Biomass Processing:

Opportunities to Improve Biomass Size Reduction and Separation Equipment

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What is Biomass ?

- Of recent biological origin
  - Grain
  - Dedicated crop
  - Crop/ forest residuals
  - Waste
- Our Focus:
  - Lignocellulosic Biomass ("Fibrous")

Personnel

Co-PI's		
A.R. Womac	Univ. Tennessee	Ag. Engineer
Philip Ye	Univ. Tennessee	Ag. Engineer
Doug Hayes	Univ. Tennessee	Chem. Engineer
Sundar Narayan	First Amer. Sci.	Mech. Engineer
David Dungate	First Amer. Sci.	Eng. & MBA
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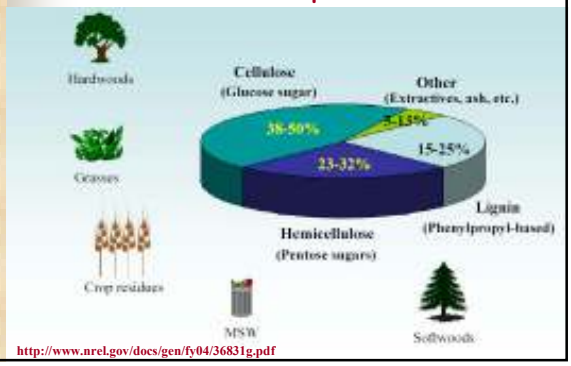
Advisory		
Lynn Wright	ORNL	Biologist
Post Doc		
Igathinathane, C.	Univ. Tennessee	Ag. Engineer
Graduate Students		
Manlu Yu Tony Yang Sarah Klasek Majaz Lindsey		

Biomass Composition



http://www.nrel.gov/docs/gen/fy04/36831g.pdf

Project Biomass Selections

Biomass	Rationale
Corn stover	model ag crop
Switchgrass	model grass
Rice Straw	ag crop fiber
Hickory wood	model/tough wood
Bagasse	tough fiber

Problems -- Opportunities

Inefficient size reduction
- High energy investment
- Bulk handling problem
- Low reactive surface area

Inefficient pre-separation
- Increased wet conversion stream volume / waste / interference
- Low targeting of constituents for best conversion

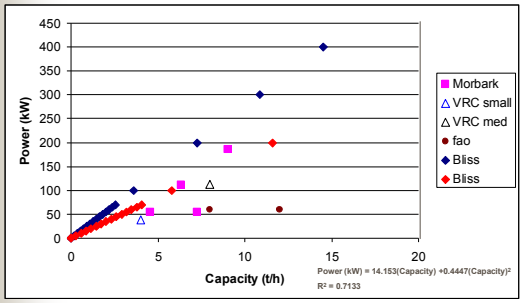
Inefficient integration
- Separation independent from grinding

Efficient size reduction
- Reduce energy
- Increase density
- Reduce transportation costs
- Increase conversion efficiency

Efficient Separation
- Increase wet conversion efficiency
- Reduce waste streams
- Improve constituent use

Efficient Integration
- Take advantage of overlapping processes

Power for Commercial Hammer Mills



Provided courtesy of Shahab Sokhansanj, December 2004

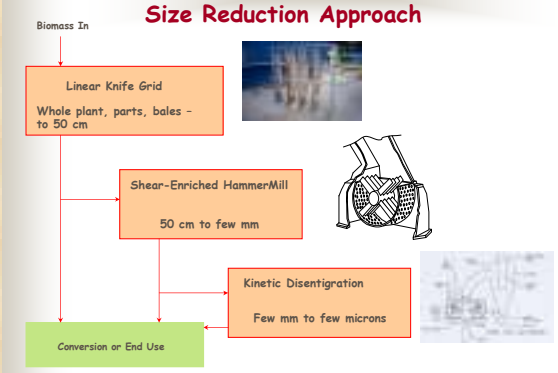
Power dependence on initial/final particle

- 1 – 2 kW-h/ton
  - Whole plant to rough cut (10-50 cm)
- 20 – 30 kW-h/ton
  - Precut (1 cm) to fine grind (600 micron)
- Questions:
  - Optimum size for conversion processes?
  - What is the largest size to accommodate plant part pre-separation?

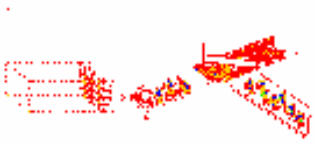
Opportunities

- Biomass Size Reduction and Separation Project
  - Identify Biomass Properties
    - Physical characteristics
    - Strength
      - (Shear $^1/_5$ to $^1/_{10}$ of Tensile)
    - Composition
  - Engineer Equipment & Processes
    - Size reduction: Shear vs. tensile failure
    - Separation: By plant part
    - Integrate Size reduction & Separation
  - Demonstrate

Size Reduction Approach

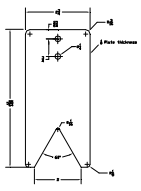


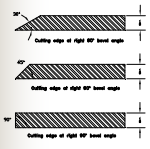
Linear Knife Grid

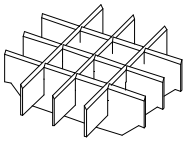


MTS Shear Devices

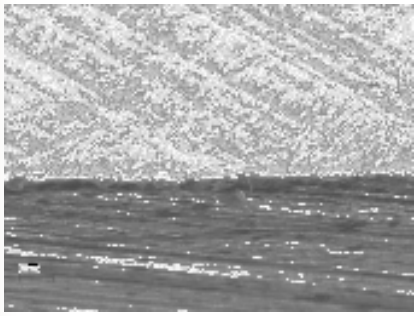
Warner-Bratzler Shear Test







Knife Sharpness & Dulling Process

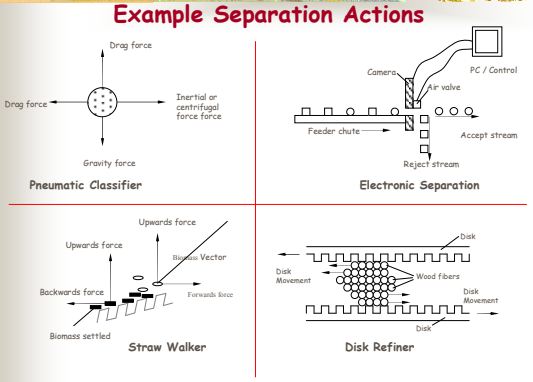


SEM 1000x - Blade initial condition: 30-degree bevel right side middle section

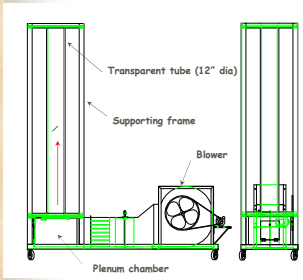
Separation Approach

- Identify underlying physics
- Inventory fundamental processes
- Examine and select
  - Target physics for select plant parts
  - Identify "threshold of difference"
  - Fill in gaps of fundamental data
- Verify separation
  - Advance non-contact identification
  - Develop rapid chemical analyses as needed

Example Separation Actions

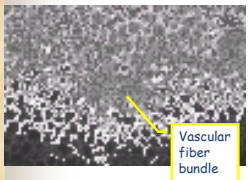


Biomass Particle Terminal Velocity



Example: Nodes vs. Internodes
Short vs. Long

Corn Stalk Close-Up

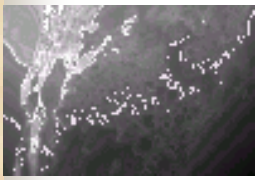


SEM x50: Corn stalk

Optical micrograph of epidermal Structure of a section of corn stalk

Photos by: Dr. Phillip Ye, UT Biosystems Engineering and Environmental Science Dept.

Switchgrass Close-Up



SEM x90: Cross-section of a switchgrass stalk (internode)

SEM x50: Cross-section of a switchgrass node

Photos by: Dr. Phillip Ye, UT Biosystems Engineering and Environmental Science Dept.

Opportunities to Collaborate

- Biomass Targets to Pre-Fractionate
- Size Reduction/ Grinding Issues
- Separation Issues

Thanks!