Introduction to Lean Six Sigma for Food Processors

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Sustainable Solutions for Health, Productivity, and the Environment.
Objectives

• **Purpose** – To provide you with an introduction to Lean Six Sigma and how it can contribute to – and not detract from – your bottom line.

• **Process** – Communicate these concepts and applications to you through lecture, discussion, and case studies.

• **Payoff** – After this presentation, you will better appreciate the importance and significance of Lean Six Sigma in the food industry, how it can reduce costs and improve product quality, and how to get started and get help.
Overview

• Benefits of Lean Six Sigma
• Introduction of Case Study
• Lean Manufacturing
• The Ten Types of Waste
• Six Sigma
• DMAIC Process
• Managerial Considerations of Lean Six Sigma
• Recap and Discussion
Sustainable Systems for Food Processing
Product Life Cycle and Environmental Impacts

- Transportation
- Packaging
- Energy
- Water

- Resource extraction
- Suppliers
- Food manufacturing

- Waste water
- Air emissions
- All other wastes

Future Generations

Consumer
Defining the System (Facility)

**Inputs**
- Water (to clean equipment)
- Energy (heating, cooking)
- Labor
- Raw Materials (tomatoes, sugar)

**Outputs**
- Wastewater (cleaning, cooling)
- Waste energy (unrecovered heat)
- Finished Food Product
- Air Emissions (VOCs)
- Solid Waste (packaging, scrap)

Food & Beverage Manufacturing Facility
Defining the System (Process)

Inputs

Sanitation and Labor are Inputs to all steps

Sifted flour
Yeast
Energy, additives
Energy
Water (cleaning, steam)

Outputs

Begin Process
Mixing and Kneading Dough
Fermentation Division & Gas Reproduction
Slicing & Packaging
End Process - Baked Bread

Packaging waste
Waste dough
CO2
Wastewater
Waste product/packaging

Sanitation and Labor are Inputs to all steps
Defining the System (Process Step)

Inputs

- Material Usage (Dough from preceding step)
- Energy Usage (Heat, steam)
- Water use (Steam, cleaning)

Outputs

- Air Emissions (Minimal)
- Solid Wastes (waste dough) & Wastewater (cleaning, condensate)
- Hazardous Wastes (None)
- Molded and baked dough (goes to Slicing and Packaging)
Dangers of Sub-optimization
How Do We Implement Sustainable Programs in Complex Systems?
Statement from Frito-Lay

“We have applied many of the concepts and tools *(of Lean Six Sigma)*, and we are realizing a five to seven times return on our annual Lean Six Sigma investment.”

- Tony Mattei, Lean Six Sigma Director
Lean Six Sigma for the Environmental Professional

• Produced by Ross & Associates Environmental Consulting, Ltd. for EPA
• Describes how Lean and Six Sigma relate to the environment
• Provides guidance on how environmental professionals can generate better results using Lean Six Sigma
What is the Lean Six Sigma System?

The Lean Six Sigma System is an active approach to doing business. It is founded on the belief that every decision and process should be based on providing the greatest value to your customer at the lowest possible cost through the continuous elimination of waste.

Source: CQAS GBLSS Training Program
Why Lean Six Sigma?

Six Sigma System is the pursuit of **ACCURACY** and making everything right the first time …

Whereas …

Lean is the pursuit of **SPEED** and making everything as fast as you can.
LSS History

1920s  Ford Production System
       Shewhart 3 Sigma Mean Correction
1950s  Toyota Production System
1980s  Just in Time Production System
       Motorola Six Sigma
1990s  Lean Manufacturing
       GE Six Sigma
2000s  Lean Enterprise
       Lean Six Sigma
Benefits from Lean Six Sigma

- Increased profits
- Fast and dramatic results
- Continual improvement culture
- Increased revenue
- Improved quality
- Increased customer satisfaction
- Reduced costs
- Increased employee involvement
Case Study – Cleaning a Fryer

- Cycle time too long – production time is at a premium in this plant
- Water consumption too high
- Excessive manual labor
- Energy costs too high
- Excessive use of chemical cleaners
- Surfaces are not completely clean – sticky to the touch
- Manual transfer of chemicals required for CIP process
- Cleaning process is too expensive
What is Lean?

Lean refers to the principles and methods of the Toyota Production System. Lean methods focus on the **systematic identification and elimination of non-value activity**, which is also referred to as waste.

Source: www.epa.gov/lean
What is Value?

• **Value** is something that the customer would be willing to pay for … or, an activity that changes the form, fit, or function of the product or service.

• Any activity that does not add value and is unnecessary is **waste** and only adds cost – and time – to the process.

• Activities that the customer is not willing to pay for but are necessary are **non-value-added**.

• Typical companies spend **less than 10%** of their time on value-added activities.

Source: CQAS GBLSS Training Program
What Is Waste?

Waste is “anything other than the minimum amount of equipment, materials, parts, space, and worker’s time which are absolutely necessary to add value to the product.”

- Shoichiro Toyoda, President, Toyota
The Ten Types of Waste
(Tim Wood, EVP)

1. Transportation
2. Inventory
3. Motion
4. Waiting
5. Overproduction
6. Overprocessing
7. Defects
8. E2 Wastes
9. Variation
10. People’s Talent
The Ten Types of Waste

• Transportation
  – Double and triple handling
  – Temporary storage
  – Transferring parts over a long distance

Source: CQAS GBLSS Training Program
The Ten Types of Waste

- Inventory
  - Covers up problems
  - Increases the cost of product
    - Extra handling
  - Extra space
    - Carrying cost
    - Extra people
    - Extra paperwork

Source: CQAS GBLSS Training Program
The Ten Types of Waste

• Motion
  – Walking
  – Move does not add value to work
  – Movements that are straining or unnecessary (e.g. looking for parts, tools, documents, etc.)

Source: CQAS GBLSS Training Program
The Ten Types of Waste

• Waiting
  – Watching machine run (no initiative to eliminate problems)
  – Equipment down
  – Needed parts or information fail to arrive

Source: CQAS GBLSS Training Program
The Ten Types of Waste

• Over-Production
  – Producing more, sooner or faster than required by customer
    • Extra handling
    • Extra space
    • Extra inventory
    • Extra machinery
    • Extra people

Source: CQAS GBLSS Training Program
The Ten Types of Waste

• Over Processing
  – Performing unnecessary or incorrect processing, typically from poor tool or product design
  – Defects

Source: CQAS GBLSS Training Program
The Ten Types of Waste

• Defects
  – Creates waiting
  – Increases lead time
  – Scrap
  – Rework

Source: CQAS GBLSS Training Program
The Ten Types of Waste

- E2 Wastes
  - Energy Waste
    - Waste Heat
    - Wasted Power
  - Environmental Waste
    - Air Emissions
    - Wastewater Discharges
    - Solid Waste
    - Hazardous Waste
The Ten Types of Waste

• Variation
  – More product given to customer than intended, decreasing profit
  – Less product given to customer than intended, resulting in complaints and poor quality

Source: CQAS GBLSS Training Program
The Ten Types of Waste

• People’s Talent
  – Reduces innovation
  – Limits improvement
  – Reduces involvement
  – Limits commitment

Source: CQAS GBLSS Training Program
What is Six Sigma?

Six Sigma – which was developed at Motorola and popularized by General Electric – refers to a method and a set of tools that utilize statistical analysis to measure and improve an organization’s performance, practices, and systems with a prime goal of identifying and eliminating variation to improve quality.

Source: www.epa.gov/lean
Normal Distribution

- Symmetric about mean
- About 68% within 1 s.d. of mean
- About 99% within 3 s.d. of mean
- About 95% within 2 s.d. of mean
## Do We Really Need 6σ?

<table>
<thead>
<tr>
<th>σ*</th>
<th>Defects per million opportunities</th>
<th>% non-defective</th>
<th>Duration of Annual Power Outage</th>
<th>Cost of Power Outage for $50M/yr plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>308,537</td>
<td>69.1%</td>
<td>3.7 months</td>
<td>$15,400,000</td>
</tr>
<tr>
<td>3</td>
<td>66,807</td>
<td>93.32%</td>
<td>3.5 weeks</td>
<td>$3,500,000</td>
</tr>
<tr>
<td>4</td>
<td>6,210</td>
<td>99.379%</td>
<td>2.3 days</td>
<td>$329,000</td>
</tr>
<tr>
<td>5</td>
<td>233</td>
<td>99.9767%</td>
<td>2.0 hours</td>
<td>$11,900</td>
</tr>
<tr>
<td>6</td>
<td>3.4</td>
<td>99.99966%</td>
<td>1.8 minutes</td>
<td>$179</td>
</tr>
</tbody>
</table>

* Note that σ here refers to the σ as defined by Six Sigma, where 6σ is actually equal to 4.5 standard deviations.
Combine Lean and Six Sigma
What is DMAIC?

- **Define**
- **Measure**
- **Analyze**
- **Improve**
- **Control**
Define Process - Steps

- Define customers and requirements
- Develop problem statement and goals
- Identify sponsor and team members
- Define resources
- Develop project plan
- Develop value stream map

Source: CQAS GBLSS Training Program
Define Process - Tools

- Value stream mapping
- Project charter
- Problem-solving tools
- Statistical thinking
- Flowcharting
Process Flow Chart

DOES IT MOVE?

No

Should it?

No

No Problem

Yes

WD-40

Yes

No Problem

Yes

Should it?

No

No

No Problem

Yes

No
Case Study – Process Flow Chart

START

PROCURE CHEMICAL FROM WALL UNITS

DRAIN FRYER

FILL FRYER WITH WATER

ADD CAUSTIC

BEGIN CAUSTIC BOILOUT

PERFORM FINAL RINSE WITH WATER

END

SCRAPE RESIDUE FROM FRYER

RINSE WITH WATER

RINSE WITH ACID

TRANSPORT CHEMICALS TO FRYER

APPLY CHEMICALS TO EXTERNAL SURFACES

RINSE WITH H.P. SPRAY WASHER

DRAIN CAUSTIC FROM FRYER
Project Charter

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
<th>Team Charter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Process</td>
<td>Describe the process in which the opportunity exists. Attach a SIPOC model to show relationship to suppliers, inputs, outputs, and customers.</td>
<td></td>
</tr>
<tr>
<td>2. Problem Statement</td>
<td>State the problem the project will focus on, including what is both in and out of the scope and linkage to strategic objectives.</td>
<td></td>
</tr>
<tr>
<td>3. Objectives</td>
<td>What improvement is targeted and what will be the impact on the key indicators. Examples of key improvement indicators are:</td>
<td>Improvement Indicators</td>
</tr>
<tr>
<td></td>
<td>• RTY – Roll Throughput Yield using % of Defect Per Unit</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• COPQ – Cost of Poor Quality in $</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Cost or Price per unit in $</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• CT – Cycle Time</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Baseline is the current level</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Entitlement is the ideal level</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Goal is a number between the baseline and entitlement indicating the level that will be achieved by this project.</td>
<td></td>
</tr>
</tbody>
</table>
Problem Statement – Case Study

The fryers require excessive manual labor to clean and cannot be cleaned consistently to plant specifications with the current process. In addition, the cleaning cycle time is too long, energy and water requirements are excessive, and the cleaning process is too expensive. Finally, long cleaning cycle times reduce production time available, which is constrained.
Measure Process - Steps

• Map the process
• Validate the measurement system
• Make the necessary measurements
• Determine what is unacceptable performance
• Estimate short and long term capability
• Select the appropriate Critical to Quality Characteristics (CTQs) to be improved

Source: CQAS GBLSS Training Program
Measure Process - Tools

- Checksheets
- Process mapping
- Failure Mode & Effects Analysis
- Value stream mapping
- Problem-solving tools
- Gage R&R
- Control charts

- Ishikawa diagram
- Capability analysis
- Takt Pacing/Pattern

Source: CQAS GBLSS Training Program
Ishikawa Diagram – Case Study

People
- No training budget
- Workers not trained
- Workers are idle, don’t pursue other work

Material
- Chemicals aren’t working properly
- Wrong concentrations used
- Final rinse not needed

Method
- Cleaning methods not being followed
- Chemical concentrations aren’t correct

Machine
- Heating cycle too long
- Too long to drain and fill

Measurement
- Piping too narrow
- Metering pump broken
- Workers not measuring chemicals

Fryer not cleaning properly
Current State Value Stream Map

Source: www.epa.gov/lean
Analyze Process - Steps

- Analyze the preliminary data to document current performance (baseline process capability)
- Benchmark key product performance measures
- Identify value/non-value added process steps
- Identify root causes of variation (independent variables) that might impact CTQs

Source: CQAS GBLSS Training Program
Analyze Process - Tools

- 5 Whys
- Process capability ($C_p$ and $C_{pk}$)
- Histogram
- Cause & Effect Matrix
- Ishikawa Diagram
- Hypothesis Testing
- Regression
- Kaizen

- Components of Variance
- Pareto Analysis

Source: CQAS GBLSS Training Program
Pareto Diagram

Customer Complaints

Significant few

Insignificant many

80% LINE

Parking Difficult
Sales Rep was rude
Poor Lighting
Layout Confusing
Sizes Limited
Clothing Faded
Clothing Shrunk
Kaizen

- Kaizen is a continuous improvement event characterized by the following:
  - A short burst of intense activity and effort – 3-5 days only
  - Biased toward action over analysis
  - Focused on improving the value stream and achieving flow
  - Driven to resolving a specific problem or achieving a specific company goal

Source: CQAS GBLSS Training Program
Improve Process - Steps

- Quantify the impact of independent variables on CTQs (e.g. via Design of Experiments)
- Determine how to intervene in the process to significantly reduce the defect level
- Look for opportunities to reduce variability
- Assess failure modes of potential solutions
- Validate potential solution

Source: CQAS GBLSS Training Program
Improve Process - Tools

- Brainstorming
- Pull Systems
- Total Productive Maintenance
- Poka-Yoke
- Setup Reduction
- Design of Experiments

- Process Flow
- Gantt Charts

Source: CQAS GBLSS Training Program
Design of Experiments

Effect of Pressure and Temperature on Strength

- Strength
- Pressure
- Temperature

- 50
- 100
- 100
- 200
Design of Experiments

Pareto of Effects

<table>
<thead>
<tr>
<th>Effect</th>
<th>Temperature</th>
<th>Pressure</th>
<th>Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.5 lbs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.5 lbs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-7.5 lbs</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Control Process - Steps

- Document and monitor the new process conditions
- Implement statistical process control methods
- Reassess process capability
- Verify benefits, cost savings, profit
- Redesign as necessary

Source: CQAS GBLSS Training Program
Control Process - Tools

- 5-S
- Kanban
- Visual Control
- Control Charts
- Pareto Charts
- Control Plan
- Histograms

- Scatter Diagrams
- Cost Saving Calculations

Source: CQAS GBLSS Training Program
Control Tool – Histogram

Heights of 30 people

Frequency

Heights in cm

www.analyzemath.com
Control Tool – 5S

SORT
Clearly distinguish needed items from unneeded and eliminate the latter

STRAIGHTEN
Keep needed items in the correct place to allow for easy and immediate retrieval

SUSTAIN
Maintain established procedures

STANDARIZED
The method by which “Sort,” “Straighten” and “Shine” are made habitual

SHINE
Keep the workplace neat and clean
Example of 5-S Implemented

Before

After

Source: CQAS GBLSS Training Program
### Cost Calculations – Case Study

<table>
<thead>
<tr>
<th>Item</th>
<th>Reduction/Improvement</th>
<th>Dollar Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less caustic needed due to use of peroxide additive</td>
<td>Reduced use of caustic from 4 oz/gal to 2 oz/gal</td>
<td></td>
</tr>
<tr>
<td>Elimination of acid rinse due to cleaner surfaces from used of peroxide additive</td>
<td>Eliminated use of acid</td>
<td>$6,000</td>
</tr>
<tr>
<td>Addition of peroxide additive (Enhance O2)</td>
<td>New chemical cost was added, which is more than offset by reduced use of caustic and elimination of acid</td>
<td></td>
</tr>
<tr>
<td>Elimination of manual scraping and acid use</td>
<td>Reduction in labor expense</td>
<td>$11,000</td>
</tr>
<tr>
<td>Reduction in rinses</td>
<td>Reduction in water consumption</td>
<td>$1,000</td>
</tr>
<tr>
<td>Replacement of wall-mounted foaming units with central foaming system</td>
<td>Reduction in labor expense due to less chemical handling</td>
<td>$7,000</td>
</tr>
<tr>
<td>Increase in production hours</td>
<td>Increased profit margin from additional revenue resulting from increased production hours</td>
<td>$45,000</td>
</tr>
<tr>
<td><strong>Total savings/increased cash flow</strong></td>
<td></td>
<td><strong>$70,000</strong></td>
</tr>
</tbody>
</table>
How is Lean Six Sigma Different?

• Focused on improving the bottom line
• Uses proven lean and statistical tools to resolve defined problems
• Focused on dealing with time, waste, and process variation
• Focused on finding assignable causes
• Produces breakthrough improvements, quantum leaps, as well as incremental improvements

Source: CQAS GBLSS Training Program
How is Lean Six Sigma Different?

- Financial goal is established and is measurable
- Data are statistically analyzed
- Black Belts and Green Belts are carefully selected
- Projects are strategically selected by senior management using a tops-down approach
- Targets areas other than manufacturing, such as Customer Service, Finance, and HR

Source: CQAS GBLSS Training Program
Lean Six Sigma Approach

1. Select the right projects
2. Select and train the right people
3. Develop and implement improvement plans
4. Manage for excellence in operations
5. Sustain the gains!!

Source: CQAS GBLSS Training Program
Differences between LSS and Classical Organizations

- Robust design vs. trial and error for manufacturability
- Preventing vs. fixing for problems
- Data vs. experience for analysis
- Process vs. product for focus
- Statistically based vs. experience based for reasoning
- Empowered teams vs. heirarchy for chain of command
- Optimization vs. automation for improvement

Source: CQAS GBLSS Training Program
Recap

• LSS can change the culture of an organization
• The benefits of LSS can far outweigh its costs
• Highly structured problem-solving approach vs. “seat of the pants”
• Empowerment of employees is key to success
Discussion
Sustainable Solutions for Health, Productivity, and the Environment.