LEAN MANUFACTURING
TECHNIQUES
APPLIED TO PRODUCT
PACKAGING

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PETER L. KING
LEAN DYNAMICS LLC
AGENDA

- What Is Lean?
- Lean adaptations for process industry challenges
- Lean Tools for packaging operations
  1) Standard Work
  2) Point Of Use Storage
  3) 5S
  4) SMED –changeover improvement
  5) Package To Order
  6) Value Stream Mapping
  7) Product Wheels
ORIGINS OF LEAN
What is known as “Lean Manufacturing” or “Lean Production” today is based heavily on manufacturing principles developed by Toyota in the 1950s – 1980s

*Toyota Production System*
THE EVOLUTION OF LEAN

- Eli Whitney, Honore’ Blanc
  - Interchangeable parts

- Frederick Taylor - Scientific management

- Henry Ford - Flow, velocity

- Toyota - Mapping, Focus on Waste, Kaizen

- MIT IMVP - “Lean” (1989)
  - Good summary of principles & benefits
  - Created high level of awareness
THE ESSENCE OF LEAN

So what is TPS – what is Lean:

- An intense focus on elimination of waste
- An intense focus on the final customer and what he values
- Manufacturing at a rate equal to customer demand ~ TAKT
- A focus on the worker and the value he can bring
- A strong value for FLOW

_Lean philosophies can be summed up in 5 key principles_
Lean focuses on Value

- Value is defined by the customer

1. **Define Value in Customer Terms**

2. **Map the Value Stream**

3. **Make Work Flow**

4. **Flow at the Pull of the Customer**

5. **Relentlessly Pursue Perfection**

Lean focuses on flow

- Flow is at the pull of the customer

Lean focuses on waste

- Waste is eliminated by a relentless pursuit of perfection
The Toyota Production System is often depicted as a house:

- **JUST-IN-TIME**
  - Right part, right amount, right time
  - Takt
  - Continuous Flow
  - Pull Systems
  - Quick Changeover
  - Integrated Logistics

- **HIGHLY MOTIVATED PEOPLE**

- **CONTINUOUS IMPROVEMENT**

- **WASTE ELIMINATION**

- **JIDOKA** (Built in quality)
  - Automatic Stops
  - Andon
  - Person-Machine Separation
  - Error Proofing
  - In-station Quality Control
  - 5 Whys

**LEVEL PRODUCTION** - Standardized Work

**OPERATIONAL STABILITY**

**VISUAL MANAGEMENT**

**TOTAL PRODUCTIVE MAINTENANCE (TPM)**

Attributed to Fujio Cho, a disciple of Taichi Ohno
THE TOYOTA PRODUCTION SYSTEM (TPS) HOUSE

TPS

MEETING CUSTOMER NEEDS
WITH THE HIGHEST QUALITY IN THE SHORTEST TIME

FLOW

PEOPLE ENGAGEMENT & CONTINUOUS IMPROVEMENT

QUALITY

STANDARDIZATION & STABILITY

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LEAN IS NOT ABOUT COST REDUCTION!

Lean, world-class athletes getting into shape:
- Don’t try to lose weight
- Try to lose fat
- Try to build muscle

Lean, world-class manufacturing operations
- Don’t try to cut costs
- Try to cut waste
- Try to build muscle
  - A trained, capable workforce
  - Standardized, disciplined processes
SEEING THE FLOW
VALUE STREAM MAPPING
LEAN THINKING
FOR PROCESS OPERATIONS
PROCESS VS ASSEMBLY

Parts Manufacturing and Assembly

- Automobiles
- Cell phones
- Computers
- Power tools
- Appliances
- Aircraft
- Medical instruments
- Consumer electronics
- Lawn mowers

Process Operations

- Chemical reactions
- Physical transformations
  - Mixing, blending
  - Extrusion
  - Sheet forming

Process Products

- Automotive and house paints
- Foods and beverages
- Personal care products
- Synthetic fibers
- Sheet goods
- Films
- Glass and ceramics
Lean was developed for discrete parts manufacture.

Process operations are different…

- They behave differently from discrete parts operations.

Lean does apply to process operations:

- Often with even more benefit.
- But must be adapted to recognize the differences.
Finished Products

Adapted from
Synchronous Manufacturing
Umble & Srikanth, 1990

Material Flow
EXAMPLE OF A “V” PROCESS

- RAW MATERIALS = 6 TYPES
- MASTER ROLLS = 50 TYPES
- PACKAGED ROLLS = 2000 TYPES
- CUT ROLLS = 1800 TYPES
- SLIT ROLLS = 1000 TYPES
- BONDED ROLLS = 200 TYPES
- RAW MATERIALS = 6 TYPES

SHEET GOODS MANUFACTURING PROCESS
STANDARD WORK
LEAN PRINCIPLE:

*Standardized tasks and processes are the foundation for continuous improvement and employee empowerment.*

- Every task should be standardized
- Every task should be examined for improvement possibilities
- No improvement should be implemented until tested, validated, authorized, documented, and communicated
- The improvement becomes the new standard

Why Standard work?

- Variation can cause defects
- Variation causes confusion
- Variation inhibits Continuous Improvement
POINT OF USE STORAGE
Point of use Storage is storing materials as close to the location where they are used as is possible

- Tools needed for product changeover
- Changeover parts: filters, screens
- Materials for future campaigns: labels, caps
- Tools needed for minor repairs
- Repair parts: fuses, lamps, etc.

And located within easy reach

Benefits:

- Eliminates searching for tools, parts, materials
- Reduces downtime
- Speeds product changeovers
Five S, 5S

1. Sort (Seiri)
2. Straighten (Seiton)
3. Shine (Seiso)
4. Standardize (Seiketsu)
5. Sustain (Shitsuke)
<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1 Sort (Seiri)</strong></td>
<td>Sort through everything in the area - get rid of anything that is not needed</td>
</tr>
<tr>
<td><strong>2 Straighten (Seiton)</strong></td>
<td>Arrange all tools, equipment, and materials in a way that facilitates smooth work flow. Locate everything as close to the precise point of use as possible</td>
</tr>
<tr>
<td><strong>3 Shine (Seiso)</strong></td>
<td>Clean the entire area, including all surfaces, so that defects, equipment problems, and any abnormal conditions will be very apparent. Make sure that all tools, parts, and fixtures are clean.</td>
</tr>
<tr>
<td><strong>4 Standardize (Seiketsu)</strong></td>
<td>Establish systems and processes to maintain the first 3 S’s including placards or signs describing standard work, and shadow boards indicating tool location. Make it easy to put things in their proper place, and difficult not to.</td>
</tr>
<tr>
<td><strong>5 Sustain (Shitsuke)</strong></td>
<td>Develop a managing process, with regular audits to insure that this becomes the way the workplace is organized and maintained.</td>
</tr>
</tbody>
</table>
EXAMPLE OF A 5S IMPLEMENTATION

- Filling lines to load house paint into 1 gallon buckets
- Eight (8) lines – installed at different times over a 40 year period
- Different control systems – different operator interfaces

5S changes

- Removed all unnecessary tools and equipment
- Cleaned floor, walls, equipment surfaces
- Standardized on a pegboard design for tools
- Standardized on an operator interface
- Not only is the area cleaner and less cluttered … …… Operators can easily move from machine to machine as needed
BENEFITS OF 5S

5S appears simple and straightforward, but the benefits are huge!

- Easier to work in an uncluttered work area
- Tools are readily at hand – eliminates time searching
- Creates more operator ownership for their work area
- Problems become much more visible
- A clean uncluttered area is a safer area
- The discipline of 5S builds the discipline needed for Standard Work
CHANGEOVER IMPROVEMENT

SINGLE MINUTE EXCHANGE of DIES
SMED IMPROVEMENT STEPS

- Identify tasks which can be external
- Move external tasks outside the changeover window
- Simplify Internal tasks
- Perform Internal tasks in parallel
Tasks which could be external
- Bring new label stock to area
- Bring new cardboard packaging into area
- Remove old labels, cardboard, etc.

Tasks which could be done in parallel
- Flushing supply lines
- Adjusting mechanical fixtures
- Replacing labels
- Replacing cardboard stock in carton erector

Tasks which could be simplified
- Everything!
North West Line Change Over W/Fluid Cleanout 6/30/2011

Operator 1
- Bottles off Line
- Drop Packer Set Up
- Fluid Cleanout & Take Sample To Lab

Operator 2
- Remove Labels & Cartons
- Drop Packer Set Up
- Case Erector Set Up, Set Up Carton Date Coder

Lead Operator
- Remove Caps From Line
- Caps, Bottles Delivered to Line
- Cap Sealer, Cap Detect or VideoJet Set Up
- Mettler Scale and Labeler Set Up
- Fluid Cleanout

Mechanic 1
- Capper/Filler Changeover

Mechanic 2
- Capper/Filler Changeover

Mechanic 3
- Unscrambler Changeover

Lab Technician
- Lab Testing

Fluid Change From: xxx To: xxx
Start: xxxam Complete: xxxam Total Time: x hrs xx min
Bottle Change: XX oz To XX oz
FINISH TO ORDER

PACKAGE TO ORDER
FTO IN PROCESS SUPPLY CHAINS

FTO is sometimes done with process products – at the final point of sale

- House paint is stocked in hardware stores only in base colors
- Small amounts of pigment are added in the store to supply the full range of colors and shades

Thus a very high degree of variety can be supplied – with modest inventories
FTO IN PROCESS PLANTS

FTO is also done within process plants

- Crop protection products – fertilizers, pesticides, fungicides – are produced in a small number of formulations
- There can be tremendous variety in packaging
- Material is often held in bulk, and bagged to order

- Paper and plastic sheet goods are sometimes stored as bonded or coated mother rolls
- They are then slit (and chopped) to order
EXAMPLE OF A “V” PROCESS

RAW MATERIALS = 6 TYPES

MASTER ROLLS = 50 TYPES

PACKAGED ROLLS = 2000 TYPES

CUT ROLLS = 1800 TYPES

SLIT ROLLS = 1000 TYPES

BONDED ROLLS = 200 TYPES

FINISH-TO-ORDER POINT

SHEET GOODS MANUFACTURING PROCESS

MASTER ROLLS = 50 TYPES

RAW MATERIALS = 6 TYPES
**BENEFITS OF A FTO STRATEGY**

- Reduced dependence on forecasts
- Differentiation based on true demand
  - Highly differentiating steps are usually near the end
- Reduced finished product inventory
- Reduced total inventory
- Final process steps more available to meet real needs
- Improved customer service levels

*Requires the ability to store materials prior to the F-T-O or Pkg-T-O Point*
PRODUCT WHEELS
Many of our production lines must package a wide variety of products: fluid, bottle size, labels, carton size.

- Should we run a regular campaign cycle?
- How long should the overall campaign be?
- How much of each material should we make on each cycle?

- Product Wheel design can answer all of these questions.
If we’re making several materials on a regular cycle, is there an optimum sequence?

Sometimes this is obvious ……

But some times not

Again – Product Wheel design has tools for determining this.
The sequence is optimized for minimum changeover loss.

- The sequence is fixed.

- Some low-volume products may not be made every cycle.

- Spokes can have different lengths, based on the Takt for each product.

- The amount actually produced can vary from cycle to cycle, based on actual consumption.

- Thus the time can vary slightly from cycle to cycle.
Product wheels support a Pull replenishment system

- Each spoke is designed based on average historical demand
- What is actually produced on any spoke is just enough to replenish what has been consumed from inventory

Product Wheels can be compatible with MRP

Product wheels can be employed in a Make-to-Stock (MTS) or a Make-to-Order (MTO) environment

MTS and MTO products can be made on the same wheel
Product Wheels were applied to several packaging lines at an automotive fluid manufacturer.

Results

- Inventories were reduced
- Many low volume products now Make-to-Order
- Brought structure & discipline – ended the chaos
VALUE STREAM MAPPING

EXAMPLES
FLOW LIMITATIONS
IN A CEREAL PLANT
FLOW LIMITATIONS IN A CEREAL PLANT

SHAPE MANUFACTURING

STORAGE SILOS

FLAKE MANUFACTURING

PACKAGING

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POOR COORDINATION IN A CEREAL PLANT

- The VSM shows the packaging area at 75% Utilization
- But - silos often fill up, so flake or shape production goes down

- The INFORMATION FLOW portion of the VSM shows that the culprit is poor scheduling, no synchronization
THROUGHPUT INCREASES IN A SALAD DRESSING PLANT
VALUE STREAM MAPPING – SALAD DRESSING

High speed bottling machine
300 bottles per minute
### Salad Dressing Bottle Filling Line

#### BN #1 - Bottle Filling Machine
- **Efficiency Capacity:** 300 Bot/Min
- **Takt:** 400 BPM
- **Utilization:** 133%
- **OEE:** 85%

#### BN #2 - Homogenizer
- **Efficiency Capacity:** 60 GPM
- **Takt:** 75 GPM
- **Utilization:** 125%
- **OEE:** 90%

#### BN #3 - Bottle Capper
- **Efficiency Capacity:** 500 BPM
- **Takt:** 400 BPM
- **Utilization:** 80%
- **OEE:** 94%

#### BN #4 - Accumulating Bottle Conveyor
- **Efficiency Capacity:** 360 BPM
- **Takt:** 400 BPM
- **Utilization:** 111%
- **OEE:** 82%

#### Accumulating Bottle Conveyor
- **Efficiency Capacity:** 33 cases/min
- **Takt:** 34 cases/min
- **Utilization:** 101%
- **OEE:** 76%

#### Shrinking Wrap Tunnel
- **Efficiency Capacity:** 122 cases/min
- **Takt:** 34 cases/min
- **Utilization:** 28%
- **OEE:** 90%

#### Case Pattetizer
- **Efficiency Capacity:** 100 cases/min
- **Takt:** 34 cases/min
- **Utilization:** 34%
- **OEE:** 94%

#### Pallet Stretch Wrapper
- **Efficiency Capacity:** 224 pallet/hr
- **Takt:** 26 pallet/hr
- **Utilization:** 12%
- **OEE:** 92%

#### Pallet Label Printer Applicator
- **Efficiency Capacity:** 170 pallet/hr
- **Takt:** 26 pallet/hr
- **Utilization:** 15%
- **OEE:** 76%

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**NOTE:** All capacities and Takt are relative to 24 oz bottles, which is the primary size run on his line.

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**Current State VSM, with the higher Takt requirement**

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- **Value Stream Mapping**
  - To understand bottlenecks
  - To find opportunities to better synchronize operations
  - To understand reasons for unnecessary inventory
  - To see opportunities to reduce/eliminate waste

- **Standard work, POUS, 5S**
  - To simplify operations
  - To reduce variation
  - To eliminate lost time
  - To build operating discipline
SMED

- To speed up changeovers
- Faster changeovers = more production time, shorter campaigns, less inventory

Finish-To-Order, Package-To-Order

- Reduce finished goods inventory
- Improve fill rates, service levels

Product Wheels

- Optimize campaign size, production sequence
- Level production to match takt within reasonable time periods
- Reduce inventory, increase predictability
The material in this presentation is featured in

*Productivity Press*

*May 2009*
QUESTIONS?

PeterKing@LeanDynamics.US
www.LeanDynamics.US