The Toyota Production System and **Lean**

2.810

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What is Manufacturing?

It is NOT

- “Making”
- Machining
- Etching
- Photolithography
- CVD
- Injection Molding
- Generic Materials Processing
- Automation
- Mechatronics and Robots
- Integrated Photonics
- Nanomaterials
- Roll to Roll Processes
- Electron Beam Epitaxy
- Welding

Manufacturing is

Making Products using **Combinations** of these Technologies to meet:

- Demand
- Cost
- Quality
- Flexibility

What are the principles of manufacturing?

Principles: Managing Uncertainties of Flow, Variation and Cost at

1. ***Unit Process (Product) level-*** Consistently Meeting Specifications on a Unit Process Basis (Quality)

2. ***Factory (Production System) level-*** Flow of Materials and Product Through a System of Rate-Limited and Failure-Prone Processes

3. ***Market (Supply Chain) Level-*** Flow of Materials and Product Through a System of Producers and Sellers

4. ***Company (Business) Level-*** Financial Aspects of Volume Production

Fundamentally: How to Produce to Meet Customer Demand and be Globally Competitive

Genesis of Toyota Production System

7 Wastes

“muda.”

Toyota’s Chief Engineer Taiichi Ohno

Genesis of Toyota Production System

A production system that has been fine-tuned

Roots of the Toyota Production System

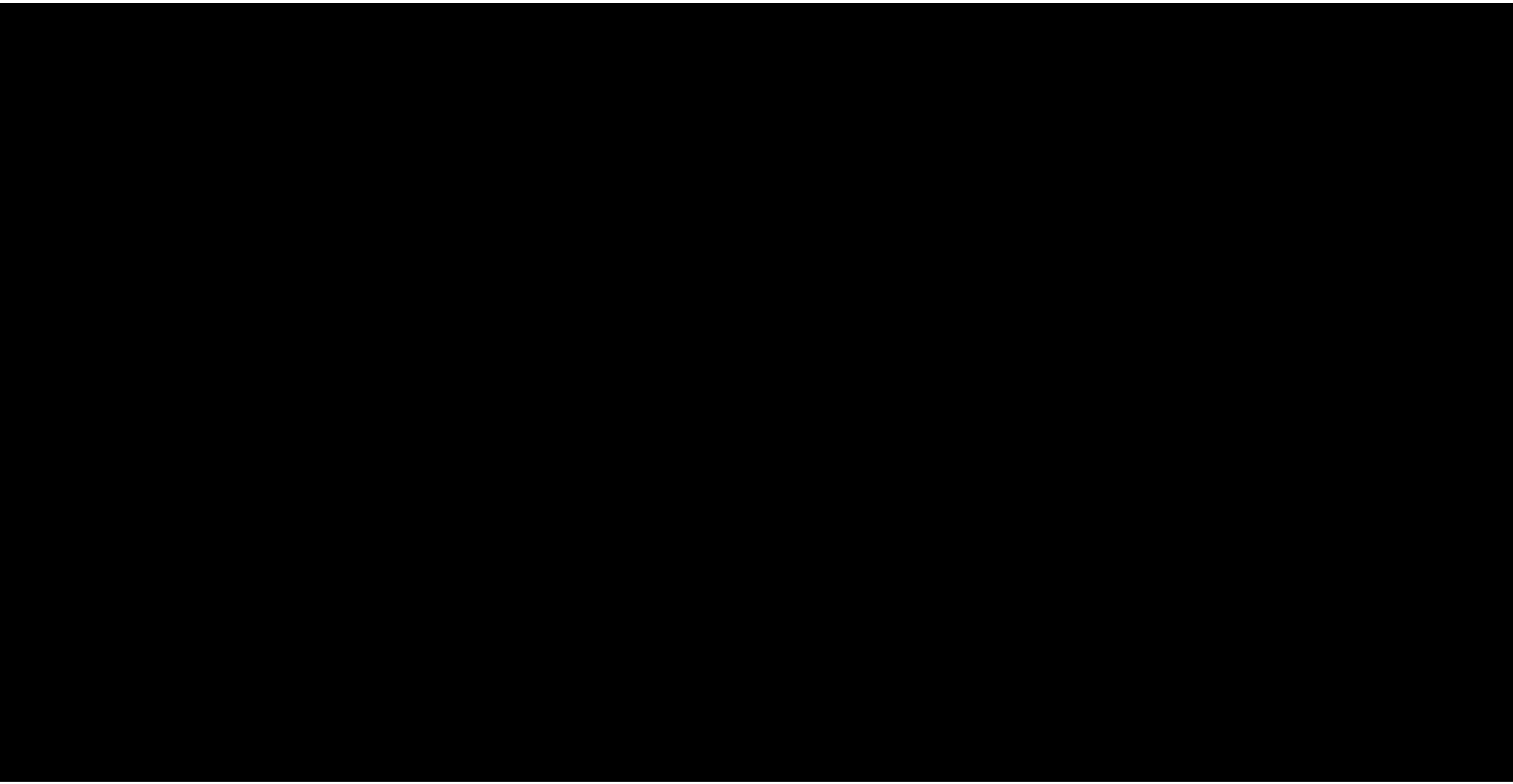
The Toyota Production System (TPS), which is steeped in the philosophy of "the complete elimination of all waste" imbues all aspects of production in pursuit of the most efficient methods, tracing back its roots to Sakichi Toyoda's automatic loom. The TPS has evolved through many years of trial and error to improve efficiency based on the Just-in-Time concept developed by Kiichiro Toyoda, the founder (and second president) of Toyota Motor Corporation.

Waste can manifest as excess inventory in some cases, extraneous processing steps in other cases, and defective products in yet other cases. All these "waste" elements intertwine with each other to create more waste, eventually impacting the management of the corporation itself.

Genesis of Toyota Production System

1. Overproduction
2. Waiting
3. Transporting
4. Inappropriate Processing
5. Unnecessary Inventory
6. Unnecessary / Excess Motion
7. Defects

Toyota Production System in Action



Real World Examples

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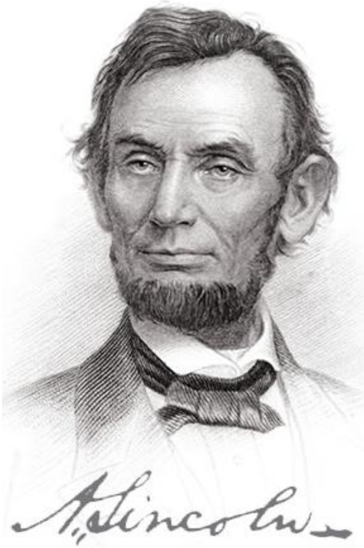

Real World Examples

Optimizing Lot Sizes and Establishing Supermarkets in a Multi-Part, Limited-Capacity Manufacturing System

by

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Bachelor of Science in Mechanical Engineering and Business, Economics and Management,
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Submitted to the Department of Mechanical Engineering on August 15th, 2014,
in partial fulfillment of the requirements for the degree of
Master of Engineering in Manufacturing.

Abstract

This thesis addresses the value of optimizing lot sizing to meet part demand within the limits of machine capacity, focusing on a method for improving productivity within the CNC turning and CNC milling departments at the Waters Corporation Machining Center in Milford, Massachusetts. A detailed study of the machining center revealed problems with low machine utilization in turning and milling, low on-time delivery performance and a need for day-to-day adjustments to the production schedule. These problems were attributed to inefficient data collection and use of data, poor production scheduling, and lot sizing that the system's capacity could not handle, causing frequent occurrence of redundant part setups and enabling delays in turning and milling which cascaded to downstream processes. This thesis addresses the latter problem by implementing optimized lot sizing for ten selected part types going through the turning and milling departments; the system design called for increases to the lot sizes of five of these part types. In order to prevent increased lot sizes from causing unforeseen problems in downstream processes, the project further implemented a supermarket for these selected parts at the end of milling operations, in order to decouple turning and milling from other processes.

The lot sizing methodology focused on parts going through a turning operation followed by a milling one, with selected part types being machined on one of two machines in each department. In order to limit increases to work-in-progress inventory caused by increased lot sizes, the supermarket was designed to be managed by a Kanban-based pull system using a modified (Q, R) inventory policy with an expected weekly service level of 95%. Over the course of the implementation period, the lot sizing methodology saved an estimated 36.75 hours of setup time for parts made in 407.25 productive hours of run time. Moreover, a simulation over a year-long period estimates that with the new lot sizes, the machines in question will achieve an aggregated increase in productive hours of nearly 10%.

Comparison of Toyota Production System and Lean

Method	Toyota Production System	Lean (1988)	Lean (1996→)
Designer	Industrial Engineers	Mechanical Engineer*	Social Scientists**
Goal	Cost Reduction Productivity Improvement	Quality Productivity	Maximize Customer Value
Principles	Continuous Improvement Respect for People	Continuous Improvement	Specify Value Identify the Value Stream Flow Pull Perfection
Normal Condition	Flow	Flow	Perfect Processes
Focus of Improvement	Human	Technical	Technical
Primary Teaching Method	Genba Kaizen	Team Leader	Classroom
Object of Interest	Waste, Unevenness, Unreasonableness	Inventories	Value Creating Activities
Desired Outcome	Customer Satisfaction Survival	High Plant Performance	Perfect Value

* John Krafcik, "Triumph of the Lean Production System" (1988) https://www.lean.org/downloads/MITSloan.pdf
** James P. Womack and Daniel T. Jones, *Lean Thinking* (1996) and http://www.lean.org/WhatsLean/ (accessed 23 January 2017)

Real World Examples

- Cellular Manufacturing
- Pull Scheduling (Kanban)
- Six Sigma/Total Quality Management
- Rapid Setup
- Team Development

Real World Examples

Optimizing the Economic Efficiency by Micro-drill Life Improvement during Deep-hole Drilling in the 212-Valve Manufacturing Process

By

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Submitted to the Department of Mechanical Engineering

On 15th August, 2013 in partial fulfillment of the

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Real World Examples

Abstract

The micro-drilling process by robodrills in the production of valves at Waters Corporation is the bottleneck caused by the short drill life. This thesis analyzed the chip formation and removal during the process to improve the tool life. The effects of the tool materials, geometry and peck drilling procedures were investigated. Based on these studies, a new micro drill bit, TY130, was selected from the commercial market and the test results for drilling 0.2794 mm holes in the workpiece made of 316-stainless steel showed that it lasted for 120 holes, 5 times longer than the currently used drill bit. An experimental study on various peck drilling procedures demonstrated the advantage of the quadratic pecking procedure, further increasing the tool life by 2 times. Upon the implementation of the new drill bit and the quadratic pecking procedure, the 212-Valve production lead time is estimated to be reduced by 11% and the EDM process will not be starved since the bottleneck process has been improved.

Real World Examples

System Improvements in Valve Manufacturing Cell at Waters Corporation

by

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Real World Examples

ABSTRACT

This thesis addresses the challenge of improving on-time delivery performance of stators in the high mix valve manufacturing cell at the Milford facility of Waters Corporation with a focus on efficient line design without exceeding the average WIP levels observed in the current system. A detailed study of the current process was done and it was concluded that the poor on-time delivery performance of stators to the assembly department could be attributed to the unacceptably long fabrication lead times—due to the long waiting induced by the fabrication of a high mix of 28 different types of stators— and the lack of an efficient inventory management policy that makes the system susceptible to extreme situations of either stock-outs or inventory explosion. Therefore, a pull-type production system with a responsive fabrication line establishing WIP control and an end of line standardized finished goods inventory management was designed and implemented.

An efficient line design was developed by dedicating lines for high volume and high mix parts and by placing in-process buffers to implement a Kanban based pull-type production process that in turn limits the amount of WIP as well. An overall lead time reduction from 21 days to 3 days was achieved through the implementation of this line design and a 40% reduction in WIP levels was observed simultaneously. For standardizing the finished goods inventory management in order to maintain high service levels while eliminating the possibility of WIP explosion, a mixed inventory review policy or the (s,S) policy—that uses a re-order point to trigger production at appropriate times and a base stock level that maintains an upper control limit on the inventory levels— is suggested for implementation. With this policy, a calculated service level of at least 96% is expected even for high demand periods alongside a 50% reduction in average finished goods inventory levels.

Real World Examples

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- Pull Scheduling (Kanban)
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Real World Examples

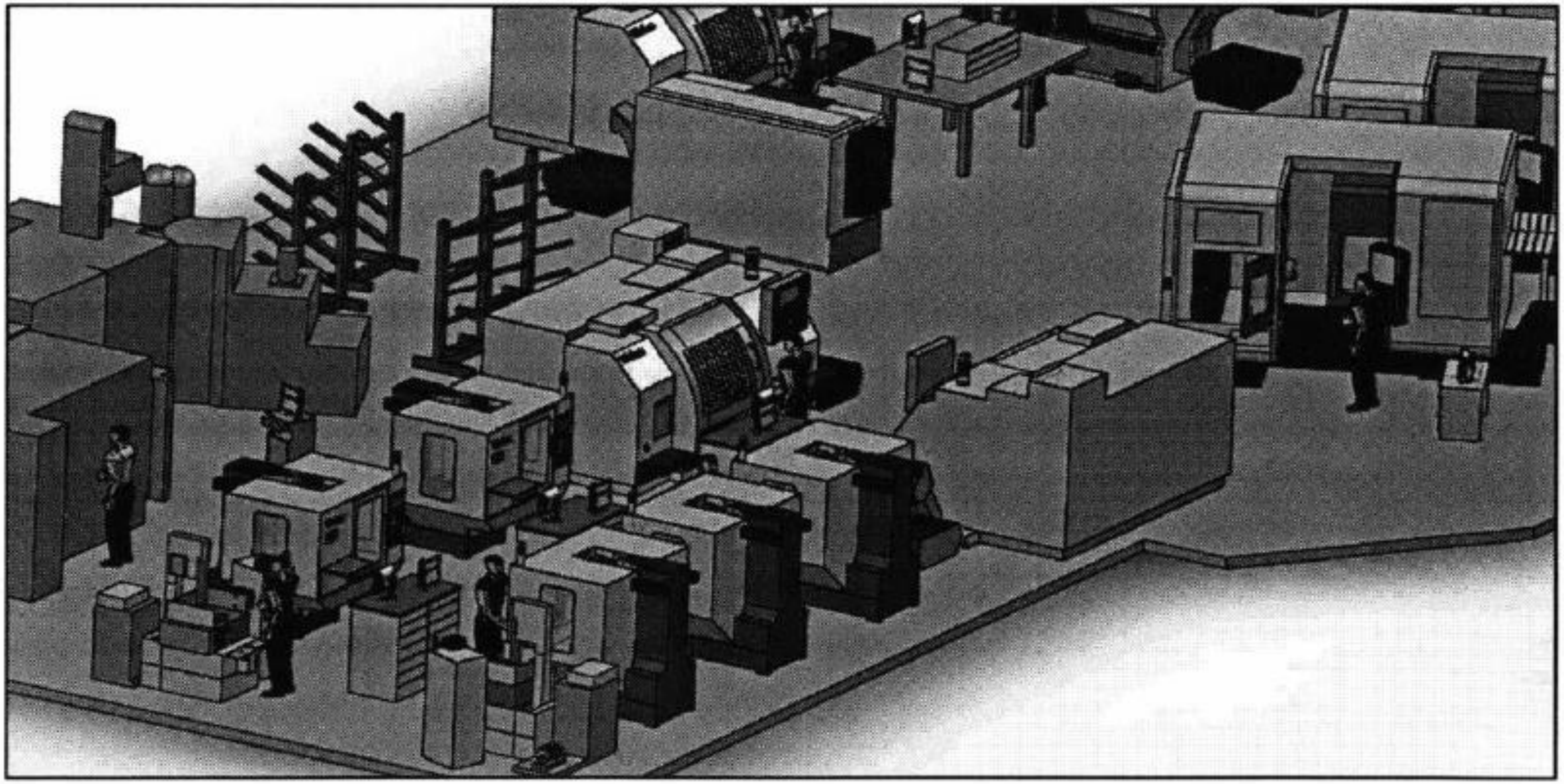

Fig. 1 Valve cell layout

Questions?