Cleaning Koppert’s Bee Bottles to Recycling Requirements

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Background

Introduction

Koppert Biological Systems is an international company that raises bumblebees for commercial pollination.

Hives are supplied with small, HDPE bottles with a fabric wick to give the bumblebees access to a sugar solution. After use, the bottles are left with an internal sticky residue and an exterior coat of dirt, sugar, and bee feces.

Justification

Due to the sticky nature of the sugar, the bottles gum recycling grinders.

Koppert’s local recycling company, Industrial Resin, started requiring the bottles to be washed out with water. HDPE has a high recycled value, ranging from $400/ton if dyed and $1400/ton if clear (Dave Smith, MSU Recycling, personal communication, February 19, 2021).

Design Alternatives

Three alternative processes were evaluated in a decision matrix. These were compared to the current washing method, which is labor intensive but results in bottles clean enough to be reused.

1. Current Process – 6 crates are loaded into carts and held vertically while rotating wands spray the exterior for 4 minutes.
2. Cutting for Drainage – cutting bottles in half would allow for increased rinsing surface area and better drainage.
3. Automatic Brush Machine – The PS400 machine inserts a rotating brush into each bottle opening, and rotates the entire bottle for exterior brushing.
4. Directed Water Spray System – pressurized water sprays in a solid stream into the bottles, as well as fanned over the exterior.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Weight (%)</th>
<th>Direct Spray</th>
<th>Cutting Bottles</th>
<th>Brush Machine</th>
<th>Do Nothing</th>
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</thead>
<tbody>
<tr>
<td>Effectiveness</td>
<td>25</td>
<td>5</td>
<td>4</td>
<td>2</td>
<td>3</td>
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<tr>
<td>Cleaning Rate</td>
<td>29</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Ease Operation</td>
<td>20</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Cost</td>
<td>15</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Use of Space</td>
<td>10</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>5</td>
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<tr>
<td>Resource Use</td>
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<td>3</td>
<td>2</td>
<td>3</td>
<td>4</td>
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<tr>
<td>Total Score</td>
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<td>4</td>
<td>3.25</td>
<td>3.1</td>
<td>3.3</td>
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</tbody>
</table>

Objectives & Constraints

Problem Statement

A process needs to be developed to remove the wicks and remove all sugar solution from the high-density polyethylene (HDPE) bottles to allow them to be recycled.

Objectives

• Collect relevant data on bottle contamination.
• Understand the current cleaning process and its drawbacks.
• Compare potential solutions in a decision matrix.
• Evaluate chosen solution for recycling expectations.
• Provide expected costs and implementation guidance.

Constraints

• Have a maximum footprint of 9 ft by 12 ft.
• Bottle must be compatible with current processes.
• Cost under $100,000.
• Be able to handle various amount of liquid in each bottle.
• Be able to handle 4,000 to 30,000 bottles per week.
• Must not create substantial waste and must be environmentally conscientious.
• Result in clean bottles, not sticky to the touch.
• 2% w/w maximum contamination of liquid residue

Testing Process

Preliminary testing showed high variation in terms of mass of contamination. The bottles are not all used for the same time period.

An apparatus of PVC piping connected to a diaphragm pump was used to test nozzle efficiency.

Economics & Conclusion

Table 3. Capital and Operating Cost

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
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</thead>
<tbody>
<tr>
<td>Flame and Conveyor</td>
<td>$16,100</td>
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<tr>
<td>Spraying Systems</td>
<td>$1,230</td>
</tr>
<tr>
<td>Flipping Mechanism</td>
<td>$490</td>
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<tr>
<td>Total Capital</td>
<td>$18,820</td>
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</table>

Safety & Regulations

• Installed guards on moving mechanical devices.
• Monitored water temperatures.
• Individual PPE options.
• No patents related to system.
• Stationary machinery must be anchored.2
• Employer must provide conveyor training for laborers.3
• Inspection program for conveyor system.3

Conclusion

The recommended design meets the constraints given by Koppert.

• The system fits in a 4.16 ft by 11.75 ft area, allowing extra space for storage or additional equipment.
• The draining and spray time is flexible to account for various bottle conditions.
• The system takes 7 consecutive hours to clean 30,000 bottles.
• Labor is decreased due to the streamlined process.
• The environmental impact of recycling the bottles outweighs the negative of water use.
• Testing resulted in bottles that were not sticky to the touch and had less than 2% mass contamination.

All constraints have been met, so the design can be recommended.

Future Directions

• Implementation of process into facility.
• Adjustment of spray temperature, pressure and time through implementation testing.
• Potential to implement water filters or a detergent to lower water use.
• Selling or recycling clean bottles.
• Potential to sell semi-clean bottles to recycling facilities/vendors.

References