By reducing the amount of product left in the tanks, • • •

The conical bottom and 3 in exit pipe are where the product is then pumped through a 3 in diameter pipe at the bottom of the cone where it exits. • • •

Minimize the environmental impact of the manufacturing process. Establish a universal process for relay, portable, and mixing tanks.

Table 1: Product Categorization from Viscosity

<table>
<thead>
<tr>
<th>Categories</th>
<th>Viscosity (cP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gels</td>
<td>Redacted</td>
</tr>
<tr>
<td>Scrubs</td>
<td>Redacted</td>
</tr>
<tr>
<td>Conditioners</td>
<td>Redacted</td>
</tr>
<tr>
<td>Shampoos</td>
<td>Redacted</td>
</tr>
<tr>
<td>Others</td>
<td>Redacted</td>
</tr>
</tbody>
</table>

- Gels are the top priority for removal, as they account for the most residual product due to their high viscosity and resulting difficulty in removal.
- Unilever wishes to implement a design solution that works for all large tanks in their manufacturing plant. These include:
  - Portable
  - Relay
  - Mixing tanks
- Portable and relay are similar in size and components, but portable tanks can be moved throughout the plant.
- Mixing tank internal elements can vary, with some mixing tanks having two impellers, both an anchor and hydrofoil impellers, whereas some have one anchor impeller.
- All mixing tanks have a baffle that is attached from the top of the tank to aid in product mixing.

Design Parameters

Table 2 identifies the most important parameters for the final design. Each parameter was ranked according to priority as specified by the client, with 1 being the highest and 6 being the lowest priority.

Table 2: Design parameters ranked by importance

<table>
<thead>
<tr>
<th>Priority Level</th>
<th>Design Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Safety</td>
</tr>
<tr>
<td>2</td>
<td>Product Recovery Rate</td>
</tr>
<tr>
<td>3</td>
<td>Scalability</td>
</tr>
<tr>
<td>4</td>
<td>Time</td>
</tr>
<tr>
<td>5</td>
<td>Cost</td>
</tr>
<tr>
<td>6</td>
<td>Change in Current Operations</td>
</tr>
</tbody>
</table>

Final Design

After analyzing the decision matrix that ranked each design alternative's performance for each design parameter, the team decided to further evaluate the antistick approach and concentrated vibrations individually and combined.

Vibrational Motor

Core Concept: Addition of microfroces to the tank
- Utilizes a heavy-duty vibrational motor
  - Attaches to the side of the tank using a metal bracket
  - Often used for aiding in the removal of grain from hoppers/bins and shaking bubbles from concrete
- Has the ability to adjust frequency of vibrations according to application

Design schematic is shown in Figures 6 and 7.

Economics

Antistick:
- Estimated cost of client testing: $100,000
- Cost of PAO: $8,000/55-gal drum

Vibrations:
- Estimated cost of client testing: $100,000 based off calculated total product loss
- Cost of heavy-duty vibrational motor: $1,000/unit
- Installation: $80/unit

Experimental

The team conducted small-scale experimentation on both proposed solutions and their combination. Four different rounds of testing were conducted, including:
- Control
- Polyalphaolefin only
- Vibrations only
- Vibrations and polyalphaolefin

Experimental Materials

- Large stainless-steel funnel
- Cone angle of inclination 33 degree
- Synthetic polyalphaolefin lubricant oil
  - Viscosity: 68 ISO, 20W SAE, 65 cSt at 40°C
  - Density: 0.0313 lb/in³
- 30 W concrete vibrator motor with speed controller (Figure 8)

Final Design

Figure 2: Blade Attachment

Figure 3: Vibrational Sheath

Figure 4: Vibrational Plate

Figure 5: Antistick Application

Measure and record viscous torque of the product at 20.30, 30.70, 90.00, and 200 rpm

Repeat this process 3 times for each product and testing method
- For antistick and combination tests, weigh out 2 g of PAO and coat the funnel prior to the addition of the product
- For vibrational and combination testing, secure the vibrational motor to the base of the clamp and operate at level 5 during draining

Results

From the experimentation, several important results were found:

- Combination testing resulted in the lowest residual for conditioner and scrub
- Vibrational testing resulted in the least residual fat for shampoo
- PAO only testing left small bubbles of oil in the drained product

These results are reflected in Figure 9.

References


doi.org/10.1007/978-1-4614-3153-2

Figure 9: Residual product remaining in funnel after draining for 3 minutes

Limitations

There were limitations regarding the team’s ability to replicate Unilever’s tank design when scaling down the experimental setup:
- Increased amount of PAO mixed with product due to a higher surface area to product ratio
- The motor was unable to be directly attached to the side of the funnel
- The conical bottom was assumed to be the place where all product stuck, whereas some product sticks to the sides of Unilever’s tanks as well as to the bottom
- The team was not able to replicate the pump connected to the outlet pump

Recommendations

A few key observations were made from bench-scale testing that led the team to the following recommendations:

1. Combination of PAO and vibrations
   - a. Resulted in the lowest residual for more viscous products
   - b. More costly than a single solution
   - 2. Vibrations only
      - a. No added materials to the products
      - b. Less costly than combination solution
      - c. Resulted in more residual than combination for more viscous products

If the client has concerns about PAO causing product adulteration, vibrations will provide a safe option. The vibrational motor is attached to the outside of the tank and will not touch the product.