Chapter 12
Lean Production

December 2, 2008

Lean Production

An integrated set of activities designed to achieve high-volume production using minimal inventories (raw materials, work in process, and finished goods)

Involves the elimination of waste in production effort

Involves the timing of production resources (i.e., parts arrive at the next workstation "just in time")

Features of Lean Production

**WHAT IT IS**

- Management philosophy
- "Pull" system though the plant

**WHAT IT DOES**

- Attacks waste
- Exposes problems and bottlenecks
- Achieves streamlined production

**WHAT IT REQUIRES**

- Employee participation
- Industrial engineering/basics
- Continuing improvement
- Total quality control
- Small lot sizes

**WHAT IT ASSUMES**

- Stable environment

Pull System

Here the customer starts the process, pulling an inventory item from Final Assembly...

Then sub-assembly work is pulled forward by that demand...

The process continues throughout the entire production process and supply chain...
The Toyota Production System

Based on two philosophies:
- Elimination of waste
  - Waste: “Anything other than the minimum amount of equipment, materials, parts, and workers (working time) which are absolutely essential to production” by Fujio Cho, President of Toyota.
- Respect for people
  - Permanent positions
  - Maintain payrolls

Ref:
Waste: JI5.avi
The Toyota Way: http://tw.youtube.com/watch?v=YTQtoeP_1oU&feature=related

Elimination of Waste
1. Focused factory networks
2. Group technology
3. Quality at the source
4. JIT production
5. Uniform plant loading
6. Kanban production control system
7. Minimized setup times

Minimizing Waste:
Focused Factory Networks

These are small specialized plants that limit the range of products produced (sometimes only one type of product for an entire facility)

Minimizing Waste: Group Technology (Part 1)

Using Departmental Specialization for plant layout can cause a lot of unnecessary material movement

Some plants in Japan have as few as 30 and as many as 1000 employees

Note how the flow lines are going back and forth
Minimizing Waste: Group Technology (Part 2)

Revising by using Group Technology Cells can reduce movement and improve product flow.

![Diagram of Group Technology Cells]

Minimizing Waste: Uniform Plant Loading (heijunka)

Suppose we operate a production plant that produces a single product. The schedule of production for this product could be accomplished using either of the two plant loading schedules below.

<table>
<thead>
<tr>
<th></th>
<th>Jan. Units</th>
<th>Feb. Units</th>
<th>Mar. Units</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not uniform</td>
<td>1,200</td>
<td>3,500</td>
<td>4,300</td>
<td>9,000</td>
</tr>
<tr>
<td>Uniform</td>
<td>3,000</td>
<td>3,000</td>
<td>3,000</td>
<td>9,000</td>
</tr>
</tbody>
</table>

How does the uniform loading help save labor costs?

Minimizing Waste: JIT Inventory Hides Problems

JIT: producing what is needed when needed and no more. Inventory Hides Problems: when inventory levels are low, quality problems become very visible.

![Diagram of JIT Inventory Hides Problems]

Example: By identifying defective items from a vendor early in the production process the downstream work is saved.

Example: By identifying defective work by employees upstream, the downstream work is saved.

Minimizing Waste: Kanban Production Control Systems

Once the Production kanban is received, the Machine Center produces a unit to replace the one taken by the Assembly Line people in the first place.

This puts the system back were it was before the item was pulled.

![Diagram of Kanban Production Control Systems]

The process begins by the Assembly Line people pulling Part A from Storage.
Determining the Number of Kanbans Needed

- Setting up a kanban system requires determining the number of kanbans cards (or containers) needed.
- Each container represents the minimum production lot size.
- An accurate estimate of the lead time required to produce a container is key to determining how many kanbans are required.

The Number of Kanban Card Sets

\[ k = \frac{\text{Expected demand during lead time} + \text{Safety stock}}{\text{Size of the container}} \]

\[ = \frac{DL(1+S)}{C} \]

- \( k \) = Number of kanban card sets (a set is a card)
- \( D \) = Average number of units demanded over some time period
- \( L \) = Lead time to replenish an order (same units of time as demand)
- \( S \) = Safety stock expressed as a percentage of demand during lead time
- \( C \) = Container size

Example of Kanban Card Determination: Problem Data

- A switch assembly is assembled in batches of 4 units from an "upstream" assembly area and delivered in a special container to a "downstream" control-panel assembly operation.
- The control-panel assembly area requires 5 switch assemblies per hour.
- The switch assembly area can produce a container of switch assemblies in 2 hours.
- Safety stock has been set at 10% of needed inventory.

Example of Kanban Card Determination: Calculations

\[ k = \frac{\text{Expected demand during lead time} + \text{Safety stock}}{\text{Size of the container}} \]

\[ = \frac{DL(1+S)}{C} \]

\[ = \frac{5(2)(1.1)}{4} \]

\[ = 2.75, \text{ or } 3 \]

Always round up!
Respect for People

- **Level payrolls**
  - Permanent workers have job security and tend to be more flexible, remain with a company, and do all they can to help a firm achieve its goals.

- **Cooperative employee unions**
  - If the company performs well, they will get a bonus. This improves workers to improve productivity.

- **Subcontractor networks**
  - Suppliers consider themselves part of a customer’s family.

Toyota Production System’s Four Rules

1. All work shall be highly specified as to content, sequence, timing, and outcome
2. Every customer-supplier connection must be direct, and there must be an unambiguous yes-or-no way to send requests and receive responses
3. The pathway for every product and service must be simple and direct
4. Any improvement must be made in accordance with the scientific method, under the guidance of a teacher, at the lowest possible level in the organization

Lean Implementation Requirements: Design Flow Process

- Link operations
- Balance workstation capacities
- Redesign layout for flow
- Emphasize preventive maintenance
- Reduce lot sizes
- Reduce setup/changeover time

Lean Implementation Requirements: Total Quality Control

- Worker responsibility
- Measure SQC
- Enforce compliance
- Fail-safe methods
- Automatic inspection
Lean Implementation Requirements: Stabilize Schedule

- Level schedule
  - Material to be pulled into final assembly in a pattern uniform
- Underutilize capacity
  - The excess capacity in labor and equipment that results is much cheaper than carrying excess inventory
- Establish freeze windows
  - Period of time during which the schedule is fixed and no further changes are possible

Lean Implementation Requirements: Kanban-Pull

- Demand pull
- Backflush
- Reduce lot sizes

Lean Implementation Requirements: Work with Vendors

- Reduce lead times
- Frequent deliveries
- Project usage requirements
- Quality expectations

Ref: Lead Time-Cummins Engine Company, Inc.: LP3.avi
Supplier Relationship- Toyota and Flex-n-Gate: SU1.avi

Lean Implementation Requirements: Reduce Inventory More

- Look for other areas
- Stores
- Transit
- Carousels
- Conveyors
Lean Implementation Requirements: Improve Product Design

- Standard product configuration
- Standardize and reduce number of parts
- Process design with product design
- Quality expectations

Lean Implementation Requirements: Concurrently Solve Problems

- Root cause
- Solve permanently
- Team approach
- Line and specialist responsibility
- Continual education

Lean Implementation Requirements: Measure Performance

- Emphasize improvement
- Track trends

Lean in Services (Examples)

- Organize Problem-Solving Groups
- Upgrade Housekeeping
- Upgrade Quality
- Clarify Process Flows
- Revise Equipment and Process Technologies
Lean in Services (Examples)

- Level the Facility Load
- Eliminate Unnecessary Activities
- Reorganize Physical Configuration
- Introduce Demand-Pull Scheduling
- Develop Supplier Networks

Ref:
JIT-New System/Criteria at McDonalds: JTM3.avi
Capacity, recovery at Hotel Monaco: SDHM8.avi
Service/scheduling at 1st National Bank of Chicago: SE5.avi

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Question Bowl

**Lean Production seeks to achieve high volume production using which of the following?**

a. Minimal inventory of raw materials
b. Minimal inventory of work-in-process
c. Minimal inventory of finished goods
d. All of the above
e. None of the above

Answer: d. All of the above

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Question Bowl

In the Toyota Production System, the “elimination of waste” involves which of the following?

a. Overproduction
b. Waiting time
c. Transportation
d. All of the above
e. None of the above

Answer: d. All of the above

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Question Bowl

In the Pull System the partner that begins the process of “pulling” is which of the following?

a. Customers
b. Vendors
c. Fabrication personnel
d. CEO
e. All of the above

Answer: a. Customer
Question Bowl

A Lean Production program requires which of the following?

a. Employee participation
b. Total quality control
c. Small lot sizes
d. Continuing improvement
e. All of the above

Answer: e. All of the above (Also included in Industrial engineering/basics)

Question Bowl

Inventory has been known to hide which of the following production problems?

a. Scrap
b. Vendor delinquencies
c. Decision backlogs
d. All of the above
e. None of the above

Answer: d. All of the above

Question Bowl

You want to determine how many kanban card sets you need for an operation. You find that average number of units demanded is 1,000 per hour, the lead time to replenish the order for this item is 10 hours, the container size is 10 units, and the safety stock is estimated to be 5% of the expected demand. Which of the following is the desired number of kanban card sets?

a. 1050  
b. 1000  
c. 605  
d. 500  
e. None of the above

Answer: a. 1050 \( \left( \frac{1000 \times 10}{1+0.05} \right) = 1050 \) 

Question Bowl

When trying to implement Lean system a “stabilized schedule” includes which of the following?

a. Demand pull  
b. Backflush  
c. Fail-safe methods  
d. All of the above  
e. None of the above

Answer: e. None of the above (These include: level schedule, underutilization capacity, and establish freeze windows.)