PURDUE UNIVERSITY

CAPSTONE EXPERIENCE 2014

NAOLEYM- Soy Based Oil Absorbing Paper

Agricultural & Biological ENGINEERING

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Objective

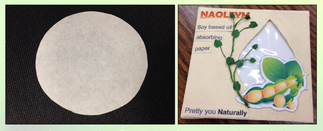
Design an industrial process of manufacturing soy-based blotting paper
- Optimize equipment and operating procedures
- Minimize production cost and energy usage

Background Review

Product – Naoleym

Naoleym is soy-based blotting paper with **higher oil absorbing ability**. Naoleym is made from all natural product: soy straw, a byproduct of soy production, was used to replace wood or grass fiber to make the paper sheet. Soy proteins are embedded to enhance the oil absorbing and retaining capacity.

Table 1: Percent composition of Naoleym paper	
Component	**Percentage by Mass**
Soy straw	**92%**
Potato starch	**6%**
Soy protein	**2%**



Naoleym (Left), Packaging (Right)

Table 2: Comparison between Naoleym and Clean&Clean Blotting Sheet		
	Commercialized Blotting Sheet	**Naoleym**
Main structure	Polypropylene	Soy straw fiber
Binding agent	Sorbitol (DMDBS)	Potato starch
Coloring agent	Zinc stearate,ultramarines	Fabric bleach concentrate
Coating agent	Mineral oil	N.A.
Functional agent	N.A.	Soybean protein

Process:

The manufacturing process of Naoleym referred to traditional paper making process which involves three essential parts:

Fiber Preparation → Pulping → Sheet Formation

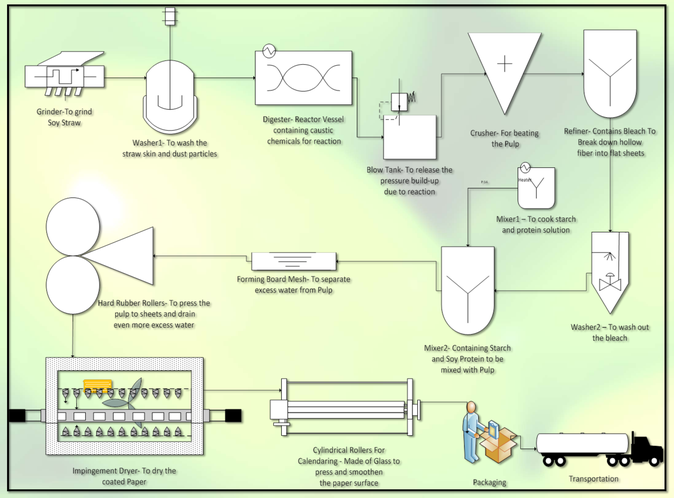
Attended Purdue University Student Soybean Product Innovation Competition (2013- 2014)
Chosen by Indiana Soybean Alliance for provisional patent (3 out of 15)

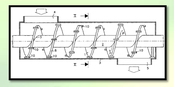
Alternative Solutions

Table 3: Final design and alternative solutions		
Unit Operation	**Final Design**	**Alternative Initial Design**
Pulping	Digester plus blow tank	Multiple digesters
Mixing	Agitator	Mixing pipe
Binding/Pulp treatment	Potato starch and Calendaring	Glycol
Sheet Formation	Roller pin	Sheet forming table ; Filter Press
Drying	Impingement dryer	Tray dryer

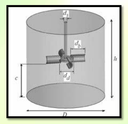
Listed above are several unit operations needed in the paper making process. Experimental research helped us find the drawbacks of the alternative or initial design of the unit operations which lead us to our final design.

Final Design

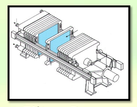




Digester



Agitator



Filter Press

Impingement dryer

Table 4 : Optimal design of main unit operations			
Unit Operation	**Mass Balance**	**Dimension**	**Power**
Digester	In: 164.85 kg soy straw/ hr Out: 65.94 kg pulp / hr	Volume: 2000 L Tank diameter: 1.37 m Tank height: 4.041 m Impeller diameter: 1.347 m	7.5 kW
Agitator	In: 59.33 kg pulp/ hr 523.43 kg water / hr Out: 571.10 kg pulp solution / hr	Volume: 1085 L Tank: 1.114 m (diameter/height) Impeller diameter: 0.44 m	0.54 kW
Filter Press	In: 571.10 kg pulp solution/ hr Out: 65.68 kg wet sheet / hr	Area: 0.485 m^2	1.29 kW
Impingement dryer	In: 65.68 kg wet paper sheet /hr Out: 10.51 kg final paper product / hr	Volume: 38.3 m^3 (L*W*H): 5m*4m*1.9m Fan diameter: 1.558 m	4542 kW

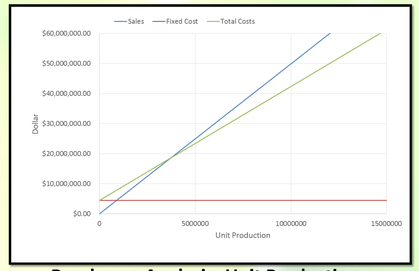
Engineering Principles

Table 5: Principles and concepts used in unit operation optimization	
Unit Operation	**Engineering Principle**
Digester Reaction	• Reaction Kinetics- Shrinking Core Model • Heat and Mass transfer
Digester Operating Conditions	• Ideal Gas Law for alkali concentration • Antoine Equation for Pressure
Refining	• Delamination and Hydration of fiber
Dryer	• Heat and Mass transfer
Filter Press	• Separation

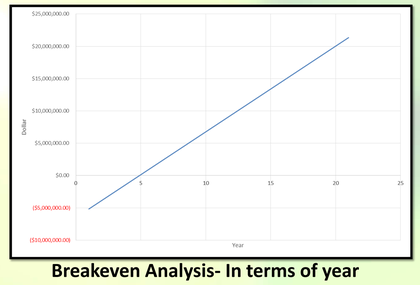
Economics

Table 6: Market and economics analysis	
Market Size (people)	10998000
Target market (10%)	1099800
Sheets produced	659880000
Fixed cost	$4,478,464
Total capital investment	$5,263,241
Production cost	$3,760,551
Variable cost	$3.79
Retailing price	$4.99
Breakeven Volume (pack)	3732053
Breakeven sales	$18,622,944.47
Breakeven year	4.8 years
Return on Investment (ROI)	92%
MARR	15%
IRR	24%

Table 7: Production yield	
Process	**Yield**
Straw to Pulp	40%
Pulp to Paper	16%
Straw to paper	6.4%



Breakeven Analysis- Unit Production



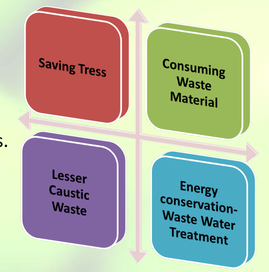
Breakeven Analysis- In terms of year

Societal & Global Impact

- No negative social, political or environmental effect
  - There are no global impact found in the making Naoleym.
- Adding value to soy by-product
  - By producing Naoleym, soy straw would turn into a commodity compound instead of just a waste.
- Safe, all natural cosmetic product
  - The natural ingredients used in this product let our product be safer to use compared to chemical based blotting paper.

Sustainability

- Water Recycling
  - Huge amount of water is required to produce our product. Due to this, a water recycling unit would be included in the final plant design.
- Energy and cost saving by eliminating coating process
  - According to the experiment, embedding soy protein inside the paper improves the oil absorbing properties.
- Saving Trees
  - Our product gives alternative ingredients to paper making process to replace trees.



Sponsor- Indiana Soybean Alliance

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Think impact.