Banana Leaf Pad Assembly Process

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Group Yellow B:

Aziz Albahar
Zach Rose
Laura Aust
Amrita Saigal

Katie Smyth
John Williams
Rob Kalwarowsky
Corey Garvey
Concept

- Women in Rwanda lack affordable feminine pads
- Low volume, low cost, low tech

Designing production sub-processes:

- Portioning
- Shaping
- Layering
- Crimping
- Cutting
# Contract

**Product Description:** Assembly machine for making banana leaf pads  
**Intended Customers:** Women in Rwanda  
**Market:** Developing World

<table>
<thead>
<tr>
<th>Customer Need</th>
<th>Product Attribute(s)</th>
<th>Engineering Specification(s)</th>
</tr>
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<tbody>
<tr>
<td>Improve production rate</td>
<td>Rate</td>
<td>Minimum: &gt; 5 pads per minute</td>
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<tr>
<td>Machinery can work within African infrastructure</td>
<td>Power</td>
<td>Less than 40W</td>
</tr>
<tr>
<td>Easy to repair/troubleshoot</td>
<td>Number of parts, robustness</td>
<td>Less than 50 parts, simple</td>
</tr>
<tr>
<td>Reduced labor cost</td>
<td>Automatic, ease</td>
<td>Less than 4 operators, steps must easy to do</td>
</tr>
<tr>
<td>Pads cost too much</td>
<td>Cost</td>
<td>Produce 10 pads for less than $1.10</td>
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Decision-Making Process

**Portioning**
- None
- Extrusion

**Shaping**
- None
- Rollers
- Stamping – Rollers
- Stamping – Vertical Press
- Pocket
- Pouring (slurry)

**Layering**
- None
- Rollers
- Folding
- Sheet Stamping

**Crimping**
- None
- Pressure

**Cutting**
- None
- Vertical Blade
- Die
- Heat
- Laser
- Hot Wire

**Actions**
- Separate when wet
- Compressed Air
- Die
- Hand
- Roller with Pocket
Significant Risks: Portioning and Shaping

- Identified major risks through discussion and group vote

![Risk Bar Chart]

- Portioning
- Shaping
- Layering
- Crimping
- Cutting
Batch Solution: Pad Die

- Polyethylene and banana fiber layered on cavity
- Die core pushes and separates pads into pockets
- Polyethylene stretching approximation:
  \[ \frac{\sigma_y}{E} = \frac{\Delta L}{L_0} \]
  yields inaccurate results

Finite Element Approximation: Polyethylene Sheet

- Displacements similar to pocket depth
- Stress does not exceed material yield
Continuous Solution: Extruder

Portioning

- Processed banana fiber inserted into chute
- Timing of linear actuator portions out pads onto polyethylene sheet

- Limitation – short stroke length (~1”)
- sand paper provides friction
- total applied force:
  \[ F = 2m \left( \cos^2 \theta + \mu g \right) \]
Continuous Solution: Cylinder

- Roller cylinder with cavity that is filled with fiber
- Metal “scraper” to brush off excess
- Continuous process, hand crank operated
- Can be used as initial step
Findings

<table>
<thead>
<tr>
<th></th>
<th>Die</th>
<th>Extrusion</th>
<th>Cylinder</th>
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</thead>
<tbody>
<tr>
<td>Portion</td>
<td>0</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Shaping</td>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Estimated Rate</td>
<td>0</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

- **Conclusions**: individually each machine does not address portioning and shaping adequately
  - Best to combine concepts based on strengths
Questions?