Automation of the Multi-Option Fuze for Artillery (MOFA) Post-launch Battery

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by
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Presentation Outline

Facility Highlights
Description
Equipment History
Process Control and DFSS/6-Sigma Lean
Material Identification and Handling
Video Clips of Equipment
Summary
MOFA Battery

ATK Ordnance and Ground Systems, LLC
Power Sources Center

Features:

- Single story, 52,000 ft² facility.
- 40,000 ft² available for manufacturing.
- 6,000 ft² of humidity controlled dryrooms (RH maintained at < 5%)
- Computer modeling and analysis capability.
- Extensive laser welding capacity.
- In-house machining and tool room.
- Multiple production lines.
- Specialized battery manufacturing and processing equipment.
- Quality Assurance ISO 9001:2000 Certified
- Extensive battery testing equipment and expertise.

Power Sources Center
Horsham, Pennsylvania

Power Sources Center has all of the physical assets and facilities required to: design, develop, manufacture, test, and analyze lithium batteries.
Description

• The MOFA Post-launch Battery is a state-of-the-art reserve lithium oxyhalide power supply.
  • It utilizes a moderate rate formulation of the lithium / thionyl chloride.
  • It can be stored in the dormant state for in excess of 20 years and then be activated by the conditions of ballistic launch.
• Supplies post-launch power to the MOFA Fuze -- Army’s next-generation, NATO standard all-purpose artillery fuze for bursting munitions.
  • Power needed for electro-mechanical operation during four fuze modes: Proximity, Time, Point Detonate, and Delay
• Automation needed to assemble large quantities of this small, hermetic vessel (current orders and future domestic/foreign forecasts include over 1 million units)
Equipment’s History

• ATK initiated design, development and procurement of automated equipment 1999.

• Installation of equipment at Horsham, PA facility was completed in November 2001.

• Average monthly production is 25K units, with surge capacity to 35K units.

• To date, the line has produced nearly 400K batteries.

• The four major pieces of automated equipment are:
  • Battery Assembly Machine (BAM)
  • Closure/Terminal Plate Welder (automatic laser)
  • Reservoir Welder (semi-automatic laser)
  • Electrolyte Fill and Seal Machine

• We have since installed another semi-automated work-cell in 2003 for inspection as part of our DFSS/Lean Six Sigma Initiatives.
Process Control and DFSS/Lean 6 Sigma

- In-process/statistical process control (SPC) data collection capability:
  - The equipment automatically monitors 14 parameters and will shut itself down if parts become out-of-tolerance
  - The program team performs weekly data review of key characteristics to review data trends and proactively respond to conditions prior to defect creation
- All equipment yields are greater than 98% with over 90% availability
- DFSS/Lean 6-sigma philosophy and tools have become instrumental to the facility to develop a culture of Continuous Improvement
  - 100% percent of manufacturing/quality engineers trained as green-belts
  - 2 engineers are currently in training for black-belt certification
  - 7 projects completed and/or underway...significant improvements seen in quality, cost, and lower risk for battery
Example: Results from Poka-Yoke

-Installed semi-automatic work-cell for final inspection
-Integrated ball-height and voltage & resistance inspection
-Eliminated risk of escapes
-Improved throughput by 20%
-Reduced labor costs by 35%
## MOFA Battery

### ATK Ordnance and Ground Systems, LLC

**Power Sources Center**

<table>
<thead>
<tr>
<th>Year</th>
<th>Hand Assembly</th>
<th>Automated Assembly</th>
<th>DFSS/Lean Six Sigma</th>
<th>DFSS/Lean Six Sigma Throughout the Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>Hand assembly</td>
<td>Automated assembly</td>
<td>DFSS/Lean Six Sigma initiated</td>
<td>DFSS/Lean Six Sigma throughout the organization</td>
</tr>
<tr>
<td>2001</td>
<td>Limited rate</td>
<td>Greatly increased throughput 10x</td>
<td>Increased throughput 1.5x</td>
<td>Increased throughput capabilities</td>
</tr>
<tr>
<td>2003</td>
<td>Operator dependent</td>
<td>Operator dependency reduced</td>
<td>Poka Yoke</td>
<td>Machine uptime &gt;95%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Machine uptime &gt; 90% and increasing.</td>
<td>Reduced defects</td>
<td>TPM incorporated on all equipment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reduced cycle time from value stream mapping</td>
<td>Trend analysis prior to creating defects</td>
<td>Kanban</td>
</tr>
<tr>
<td>2004</td>
<td>Supplier variation in parts</td>
<td>Supplier variation in parts</td>
<td>Reduced part variance.</td>
<td>Reduced part cost, number of parts, and variance</td>
</tr>
</tbody>
</table>
Now: **Material Identification and Handling**

- Pin-stamping required for lot identification purposes
- Date-coding added to record material pedigree information
- Auto-laser has *Telesis PINSTAMP Dot Peen Marking System*
- Started implementation of Lean Manufacturing using value stream mapping and Kanban to reduce cycle time and WIP

Next Step:

- 2-D code direct part marking (DPM) and reading capability. Improves quality and satisfies DoD’s new UID initiatives
- Complete implementation of Kanban
Battery Assembly Machine (BAM)
- 8 dies to punch anode, cathode, and separator.
- 5 robots to assemble stacks.
- Rate = 800 batteries per shift.
- Automated SPC on 14 characteristics
MOFA Battery

Auto-Welder
- 1 robot
- 4 position index table
- Terminal plate to case
  - 240/hour
- End plate to case
  - 240/hour
- Lot marking
- Date marking
Fill Machine
• Fill and seal battery
• 1 robot
• 8 position index table
• 800 per shift
• Automated SPC on fill weight.
Summary

• LESSONS LEARNED: Automated equipment by itself did not achieve the results we wanted. It took a team focused on DFSS/Lean Six Sigma at the Enterprise level using automation as another tool for continuous improvement.

• We have the proven capability to manufacture high volume battery programs through the use of automated equipment.

• Power Sources Center has embraced DFSS/Lean Six Sigma concepts throughout our facility to make improvements in quality, cost, and reduced risk.

• We are a leader in the design, production, test, and analysis of lithium batteries.

• We appreciate the sponsorship and technical contributions of the U.S. Army ARDEC and US. Army Research Laboratory.