1. Motivation and Background

Agriculture accounts for more than 80% of the water consumed in Africa. While drip irrigation can drastically reduce water consumption, it is not widely practiced because of high costs. With the number of bags thrown away in the U.S. each year, we can make enough pipes to irrigate more than the state of Rhode Island.

2. Objectives

Create a low-tech, low-cost device to produce drip irrigation pipe kits by recycling high density polyethylene (HDPE) shopping bags.

3. Design

The mechanical device (Fig. 1) was designed such that tubes could be continuously produced by heat-welding. Resistive heaters heat two aluminum rollers to above 125°C to create two parallel seams through eight layers of HDPE shopping bags. This creates a thin-walled, multi-layer tube (Fig. 2).

4. Weld Quality Testing

The strength of a heat weld is determined by processing temperature T, time (or processing speed v) and pressure, as follows:

\[ \sigma_{\text{weld}} \propto \sigma_{\text{material}}^{(T-v)/4} \]  

Eq. 1

Samples were made for varying temperatures (94°C-156°C) and processing speeds (2-63 mm/s). Weld quality was evaluated by performing peel tests according to ASTM D6392-08. Stronger welds were observed for temperature-velocity ratios of 50-80 K/(mm/s) (Fig. 3). Most welds were stronger than the minimum required 0.5 N/mm. Scanning electron microscopy images (Fig. 4) show a monolithic seam.

5. Cost Analysis

The cost of the device, energy and labor were taken into consideration to maximize strength per cost. Optimal processing parameters are 130°C, and 6.3 mm/s, at which 1100 20m-pieces/yr can be produced at $1.15/piece.

<table>
<thead>
<tr>
<th>Product</th>
<th>Price (for 20m pipes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEPS</td>
<td>$1.15</td>
</tr>
<tr>
<td>Kr-shak Bandhu Family Nutrition Kit</td>
<td>$4.00 (Est.)</td>
</tr>
<tr>
<td>Past 3.042 Project</td>
<td>$98.00</td>
</tr>
</tbody>
</table>

6. Future Work

- Reducing fixed costs by replacing device parts,
- Reducing energy consumption, and
- Improving tube quality

7. Summary

We were able to produce a low-tech and low-cost device that can heat-weld high density polyethylene shopping bags to create irrigation pipes. The pipes produced are composed of 100% recycled plastic bags, can withstand water pressures of at least 0.2 atm and are competitively priced at ~$1.15 per 20m piece.

8. Acknowledgements

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