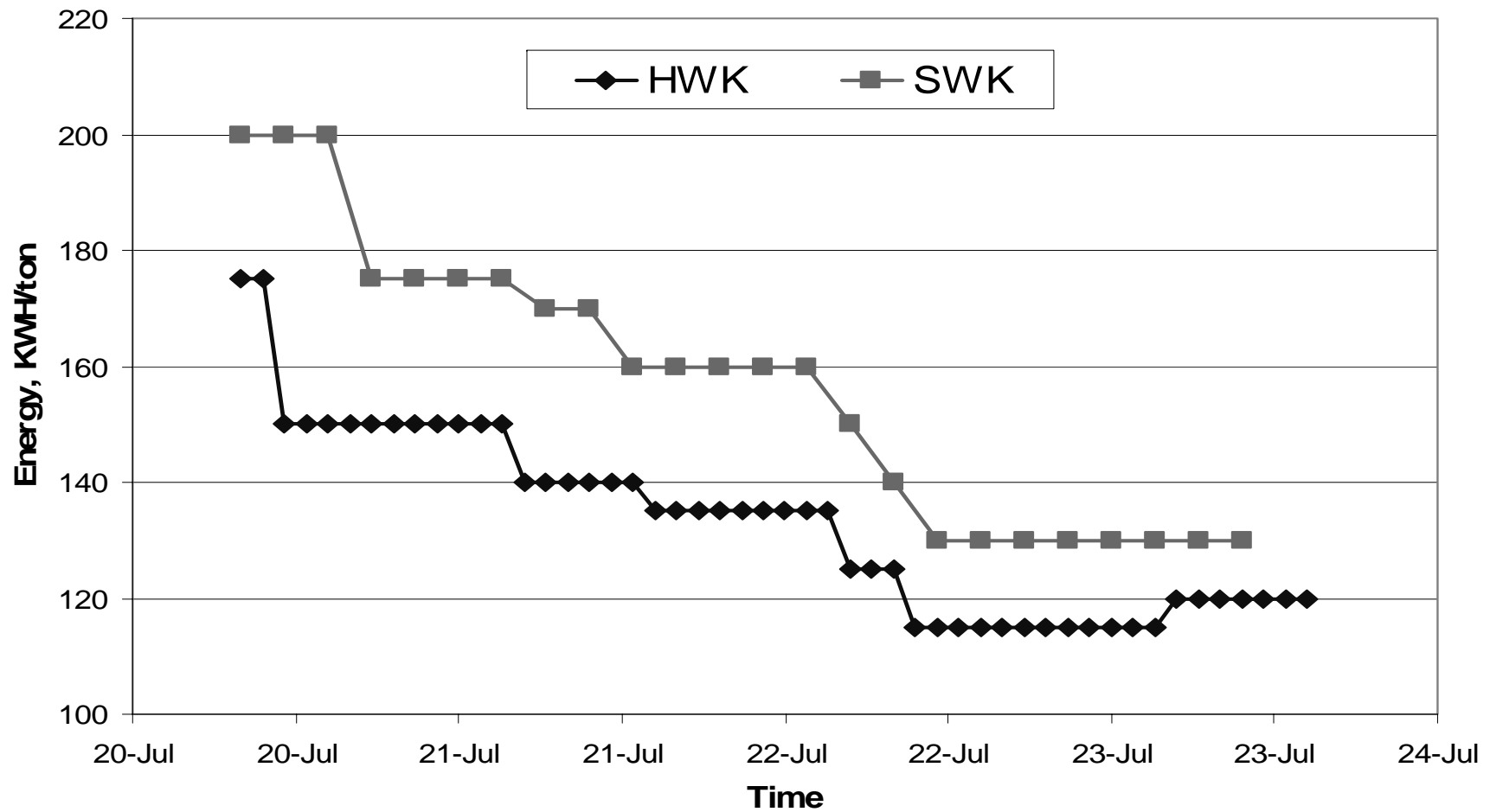


# Mill Example #2 – Graphic Coated Board

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<b>Mill Location:</b>	<b>India</b>
<b>Paper Produced:</b>	<b>Coated Graphic Paper/Board</b>
<b>Furnish:</b>	<b>Virgin SWK &amp; HWK</b>
<b>Enzyme dose:</b>	<b>0.092kg enzyme/ton dry pulp</b>
<b>Pulp production:</b>	<b>300 Ton/day</b>
<b>Enzyme addition place:</b>	<b>Batch Pulper</b>
<b>Pulp processing temperature:</b>	<b>40°C, 104°F</b>
<b>Pulp pH:</b>	<b>7.0</b>
<b>Retention time:</b>	<b>180 minutes</b>

# Energy Reduction in Mill #2



# Biorefining Benefits for Mill #2

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- **Saved 75 KWH per softwood ton**
- **Saved 60 KWH per hardwood ton**
- **Increased softwood line capacity**
- **Saved 300 kgs of steam per paper ton**
- **Final paper quality maintained**
- **Reduced chemical usages**
- **Cleaner water loop**

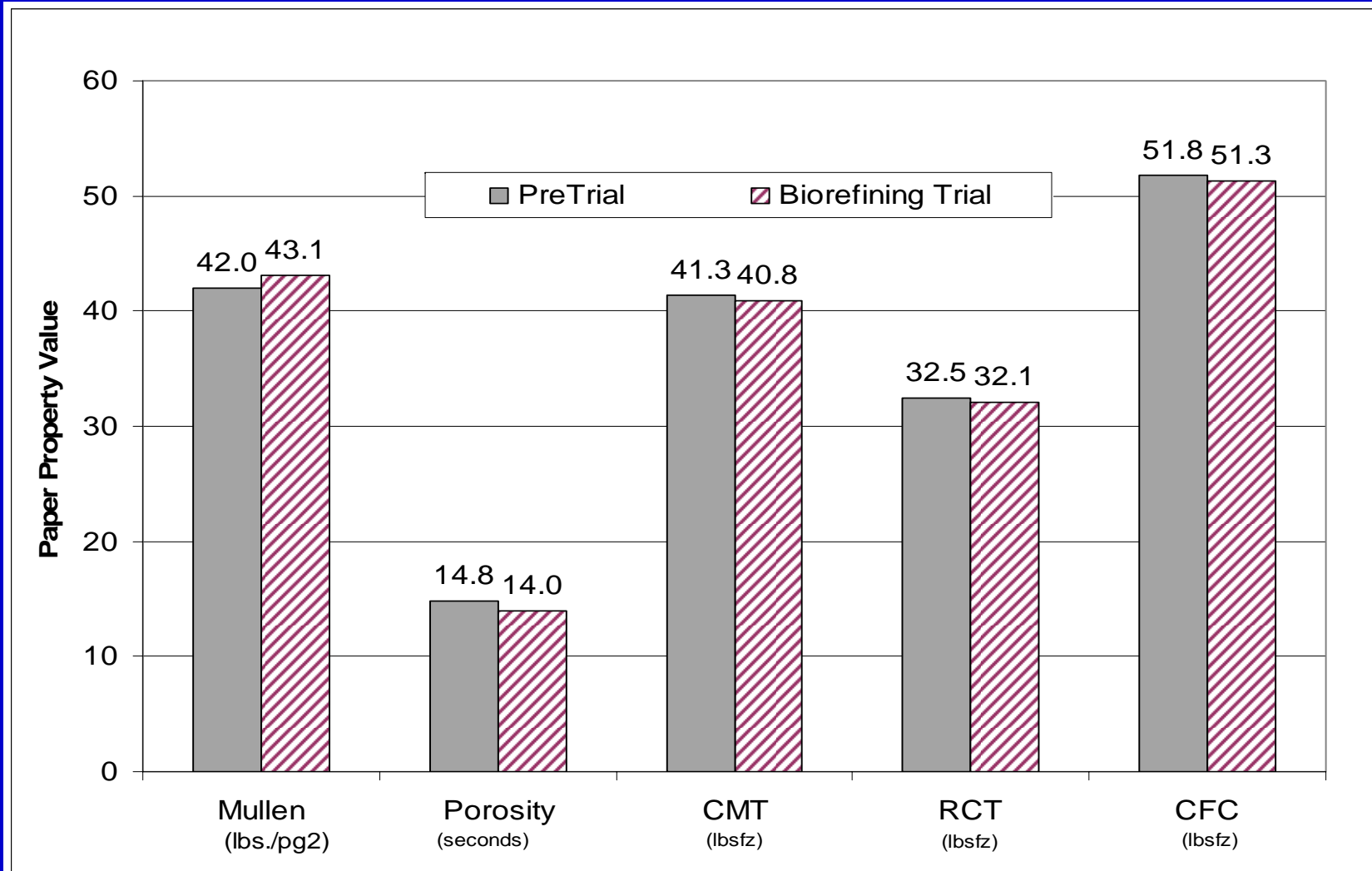
# Mill Example #3 – Liner & Medium

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<b>Mill Location:</b>	<b>Mexico</b>
<b>Paper Produced:</b>	<b>Linerboard &amp; Medium</b>
<b>Furnish:</b>	<b>OCC</b>
<b>Enzyme dose:</b>	<b>0.125kg enzyme/ton dry pulp</b>
<b>Pulp production:</b>	<b>150 Ton/day</b>
<b>Enzyme addition place:</b>	<b>Continuous Pulper</b>
<b>Pulp processing temperature:</b>	<b>45°C, 115°F</b>
<b>Pulp pH:</b>	<b>7.0</b>
<b>Retention time:</b>	<b>90 minutes</b>

# Paper Strength Properties – Mill #3

Paper Basis Weight = 127 grams per square meter



# Mill #3 Trial Results - Summary

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- **Reduced refiner energy usage by 34 KWHr/ton**
- **Reduced machine steam usage by ~ 10%**
  - » **Eliminated drainage aid**
- **Decreased Paper Breaks**
- **Decreased level of colloidal material in the paper machine**
  - » **Reduced stickies control and felt cleaner products**
  - » **Reduced white water clarification polymer**

# Summary of C1 Enzyme Biorefining Advantages

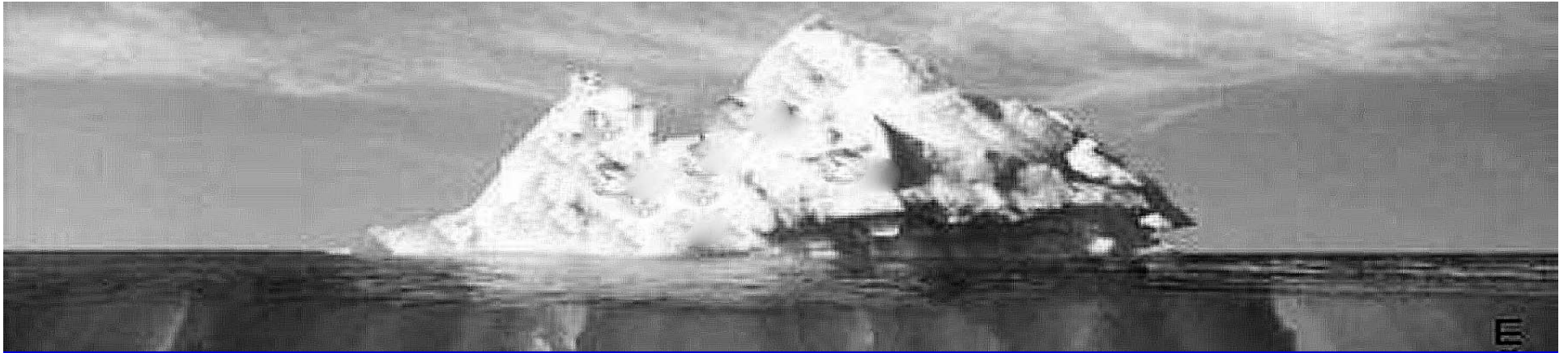
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- **Refining Energy Reduction**
  - » Reduce refiner energy usage 18% to 66%
  - » Increase refiner throughput
- **PM Drainage Rate Improvement**
  - » Lower steam & retention / drainage aid usage
  - » Increase PM speed and production
  - » Improve paper formation

# Summary of C1 Enzyme Biorefining Advantages (cont'd)

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- **Water Loop Cleanliness Improvement**
  - » Reduce stickies & felt/wire washing chemicals
  - » Reduce wastewater treatment demand
  - » Improve BOD/COD ratio
  
- **Potential Increased Strength Properties**
  - » Improve ply bonding values
  - » Reduce paper basis weight
  - » Reduce strength additives
  - » Reduce paper breaks



# Questions and Discussion

