IRM Capping Project
Dentsply/Caulk, Inc.
Final Review

University of Delaware
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Advisor: Dr. James Glancey
December 7, 2001
Agenda

- Overview of Problem
- Design Process
- Final Design
- Fabrication and Assembly
- Testing and Analysis
- Handoff Plan
The Problem

- Project Proposed by Dentsply/Caulk, Inc.
- The Intermediate Restorative Material (IRM) filling and packaging machine currently employs workers to hand-cap the product.
- Workers have developed Repetitive Motion Injury due to quickly capping the product at a rate of 60 parts per minute.
IRM Machine
Hand Capping
Problem Statement

To develop an automatic capping station to add to the existing equipment that will reduce operational injury of the workers and increase the production rate to 70 parts per minute.
Customers and their Wants

- Dentsply/Caulk, Inc. - Reliable, increase in productivity, synchronized, removable
- Capping Operators - Easy to operate, easy to locate problems, accessible
- Maintenance Engineers - Reliable, accessible, easy to locate problems, standard parts used
- Dentists - Easy to remove caps/caps stay on during shipping, no contamination
- M&O Perry Industries - Reliable, adaptable, inexpensive
Customer Constraints

- Safe
- Cost of $25,000 or less
- Must work with the existing machinery
- Limited Size
## Metrics and Target Values

<table>
<thead>
<tr>
<th>Metrics</th>
<th>%</th>
<th>Target value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Parts per minute</td>
<td>21</td>
<td>70</td>
</tr>
<tr>
<td>Reliability</td>
<td>18</td>
<td>99 / 100</td>
</tr>
<tr>
<td>Time to cap</td>
<td>10</td>
<td>.85 sec / cap</td>
</tr>
<tr>
<td>Height of device</td>
<td>9</td>
<td>&lt; 28&quot;</td>
</tr>
<tr>
<td>Number of Signals</td>
<td>7</td>
<td>&gt; 2</td>
</tr>
<tr>
<td>Number of controls</td>
<td>6</td>
<td>&lt; 3</td>
</tr>
</tbody>
</table>
# Wants to Metrics Cross-Correlation

<table>
<thead>
<tr>
<th>Metrics</th>
<th>Wants</th>
<th>Reliability</th>
<th>Productivity</th>
<th>Ease of operation</th>
<th>Easy to locate</th>
<th>Accessibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Parts per minute</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of usable Parts per</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time to cap</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height of device</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Sensors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Very Strong Correlation**
- **Strong Correlation**
The Design Process

1. Four initial ideas
2. Compared each concept to the existing system of hand capping
3. Compared each concept to metrics and target values
4. Used an evaluation system to decide on the final design
Chosen Design: Indexing Wheel with Linear Capper
Details of the Design

Main Features:
- Indexing Wheel
- Pneumatic Cylinder
- Servo Motor
- Programmable Logic Controls (PLCs)
- Cap Track and Flapper
- Sensors
- Hoses and Connections
Step by Step Description

1) Load pucks into indexing wheel
2) Index wheel
3) Activate cylinder
4) Vacuum picks up cap
5) Capsule is capped
6) Cylinder retracts, vacuum is released
7) Puck indexes out of station
Fabrication and Assembly of Prototype

- AutoCAD drawings
- Machine shop work
- Order parts
- Program motor and PLC
- Assemble prototype
- Troubleshooting of entire system
Visualization of our Indexing Wheel with Linear Capper
Programming Logic

- Sense the cylinder in the up position
- Sense a queue of parts
- Sense a capsule to be capped in the indexing wheel
- Output signal to the motor to index 30°
- Index the wheel 30°
- Input signal to PLC that the motor has indexed
- Output signal to pneumatic cylinder to cap
- Cap the capsule
- Sense the cylinder is in the up position
Initial Testing and Analysis

- First stage of testing of critical elements:
  - Reliability of linear capper - 84%
  - Cap loading into the flapper - 100%
  - Reliability of capper with flapper - 96%

- Initial testing showed that the system worked, but needed improvement
Final Testing

<table>
<thead>
<tr>
<th>Metrics</th>
<th>Target value</th>
<th>Value Achieved through Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Parts per minute</td>
<td>70</td>
<td>86 per minute</td>
</tr>
<tr>
<td>Reliability</td>
<td>99 / 100</td>
<td>75 / 100</td>
</tr>
<tr>
<td>Height of device</td>
<td>&lt; 28&quot;</td>
<td>16&quot;</td>
</tr>
<tr>
<td>Number of Signals</td>
<td>&gt; 2</td>
<td>3</td>
</tr>
<tr>
<td>Number of controls</td>
<td>&lt; 3</td>
<td>2</td>
</tr>
</tbody>
</table>

More testing is needed for reliability
Handoff

- Deliverables:
  - Prototype
  - Standard Operating Procedure manual
  - AutoCAD drawing package
  - Program Logic sequence
  - Wire schematic

- Handoff taking place early next week
Recommendations to Sponsor

To implement/install our prototype:
- Add diagnostic capabilities to PLC program
- Cover moving parts for safety purposes
- Perform further testing for reliability
- Install automatic capper on IRM machine
## Cost Estimate

<table>
<thead>
<tr>
<th>Item</th>
<th>Manufacturer</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indexing Wheel and Accessories</td>
<td>Shop</td>
<td>$700.00</td>
</tr>
<tr>
<td>Stagger Tooth Side Cutter</td>
<td>MSC</td>
<td>66.09</td>
</tr>
<tr>
<td>Materials/Hardware</td>
<td>McMaster-Carr</td>
<td>59.87</td>
</tr>
<tr>
<td>Pulley System</td>
<td>Kaman</td>
<td>41.83</td>
</tr>
<tr>
<td>Servo Motor and Accessories</td>
<td>Emerson</td>
<td>3000.00</td>
</tr>
<tr>
<td>PLC and Accessories</td>
<td>Keyence</td>
<td>250.00</td>
</tr>
<tr>
<td>Pneumatic Cylinder and Connections</td>
<td>Bimba</td>
<td>40.00</td>
</tr>
<tr>
<td>Various Parts</td>
<td>Team 5-Spencer Machine Shop</td>
<td>500.00</td>
</tr>
<tr>
<td>Sensors</td>
<td>Keyence</td>
<td>400.00</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
<td>60.00</td>
</tr>
<tr>
<td>Labor</td>
<td>Team 5</td>
<td>3000.00</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>$8,117.79</strong></td>
</tr>
</tbody>
</table>
Summary of Semester

- AutoCAD Hours - 60
- Spencer Machine Shop Hours - 200
- Average Weekly Hours - 25
- Testing Hours - 15
- Troubleshooting Hours - 30
- Programming Hours - 40

TOTAL HOURS SPENT ON PROJECT: 695 hours
Special Thanks to:

- Dentsply/Caulk, Inc. especially Jim Foreman, Mike Utley, Robin Sirkis, Andy Johnson, Jim Sirkis, and the machinists at Dentsply
- Art Baeckel and Dave Styer from the Spencer Machine Shop
- Ed Brogan from Airline Hydraulics
- Dr. Glancey and the Senior Design Staff
- Dave and Al from the Colburn Lab Machine Shop
Questions?

Thanks for a great semester!