The Lean Manufacturing Pocket Handbook

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# The Lean Manufacturing Pocket Handbook

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Introduction

In the fifteenth century a visitor to the great Arsenal of Venice (1418-1449) noticed an area where spare pieces of cut lumber were organized by their length. Workers needing a piece of lumber of a certain length, would first go to the cut pile, find a piece equal to or slightly longer than the one they needed and cut it down to length, thus helping to minimize material waste. At that time materials were the dominant factor in production cost.

In the latter half of the Industrial Revolution the complexity of products increased. Labor cost content began to overtake material cost. This change gave rise to the ideas of Fredrick Taylor and Frank Gilbreth and the age of Scientific Management was born.

With the beginning of the information age, the advent of the computer and the expansion of global trade, the complexity of products and their corresponding supply chains exploded. The escalation in complexity has had two drawbacks. It has increased the capital cost content of products, and it has exacerbated the difficulty of maintaining uniform quality. The globalization on the other hand has generated unparalleled market competition.

The objective of Lean Manufacturing is to minimize the waste endemic in this increasingly complicated world of manufacturing and thus improve competitive performance.

Many of the ideas embodied in Lean Manufacturing date back to Fredric Taylor and his Scientific Management. Most of the new ideas are based on the work of Dr. William E. Deming and Dr. Shigeo Shingo. The Toyota Motor company was the first to introduce the combined system of ideas which became known as Lean Manufacturing.

When implementing this system it is important to remember that the principals of Lean Manufacturing are directions not destinations. The fundamental rule of making a profit still applies. Always remember, those who dictate perfection, or destruction create vastly more destruction than perfection.

Glossary of Key Terms

5S - a methodology for organizing, cleaning, developing, and sustaining a productive work environment

Batch size Reduction - a manufacturing approach that emphasizes the reduction in process batch sizes by eliminating the system constraints that force large batch sizes (see Batch size Reduction section, page 27)

Cellular Manufacturing - a manufacturing approach in which equipment and workstations are arranged to facilitate small-lot, continuous-flow production (see Cellular Manufacturing section, page 28)

Cross Training - a management approach in which multiple employees are trained to perform each production task, thereby eliminating skills monopolies

External Set Up Time - time spent converting from one product production setup to another while production is in progress

Gantt Chart - a chart of events showing both duration and sequence (Invented by Henry Gantt 1861-1919)

Internal Set Up Time - time spent converting from one product production setup to another while production is halted

JIT - an acronym (Just In Time) - the production control philosophy based on the concept - produce the necessary units, in the necessary quantities, at the necessary time (see JIT section, page 5)

Job Shop - a facility that has no product line of its own but simply sells its manufacturing capacity on an as-needed job-by-job basis
**Glossary of Key Terms**

**Kaizen** - Japanese for "Continuous Improvement" - a management philosophy emphasizing employee participation, in which every process is continuously evaluated and re-evaluated for the elimination of waste (see Kaizen section, page 26)

**Kanban** - Pull Scheduling combined with traveling instructions conveyed by simple visual devices (see Kanban section, page 34)

**Local Optimization** - actions which benefit a particular segment of an organization but are at the expense of either other segments or the organization as a whole

**One Piece Flow** - see Batch Size Reduction

**Point of Use Systems** - a manufacturing strategy for positioning required resources at the site of production

**Poka Yoke** - Japanese for "error proof" - A quality improvement strategy emphasizing preventing defects through the selection of low defect rate design options (see Quality at the Source section, page 22)

**Production Leveling / Smoothing** - strategies for redistributing production volume and mix over time in order to minimize extremes (see Production Leveling / Smoothing section, page 32)

**Quality at the Source** - a Quality Assurance Philosophy that places responsibility for meeting customer specifications and standards at the point of manufacture (see Quality at the Source section, page 21)

**Repair** - actions required to bring products into compliance with deviated specifications

**Rework** - actions required to bring products into compliance with specifications

**Scrap** - material determined to be unusable for production or sale

**SMED** - an acronym (Single Minute Exchange of Dies) - also the name for a group of quick-change-over strategies (see SMED section, page 26)

**Standardized Work** - the process of documenting and standardizing tasks throughout the value stream (see Standardized Work section, page 30)

**Takt Time** - the production tempo (Takt is German for "beat") - time per unit Takt time = Time Available (within a work center)/Demand (see Takt Time section, page 31)

**Total Productive Maintenance** - see TPM

**TPM** - an acronym (Total Productive Maintenance) - strategies for creating employee ownership and autonomous maintenance of production equipment (see TPM section, page 24)

**Value Stream** - all actions (both value added and non-value added) required to bring a specific product or service from raw material to the possession of the customer (this includes information flows)

**Value Stream Mapping** - the process of identifying and charting the flows of information, processes and physical goods across the entire supply chain from the raw material supplier to the possession of the customer (see Value Stream Mapping section, page 18)

**Visual Management** - the strategy of providing visual information on daily activities available for everyone in the workplace (see Visual Management section, page 25)

**Waste** - non-value adding activities or information flows (cost without compensating benefit)

**Work Balancing** - see Takt Time

**Zero Quality Control** - see Quality at the Source
JIT - Explained

Discussion:
We all know the words “Produce the quantity required, at the rate required, at the time required”. Sadly that’s all most people know about JIT. Even worse, I have watched while some of those people have taken perfectly good companies right over the cliff and muttered that mantra all the way down to the rocks. As Thomas Huxley said “a little knowledge is dangerous”.

The most important thing to realize about JIT is that JIT is what happens after, after setup times are eliminated, after defect rates are zero, after equipment breakdowns are prevented, after lead times are abolished, after optimal lot sizes are one, after handling is minimized and after... well you get the idea. That’s right, JIT is the logical result of tangible production improvements not the reverse. You should always operate to optimize profit. When you have achieved a truly Lean Manufacturing organization that optimum will be JIT.

The Theoretical Basis:
To understand the theory behind JIT we must first return to the concept of Economic Order Quantity (EOQ). The economic order quantity model is driven by Order Costs and Carrying Costs.

Unit order costs start at a high point chiefly because of the initial impact of setup costs which are typically higher than unit production costs. This setup cost component is marginalized as the quantity of units increases. As a result, the unit order cost curve flattens. Carrying costs tend to be linear with time. The number of units produced in a lot determines how long they will be in inventory while consumption catches up with production.

EOQ Model

Given the two cost curves (average unit costs) it is possible to calculate the EOQ and the point of Lowest Average Unit Cost (LAUC). From this information we can generate an Inventory Model.

Inventory Model

All of this is of course standard inventory theory, and it remains applicable under Lean Manufacturing. The difference under Lean Manufacturing is that we operate on the Order Cost curve and hence the Total Cost curve.
JIT - Explained

Under Lean Manufacturing the Order Cost curve is both flattened and shifted downward. The flattening is the effect of reduced setup times while the shift is the effect of improvements in both Productivity and Quality. For the purpose of this example I have not completely flattened the setup component of the Order Cost curve. Although this is a primary goal of Lean Manufacturing, intermediate steps are more illustrative of the step by step progress practitioners will experience.

The above chart would be typical of a first cycle of improvement. Progress has been two fold. Both the Lowest Average Unit Cost and the Economic Order Quantity have declined. While the benefit of a decline in average unit cost is obvious, the benefit of a smaller EOQ can be very important as well (see Over Production, Wait Time, Inventory and Defect, Waste).

It is important to note that failure to adjust order sizes after a shift in the cost curves would result in higher average unit costs. This fact is fundamental to the reasoning behind JIT.

Movement toward JIT is not in spite of EOQ, movement toward JIT is because of EOQ.

The changes have equally dramatic effects on the Inventory Model. A smaller EOQ results in a decline in inventory levels and hence the capital tied up in those inventories. Reductions in setup and run times automatically reduce lead times. The response time to customer orders is reduced and the new smaller lots are therefore easier to schedule.

It might be beneficial to review the effects of achieving an EOQ of one (True JIT). With a complete flattening of the Order Cost curve, inventory levels would collapse to the absolute minimum. Units could simply bypass the expense of entering inventory and go directly to the shipping dock.

Epilog:

Not all manufacturing organizations can or should attain true JIT. The exceptions mostly revolve around highly capitalized batch processes which prevent one piece flow. But all manufacturing organizations can and should move towards optimal performance which is almost always closer to JIT.
Lean Manufacturing: A simple Definition

A Simple Definition
Consider a Venn Diagram.
Two circles, one inside of the other.
The large circle represents the Value Stream (all of the activity and information streams that exist between the raw material supplier and the possession of the customer). The smaller circle represents Waste (Cost without Benefit).

Lean Manufacturing is simply a group of Strategies for the Identification and Elimination of the Waste inside the Value Stream.

A Word of Comfort:
You already know most of Lean Manufacturing.

Lean Manufacturing - Philosophy

The Philosophy:
The Identification and elimination of waste from the value stream is the central theme of the Lean Manufacturing Philosophy.
Lean manufacturing is a dynamic and constantly improving process dependent on the understanding and involvement of all of the company's employees. Successful implementation requires that all employees be trained to identify and eliminate waste from their work. Waste exists in all work and at all levels in the organization. Effectiveness is the result of the integration of Man, Method, Material and Machine at the worksite.

The Three Pillars:
- The Problem - Waste exists at all levels and in all activities
- The Solution - The Identification and Elimination of Waste
- The Who - All of the employees and departments comprising the organization

Seven Types of Waste

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Waste - Over-Production

Over-Production Waste

**Definition** - producing more than is needed, faster than needed or before needed

**Characteristics:**
- Batch Processing
- Building Ahead
- Byzantine Inventory Management
- Excess Equipment/Oversized Equipment
- Excess Capacity/Investment
- Excess Scrap due to Obsolescence
- Excess Storage Racks
- Inflated Work Force
- Large Lot Sizes
- Large WIP and Finished Goods Inventories
- Outside Storage
- Unbalanced Material Flow

**Causes:**
- Automation in the Wrong Places
- Cost Accounting Practices
- Incapable Processes
- Just in Case Reward System
- Lack of Communication
- Lengthy Setup times
- Local Optimization
- Low Uptimes
- Poor Planning

**Example:**
Units which were produced in anticipation of future demand are often scrapped due to configuration changes.

Waste - Wait Time

Wait Time Waste

**Definition** - idle time that occurs when codependent events are not fully synchronized

**Characteristics:**
- Idle Operators waiting for Equipment
- Lack of Operator Concern for Equipment Breakdowns
- Production Bottlenecks
- Production Waiting for Operators
- Unplanned Equipment Downtime

**Causes:**
- Inconsistent Work Methods
- Lack of Proper Equipment/Materials
- Long Setup Times
- Low Man/Machine Effectiveness
- Poor Equipment Maintenance
- Production Bottle Necks
- Skills Monopolies

**Examples:**
An operator arrives at a work station only to find he must wait because someone else is using the equipment for production.

A production lot arrives at a processing center only to find that the only qualified operator is not available.
Waste - Transportation

Transportation Waste

Definition - any material movement that does not directly support immediate production

Characteristics:
- Complex Inventory Management
- Difficult and Inaccurate Inventory Counts
- Excessive Material Racks
- Excessive Transportation Equipment and shortage of associated parking spaces
- High rates of Material Transport Damaged
- Multiple Material Storage Locations
- Poor Storage to Production floor space ratio

Causes:
- Improper Facility Layout
- Large Buffers and In Process Kanbans
- Large Lot Processing
- Large Lot Purchasing
- Poor Production Planning
- Poor Scheduling
- Poor Work Place Organization

Example:
Production units are moved off the production floor to a parking area in order to gather a "Full Lot" for a batch operation.

Waste - Processing

Processing Waste

Definition - redundant effort (production or communication) which adds no value to a product or service.

Characteristics:
- Endless Product/Process Refinement
- Excessive Copies/Excessive Information
- Process Bottlenecks
- Redundant Reviews and Approvals
- Unclear Customer Specifications

Causes:
- Decision Making at Inappropriate Levels
- Inefficient Policies and Procedures
- Lack of Customer Input Concerning Requirements
- Poor Configuration Control
- Spurious Quality Standards

Examples:
Time spent manufacturing product features which are transparent to the customers or which the customer would be unwilling to pay for

Work which could be combined into another process
Waste - Inventory

Inventory Waste

Definition: any supply in excess of process requirements necessary to produce goods or services in a Just-in-Time manner.

Characteristics:
- Additional Material Handling Resources (Men, Equipment, Racks, Storage Space)
- Extensive Rework of Finished Goods
- Extra Space on Receiving Docks
- Long Lead Times for Design Changes
- Storage Congestion Forcing LIFO (Last In First Out) instead of FIFO (First In First Out)

Causes:
- Inaccurate Forecasting Systems
- Incapable Processes
- Incapable Suppliers
- Local Optimization
- Long Change Over Times
- Poor Inventory Planning
- Poor Inventory Tracking
- Unbalanced Production Processes

Example:
Large lot purchases of raw material which must be stored while production catches up.

Waste - Motion

Motion Waste

Definition: any movement of people which does not contribute added value to the product or service.

Characteristics:
- Excess Moving Equipment
- Excessive Reaching or Bending
- Unnecessarily Complicated Procedures
- Excessive Tool Gathering
- Widely Dispersed Materials/Tools/Equipment

Causes:
- Ineffective Equipment, Office and Plant Layout
- Lack of Visual Controls
- Poor Process Documentation
- Poor Work Place Organization

Example:
It is not uncommon to see operators make multiple trips to the tool crib at the beginning of a job. A lack of proper organization and documentation is in fact the cause for many types of waste.
Waste - Defect

Defect Waste

Definition - repair or rework of a product or service to fulfill customer requirements as well as scrap waste resulting from materials deemed to be un-repairable or un-reworkable

Characteristics:
- Complex Material Flows
- Excess Finished Goods Inventory
- Excessive Floor Space/Tools/Equipment
- Excessive Manpower To Inspect/Rework/Repair
- High Customer Complaints/Returns
- High Scrap Rates
- Poor Production Schedule Performance
- Questionable Quality
- Reactive Organization

Causes:
- Excessive Variation
- High Inventory Levels
- Inadequate Tools/Equipment
- Incompatible/Incompatible Processes
- Insufficient Training
- Poor Layouts/Unnecessary Handling (Transport Damage)

Value Stream Mapping

Value Stream Mapping

Definition - the process of identifying and charting the flows of information, processes, and physical goods across the entire supply chain from the raw material supplier to the possession of the customer.

Value Stream Mapping is a basic planning tool for identifying wastes, designing solutions, and communicating lean concepts.

Benefits:
- Highlighted Dependencies
- Identified Opportunities for the Application of Specific Tools and Strategies
- Improved understanding of highly complex systems
- Synchronized and prioritized Continuous Improvement activities

Objectives of Value Stream Mapping:
- Visualization of Material and Information Flows
- Facilitate the Identification and Elimination of Waste and the Sources of Waste
- Support the Prioritization of Continuous Improvement activities at the plant and Value Stream levels
- Support Constraint Analysis
- Provide a common language for Process Evaluation

Organization of Value Stream Maps:

Types:
1. Production: Raw Material to the Customer
2. Design: Design to Concept Launch
3. Administrative: Order-taking to Delivery

States:
1. Current State - the existing conditions in the value stream
2. Future State - reflects the future vision of the value stream
Value Stream Mapping

**Action Plan**

Select Map Type and Subject → Current State Map → Future State Map → The Work Plan

**Graphic Element Identification:**

- **Inventory:** Product/Material not being processed
- **Vendor:**
- **Transportation:** Shipment to or from external facilities
- **Functional Group:** Processes information but adds no direct value to product production
- **Process:** Operation where value is added to the product
- **Information Flow:** Instructions concerning production
- **Push Arrow:** Product being pushed into next process
- **Flow Arrow:** Product flows from one process to another
- **Pull Arrow:** Upstream customer or process pulls product
- **Kanban Queue:** A small next-process Pull Inventory

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**Value Stream Mapping**

**How to:** (Make a Current state Map)

1. Determine the type of map. Begin with a traditional process flow chart. Be very general at first and add uniform detail as you go along. Pay particular attention to critical paths. Be sure to include elements such as inspection and test, waste is waste, their productivity is of equal importance.
2. Add in inventory points, transportation elements, vendor facilities and customer end points.
3. Attach the functional groups and information flows (be sure to identify exactly what information is being transferred).
4. Develop and attach data to all elements (Lead times, setup & process times, transportation distances and times).

**How to:** (Make a Future state Map and Work plan)

1. Use the current state map as your base line.
2. Utilizing the 7 waste type definitions, go through each element, one at a time and determine which elements contain waste. Attach some measurement of scale to the waste.
3. Look for possible applications of: Quality at the Source, SMED, Batch Size Reduction, Cellular Manufacturing, Point-of-Use and Kanban systems. Attach some measurement of scale to your expectation of productivity gains.
4. Make estimates of the resources required to accomplish the changes. Pay particular attention to the human resource requirement (critical). Be very careful not to over-estimate the available human resources.
5. Select the low hanging fruit consistent with your available resources during a selected time frame (first cycle no more than 6 to 10 weeks).
6. Redraw your map consistent with your change selections.
7. With the selected projects make a detailed work plan of who, what, when and how. Regular progress reviews should be scheduled. Plan deviations need to be agreed to in advance.
8. At the conclusion of the work adjust the map to reflect any deviations. This is now your current state map. Decide whether to go for another cycle or to change map subjects.
Quality at the Source

Quality at the Source

Definition - A quality philosophy that places the responsibility for meeting customer specifications and standards at the point of manufacture.

Approaches:
1. Source inspection for purchased components
2. Operators self-inspect their work as well as inspecting (and/or rejecting) the work of previous operators.

Discussion:
Quality at the Source concepts are based on a theoretically ideal scenario. However, by using these principles and concepts, significant quality improvements can be made. The idea is to cut off mistakes at the earliest possible point (including at the point of design). Defects are a waste that increases in magnitude as product moves further along the value stream.

The following are required in plant applications:
1. The employees must be introduced to the concept along with the idea that it represents a fundamental change in their role in production.
2. Stage by stage accept/reject criteria must be set.
3. Employees must be trained in these criteria as well as how to bring them to the attention of their co-workers.
4. Employees must be trained in rework methods. It is very important that when ever possible an employee is responsible for reworking his/her own work.
5. Rework should be internalized in the work group, no paper, no engineers, no quality assurance.
6. Best results are achieved in one piece flow manufacturing environments.

Quality at the Source - The Poka Yoke Approach

Poka Yoke

Definition - A design approach to quality that places the responsibility for preventing defects within the design of the product and/or production process.

Approaches:
- Design - Within the product design specifications replace those specs which require defect prone processes/components with those that require non-defect prone processes/components.
- Process/Fixture - Within manufacturing replace those processes/fixtures which are defect prone with those that are not.

Example: Design - "We've Been Disconnected"
An Electronics manufacturer had three circuit cards connected by flex cables which were hand soldered into the boards. A high scrap rate was noticed with the boards. Occasionally operators would burn the boards while soldering. Some cables were snapped off during integration. Often test failures required the cables be removed for diagnosis and boards would be damaged during rework. The boards were redesigned with telephone jacks which could be soldered on using the normal solder wave equipment. The flex-cables were replaced with phone cables which were installed during the integration process.

Example: Process/Fixture - "Our Rivets Rattle"
Stainless steel rivets are notorious for their sensitivity to proper installation. The rivet's head must be flush and at a 90 deg. angle to the installation surface for proper installation. One manufacturer placed a collar with an on/off switch on the ends of it's rivet guns. The collar prevented improper alignment and the switch forced the rivet to be flush before the gun would fire.
5S (Workplace Organization)

**Definition** - a methodology for organizing, cleaning, developing, and sustaining a productive work environment.

**Sort** - Get rid of clutter - Items which are not used in work area should be removed - Items infrequently used should be properly identified and stored out of sight.

**Set In Order** - Organize the work area - A place for everything and every thing in its place - All production items and their storage locations should be clearly identified - Accessibility should be prioritized with reference to use - cleaning materials/utensils must be stored in the work area - The sharing of cleaning materials/utensils between work areas should be discouraged.

**Shine** - Clean and Buff up the work area - It is essential that enough attention be paid to the neatness of work stations so that the workers will be able to take pride in ownership.

**Standardize** - Establish written standards for order and cleanliness - Specific time should be reserved for cleaning work stations (end of day and/or end of task).

**Sustain** - Maintain the standards through training, empowerment, commitment, and discipline.

**Benefits:**
- Employee Ownership of Workspace
- Improved Maintenance
- Improved Moral
- Improved Productivity
- Improved Safety
- Improved Transparency

---

TPM (Total Productive Maintenance)

**Definition** - an acronym (Total Productive Maintenance) - strategies for creating employee ownership and autonomous maintenance of production equipment.

**TPM Strategies**

- **Design products that can be easily produced on existing machines.** This strategy has three primary advantages. First, by routing products through existing equipment, better rates of equipment utilization will be achieved. Second, existing equipment represents existing process know-how. You will experience shortened learning curves and minimal quality drop-offs. Thirdly by utilizing existing equipment, you will minimize the need for additional training in equipment operation and maintenance.

- **Design machines, tooling and fixturing for easier operations, changeover, and maintenance.** These items are essential in minimizing setup time, unit time and maintenance down time.

- **Train and retrain workers to operate and maintain machines.** Skilled labor is an essential element in achieving high levels of productivity. Equipment operators are the employees most keenly aware of the status of production equipment and are immediately available for servicing when equipment fails.

- **Purchase machines that maximize productive potential.** Note: productivity is product per dollar not product per employee. Be sure to account for support services involved with more complicated equipment.

- **Design a preventive maintenance plan that spans the life of the machine.** The least cost point for establishing a preventative maintenance program is at purchase/receipt of the equipment. The second least cost point is now.
Visual Management

Definition - making information about production processes and fundamental daily activities visually available in a coherent, timely, and regular manner

Benefits:
- Clear, simple Visuals for Production Status
- Improved Communication between Departments and Shifts
- Quicker Response to Abnormalities
- Increased awareness of Waste/Scrap
- Culture Change
- Peer Pressure for Improvement

Typical Topics:
- Safety
- Cross Training
- Productivity Measurements
- Production Status
- Process Performance
- Housekeeping
- Defect/Scrap Rates

Discussion:
The theory of Visual Management is "what gets measured (and displayed) gets done." The practice is simple: display performance data and goals in high visibility locations. Introduce performance first. Goals should be given (must be fair, honest and truthful). Update charts regularly to show achievements (or failures). Never be seen alone showing off your charts to upper management and never boast about the goals you set to anyone. This is a serious long term tool. Use it for both improving and maintaining performance not as a "dog and pony show."

SMED (Single Minute Exchange of Dies)

Definition - a methodology for the reduction of setup times

The Basic Approach:
1. Separate internal and external setup as it exists
2. Convert internal setup to external setup
3. Streamline all aspects of the setup operation
4. Perform setup activities in parallel, or eliminate them entirely
5. Document set up procedures

Approaches to Streamlining:
1. One-turn attachments
2. One-motion methods
3. In-product landmarks
4. Dedicated fixturing
5. Electronic data storage and transfer

Benefit:
- Documentation of set up procedures
- Improved flexibility and responsiveness to customer changes
- Increased ability to pursue smaller lot sizes
- Increased capacity
- Reduced batch sizes and reduced inventories
- Reduction of setup time (set-up times are often cut by more than half)

Example:
A traditional bolt and T-nut lockdown fixture can take 20 turns to engage. Only the last turn actually engages the T-nut. Ninety five percent of the effort is consumed in aligning the bolt. By replacing the traditional fixture with a one motion fixture, the vast majority of the setup time can be eliminated.
**Batch Size Reduction** (One-Piece-Flow)

**Definition**: A manufacturing approach that emphasizes the reduction in process batch sizes by eliminating the system constraints requiring large batch sizes - also known as One-Piece-Flow.

**Discussion**: Batch size reduction is critical if a truly JIT organization is to be achieved. The first thing to understand is that this is a completely different problem from Setup Reduction. Batch size is driven by constraints within the batch process and has nothing to do with setup or order size. Those constraints are:
- Tradition - "we've always done it this way"
- Lack of Instructions - "I don't know how"
- Equipment Limitations - "it only works this way"
- Material Limitations - "it comes in this quantity"
- Co-dependency - "it takes two pieces to make it work"

Large batches result in bulges within the production stream. Bulges cause enlarged WIPs, personnel/equipment strain, and imbalances in the production tempo (Takt times).

As with all other Lean Manufacturing approaches whether or not to effect change is ultimately a question of cost versus profit.

**How To**:
1. Identify the batch operations and constraining factors.
2. Develop the alternatives and determine their feasibility (note: you must answer the question, how does this improve profitability).
3. Implement the chosen alternative.
4. Review and re-evaluate after implementation (Kaizen).

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**Cellular Manufacturing**

**Definition**: A manufacturing approach in which equipment and workstations are arranged in a bounded area to facilitate small-lot, continuous-flow production.

**Discussion**: Cells are often established in a U-shaped configuration. All cell operations necessary to produce a component or subassembly are performed in close proximity. Near-zero operation-to-operation transfer times are typical. When defects or other issues arise within the cell, the quick feedback between operators improves quality. Workers in a manufacturing cell are typically cross-trained and, hence, able to perform multiple tasks as needed.

**Benefits**:
- Better use of human resources
- Easier to automate
- Easier to control
- Multifunctional workers
- Reduced material handling and transit time
- Reduced setup time
- Reduced work-in-process inventory

**Contraindications**:
- Inadequate part families - Process variability and process sequence variability will result in cell layouts with low overall levels of productivity.
- Poorly balanced cells - Bottle neck operations, long cycle operations or unavoidable batch processes prevent Takt time performance.
- Craftsman Skills requirements - Expanded training and the difficulty in scheduling workers hampers Cellular Manufacturing.
- Increased capital investment - Multiple cells with duplicate equipment requirements may result in unaffordable capital requirements.
Cellular Manufacturing

Fundamentals:
- Material Flow: Cells are arranged in relation to each other so that material movement is minimized.
- Capital Proximity: Large and/or expensive machines which cannot be easily relocated to cells should be located between the cells that use them (Point-of-Use).
- Assembly line: The layout of machines within each cell should resemble a small assembly line.
- Mobility: Quick positional adjustments should be used to rearrange/rearrange the machines within a cell.
- Layout Proximity: Sequential processes need to be placed side by side.
- Unified Management Structure: The productive resources need to answer to the same voice.

U shaped Cellular Layout with no card Kanban

Unit "A" Production

Standardized Work

Standardized Work

Definition: the process of documenting and standardizing tasks throughout the value stream (Process Instructions and Standard Operating Procedures)

Benefit:
- Increase in the Effectiveness of Cross-training
- Increased sustainability of product and procedural improvements
- Less downtime due to absenteeism
- More Consistent production Schedules
- Reduced product variability
- Reduced training costs

Discussion:
Many companies have undocumented procedures for operating equipment and producing products. The result is high product variability, high training costs, downtime due to the absence of a "critical employee", and constant production schedule disruptions. By standardizing work throughout the plant, products are replicated to the identical procedure, regardless of who the operator is. Training costs are reduced and cross-trained employees can readily substitute for each other.

Process Instruction Content:
1. Part number and description
2. Drawing revision
3. Next use list
4. Process Instruction revision
5. Process bill of material
6. Tool/Fixture list
7. Miscellaneous specifications (Equipment settings, time requirements, etc.)
8. Task Instructions: The instructions should be complete and adequate to enable a qualified equipment operator to perform the process. The liberal use of visual aids
Takt Time

**Definition:** Takt is German for “beat” - the Takt Time defines the manufacturing line speed and the cycle times for all manufacturing operations.

Where:

\[ T = \frac{I}{D} \]

- **T** = Time available during a production period
- **D** = Unit Demand during that production period
- **T** (Takt Time) the production pace (e.g. units per hour)

**Benefits:**
- Eliminates Overproduction Waste
- Permits Accurate Scheduling
- Permits Synchronized Product Production
- Provides a Baseline Measurement
- Provides a Stable Production Rate
- Provides essential scaling information for Work Cell Design
- Provides immediate Feedback of Performance
- Reduces WIP

**Discussion:**
To put it in a nutshell, the idea is to determine the exact pace at which production needs to proceed in order to meet on-going demand. Then staff/structure the production cell line to produce the quantity required, at the rate required, at the time required.

Takt time is best used on continuous production lines or on work cells manufacturing a family of similar products. Job shop environments are a contra indicator.

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Production Leveling / Smoothing

**Production Leveling**

**Definition:** strategies for redistributing production volume and mix over time in order to minimize extremes

**Discussion:**
"Don't brag about your lightning pace, for Slow and Steady won the race" (Aesop’s Fables, 550 BC). Well, forget the slow part but steady remains valid. Essentially the idea is avoid both burnout and idleness. This is equally applicable to workers and organizations.

**Example 1:**
A sporting goods company experienced a wide variance in seasonal sales. This resulted in frequent layoffs. By entering the export market to the southern hemisphere they were able to increase profits, smooth their demand and gain a reputation as a reliable employer.

**Example 2:**
On a particular day three products are scheduled to be produced. Three big lots is the typical approach. However this will result in unnecessary strain on the work force (i.e. repetitive stress). The Production Leveling approach is to break the big lots into many small lots thus relieving those stresses as well as eliminating prolonged pauses between the lots.
Point-of-Use Systems

Definition - a manufacturing strategy for positioning required resources at the site of production

Discussion:
The idea behind Point-of-Use is to eliminate Waste and increase Productivity and Quality by bringing tools, fixtures, process instructions, quality standards and visual aids within reach or line of sight of the operator performing the work. The secret is immediate availability. All of the tools necessary to complete a task should be at the work station. If two stations need the same equipment or tool, buy another, move the work stations next to one another or counter-schedule their work.

Example #1:
A mail box manufacturer saw a significant improvement in their productivity when they moved their three types of fasteners from shelves behind the assemblers to buckets suspended under the conveyor line. Even this was surpassed when the employees were given aprons with three large pockets.

Example #2:
A circuit card manufacturer noticed the heavy traffic between the assembly department and the test and diagnostic department. Since test failures were returned to assembly for rework the circuit cards averaged 1.07 trips to test. By placing a simple go no go tester in the assembly department and only sending the defective circuit cards to the test department the average number of trips fell 93%.

Kanban

Definition - Kanban is Japanese for “card” - Pull Scheduling combined with traveling instructions conveyed by simple visual devices in the form of cards, balls, carts, containers, etc. and can be applied to both material flow in the factory, information or project flow in the office, and material flow between suppliers and customers.

Benefits:
- Reduced Inventories
- Predictable flow of Materials
- Simplified Scheduling
- Visual Pull System at the Point of Production
- Improved Productivity

Discussion:
It is important to understand that Kanban is not a automatic decision. There are contra indicators to its usage (IE: job shop environment, poorly balanced operations, large batch processes). There is a wide variety of Kanban variants based upon individual business needs. Your company’s type, size, resources, market structure, market conditions, product variability and the current state of lean manufacturing should all enter into a well considered individualized decision.

Prerequisites:
- Repetitive production in small lots
- Balanced manufacturing system (capacity balancing model)

Basic Kanban Types:
No card Kanban
One card Kanban
Two card Kanban
Kaizen (Continuous Improvement)

Kaizen

Definition - a philosophy of continual improvement, emphasizing employee participation, in which every process is continuously evaluated and improved in terms of time, resources, quality, and other aspects relevant to the process.

Two types of Kaizen:
- Flow Kaizen - value stream improvement
- Point Kaizen - elimination of waste

Discussion:
Kaizen is often confused with Kaizen Events. They are not the same. Kaizen events are artificial groups setup to address single subjects/areas. They are usually one time only affairs. Kaizen is intended to be incorporated as a normal day by day approach to the improvement of the entire value stream.

How To: Hold a Kaizen Event

1. Select a subject for the event.
   Select a bounded, on-going activity to be the subject of the event. You should concentrate on those activities which are associated with significant revenue flows and where you already suspect there could be significant savings available.

2. Select and assemble the team.
   The team must have a cross section of talents and experiences. Every member selected should be selected because of what they bring to the group not because they are available surplus at the time of selection. It is critical that a healthy number of experienced on-the-floor operators be included. Likewise, some of the local supervision and procedural personnel should be included.

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How To: Hold a Kaizen Event (continued)

3. **Affirm management's commitment.**
   It is essential that Upper Management adopt a visible profile throughout the process. Upper Management should attend the kickoff meeting. Management should express their support for change and their acceptance that some money may have to be spent. The normal command structure should be suspended with reference to the team's activities.

4. **Present a road map.**
   An outline of the normal approach along with a time frame should be given to the team (See steps 5 through 12).

5. **Train the team.**
   Train the team in the 7 Wastes and the 14 Techniques involved in Lean Manufacturing. A generous number of examples should be given. A discussion should be held about parallel approaches to the area under consideration. The team should be given some time to go away and formulate their ideas.

6. **Perform a "present state" analysis.**
   A review of the current state of affairs in the area in question should be held. Layouts (complete with distances), process charts (complete with setup and process times) should be evaluated. Depending on circumstances, Takt times should be calculated and a current state Value Stream Map should be created.

7. **The "next step" proposal should be generated.**
   The team should discuss its different ideas and proposals. A proposal list should be written up and those items on which additional data are required noted. The additional information should be gathered and the full list should be given a final thumbs up review. An action plan consisting of the best ideas should be written up.

(continued on next page)
Kaizen (Continuous Improvement)

How To: Hold a Kaizen Event (continued)

13. Say “Thank You”. Management should take the time to properly comprehend and evaluate the contributions of the team; then, truthfully express appropriate appreciation for the team's efforts and accomplishments. Don't hype or dismiss. The team members know what has been accomplished. Hype will be seen as patronizing, dismissing will be seen as ingratitude. Remember, you may need to return to this well, so watch what you pour down it. A member of management should be assigned to follow up the continuing action items and maintain the Visual Management system until closeout. The team is now disbanded.

Implementation

Implementation

First, recognize that there is no “one path” in Lean Manufacturing. Your company is different from any other. One Piece Flow, Kanban, Cellular Manufacturing, Batch Size Reduction and Production Leveling are not universally applicable. Managerial judgment will have to be applied to determine where the low hanging fruit are. The techniques you select and the methods used to implement them must reflect the business realities of your company.

Depending on the material and human resources you have available, you may or may not wish to engage a consultant. Don't overlook free resources. Some States have programs intended to help businesses implement Lean Manufacturing. There are technical associations in your area. Other businesses interested in achieving greater productivity may be willing to pool resources. Colleges, Universities, and your local “Tier One” businesses have personnel you can hire to come in and give seminars.

In the long run, the results you achieve and maintain will depend on your home team's knowledge. Implementation of Lean Manufacturing should therefore begin with a broad based education plan. It must be made clear that simply being able to repeating the mantras is not enough. The entire management team from the floor supervisors to the upper management level must attain at least a basic understanding of Lean manufacturing. You should consider the information inside this pocket hand book to be the baseline minimum.

Finally and most important of all, it must be made clear that everyone will be participating. This is an effort to determine what type of business your firm will be. In the end there will only be two types of businesses, the quick and the dead. The team decides which, Godspeed.