Polyethylene Pipes Systems

Project Update
Feb 25, 2010
Agenda

1. Previous Stage

2. Current Progress
   1. Thermal Analysis
   2. Composition Analysis
   3. Testing of heat-welding parameters

3. Next Steps
   1. Continue testing of heat-welding parameters
   2. Evaluate possible heat sources via testing
   3. Determine heat source
Previous Stage

- Recycle HDPE shopping bags into irrigation tubes

- Initial concept proven:
  - Possible to make tubes via heat-welding
  - Failure stress of heat-welded sheets = 4.4 MPa
  - Elastic modulus of heat-welded sheets = 181 MPa

- Needed more information on:
  - Properties of raw material
  - Bonding mechanisms of polyethylene
  - Heat-welding parameters
Current Progress

Thermal Analysis via Differential Scanning Calorimetry (DSC)

• Tested 6 different bags

• Average melting temperature, $T_m = 124.9 \pm 1.3{^\circ}C$

• Softening point, $\sim 105-115{^\circ}C$

• Average heat capacity, $C_p = 2.1 \pm 0.6 \text{ kJ/kg}^{\circ}\text{C}$

### Current Progress

**Elemental Analysis via Scanning Electron Microscope (SEM)**

<table>
<thead>
<tr>
<th>Elements</th>
<th>Processed Shaws Bag w%</th>
<th>Processed Target Bag w%</th>
<th>IDE Kit Tubes w%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen</td>
<td>48.52</td>
<td>85.44</td>
<td>14.05</td>
</tr>
<tr>
<td>Carbon</td>
<td>25.85</td>
<td>4.39</td>
<td>54.19</td>
</tr>
<tr>
<td>Sodium</td>
<td>10.23</td>
<td>3.62</td>
<td>0</td>
</tr>
<tr>
<td>Calcium</td>
<td>5.45</td>
<td>1.71</td>
<td>0</td>
</tr>
<tr>
<td>Aluminium</td>
<td>1.03</td>
<td>0.86</td>
<td>7.53</td>
</tr>
<tr>
<td>Silicon</td>
<td>2.13</td>
<td>0.82</td>
<td>6.38</td>
</tr>
<tr>
<td>Chlorine</td>
<td>1.6</td>
<td>1.09</td>
<td>2.77</td>
</tr>
</tbody>
</table>
Current Progress

Heat-welding parameters VS
Quality of weld

- Ideal temp, time and pressure combination:
  - Temp = 105-115°C
  - Time = 5 s
  - Pressure = 0.1 psi
Next Steps

• Continue testing heat-welding parameters:
  o Can we heat-weld at lower temperatures?

• Determine heating element for our device
  o Minimum working temp for HDPE is 85°C
  o Possible Heat Sources:
    1. Boiling water with solute
    2. Resistive Heating
    3. Coal

• Determine mechanical design of device

1. Matweb.com
Boiling Water with Solute

• $T_b = 102^\circ \text{C}$ for 3 tablespoons of salt in 1L water

• Advantages:
  o Controlled temperature
  o Low cost
  o Ease of access

• Challenges:
  o Operating at low temperatures
  o Possibly need more processing time
Resistive Heating

• Advantages:
  o Consistent heat source
  o Even distribution of heat

• Challenges:
  o How do we control the temperature?
  o Cost of unit/operation
Heated Coals

- Advantages:
  - Low cost
  - Ease of access

- Challenges:
  - Temperature control
  - Temperature uniformity
Previous Gantt Chart
## New Gantt Chart

### What changed:
- Heat source selection added
- Final Design creation shortened to accommodate
Questions?
Thermal Analysis
Elemental Analysis on SEM
Stress-Strain Response

Stress-strain Response of Processed HDPE Bags

Stress (MPa) vs. Strain (%)
Heat conduction approximation:

$$\Theta = \frac{1}{2} \sqrt{\frac{\alpha t}{\pi}}$$

$$\Theta = \frac{T - T_s}{T_o - T_s}$$

$$T = 98^\circ C$$

$$T_o = 25^\circ C$$

$$\alpha = 4 \times 10^{-7} \text{ m}^2 / \text{s}$$

$$x = 0.25 \text{ mm}$$

For:
- Ts=100°C, t = 48 sec
- Ts=110°C, t = 2 sec
- Ts=102°C, t = 13 sec