Solar Recycl o Sort

“Working for a Bluer World”
Problem

• Solar Powered *Compactor and Sorter* for Recyclables
• Problems with Current Products: After compacting, cannot separate recyclables from trash

Market

• 9000+ Curbside Recycling Programs in U.S.
• Market $4.5 million dollars per year
  • For 10 years
  • 10% penetration
• Benchmarking: Most similar product price = $4300.
Demonstration
Design Requirements

Initial Customers
Codman Square: Cynthia Loesch
Boston Harbor Association: Vivien Li

Customer Needs
• Sort aluminum cans, plastic and glass
• Compacts recyclables to reduce pickups
• Low Cost
• Low Power, portable
• No Maintenance
• Operates under wet and sticky conditions
• Aesthetically pleasing and intuitive
Design Concept: Sorting

Control Board

Deformation Sensor

Object Entry Sensor

Metal differentiation sensing

Learned from Model
- Low cost parts work
- Simple digital logic works
- Can sort between aluminum, glass, plastic

Future Work
- Redundancy
- Automation with servos
- Component Robustness
Design Concept: Compacting

Experimental Results

<table>
<thead>
<tr>
<th>Container</th>
<th>Force</th>
<th>Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum Can</td>
<td>362N</td>
<td>43.4J</td>
</tr>
<tr>
<td>Plastic Bottle (no top)</td>
<td>453N</td>
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</tr>
<tr>
<td>Plastic Bottle with top (estimate)</td>
<td>1200N</td>
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Power

3.5ft² solar panels
Generate 38 W-hrs (137kJ)*
Crushing ~570 bottles/day

\[ T_{Motor} = \frac{a}{a + b} \frac{R \cdot Force}{\cos(\theta_4) \cos(\theta_2)} \]

Torque from Motor ~ 2.17N*m

*Boston in the Winter
Design Alternatives

**Sorting**
- Optical Sorting (camera)
- Break Beam Sensors
- Thermal Conductivity Material Sensing
- Melting
- Crushing Force Sensing
- Eddy Current Sensing
- Etc…

**Crushing**
- Two-sided crusher (up/down and left/right)
- Linear motor crusher
- Shredding/Breaking
- Crushing while in the bin
- Crushing before sorting
- Etc…
Questions ?
Backup Slides

Additional information is in the following slides covering benchmarking, market, customer needs, concept, design alternatives, and experimental data.
Problem

- Produce >245 million tons of waste (2005)
- Currently recycling:
  - 44.8% of Aluminum cans
  - 34.1% of Plastic bottles
  - 25.3% of Glass containers
- Current Products:
  - After compacting, cannot separate recyclables from trash
Market

- Codman Square
  - Contact: Cynthia Loesch
- Boston Harbor Association
  - Contact: Vivien Li
- Curbside Recycling Programs
  - 9,000+ U.S. programs (2005)
- Municipalities
  - Cities, Parks, Suburbs
- Virtually untapped $45+ million market
Benchmarking

- Industrial Compactors (balers)
  - $5,000

- Industrial Sorter
  - Worker paid $9/hr
  - Optical Sorter ~$100-200K

- Home Compactors
  - $400
  - 1/3 hp, F = 9000N

- **Curbside Compacting**
  - Solar Compactor on Newbury ($4,300)
  - $860,000 in competitor products
Design Requirements:

Customer Needs

- Sort aluminum cans, plastic and glass
- Compacts recyclables
- Low Cost
- Low Power, portable
  - Operates on solar panels
- No Maintenance
  - Operates under wet and sticky conditions
  - Compacts to reduce pickups
- Aesthetically pleasing and intuitive
- Reduce environmental footprint

Vivien Li
Risks and Feasibility

• 3 tier sorting system
  – Object entry
  – Metal differentiation sensor
  – Deformation sensor
• Compacting mechanism
  – $F_{\text{max}} = 1,200 \text{ N}$
• Power (3.5ft$^2$ surface)
  – Generate 38 W-hrs (137kJ)
  – Boston Winter
  – Crushing ~570 bottles/day
Design Concept

- Round hole to encourage bottles and cans
- Access panel for removal of recyclables
- Blue color to encourage recycling
- Off the ground to prevent water collection
- Solar Panels
- Intuitive color and entry for recyclables, easy product to use
Design Concept: Sorting

Control Board

Deformation Sensor

Object Entry Sensor

Metal differentiation sensor
Design Concept: Compacting

Experimental Results (high end)

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Torque $\sim 2.17N\cdot m$

For dimensions: $a = 0.15$, $b = 0.4$, $d = 0.2$, $R = 0.01$, Force = 540N, Theta1 = 45deg, Theta2 = 20deg

The force components are:

$F_2 = \frac{a}{a+b} \frac{\text{Force}}{\cos(\theta_4)}$

$T_{\text{Motor}} = \frac{a}{a+b} R \frac{\text{Force}}{\cos(\theta_4) \cos(\theta_2)}$
Design Alternatives Explored

**Sorting Alternatives**
- Optical Sorting (camera)
- Break Beam Sensors
- Thermal Conductivity Material Sensing
- Melting
- Crushing Force Sensing
- Eddy Current Sensing
- Etc...

**Crushing Alternatives**
- Two-sided crusher (up/down and left/right)
- Linear motor crusher
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