# Getting Started with Lean Manufacturing Principles in Flexible Substrate Coating and Converting

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## Abstract

Lean manufacturing has become a highly popular approach used in many industries around the world. But are lean principles valid in continuous process operations such as coating and converting? The answer is YES they are, and for coaters to be competitive in today's environment, lean thinking will likely play an important role. This paper will describe the key aspects of lean manufacturing and present examples of how they have been applied in coating and converting operations.

## Introduction

Lean manufacturing evolved out of the thinking behind the Toyota Production System (TPS), and at a high level can be illustrated with the "House of Lean" shown in Figure 1. The foundation of a lean system is a level and stable process. There are two key pillars of the system: one is "Jidoka" and the other is "Just-in-Time." The five main objectives

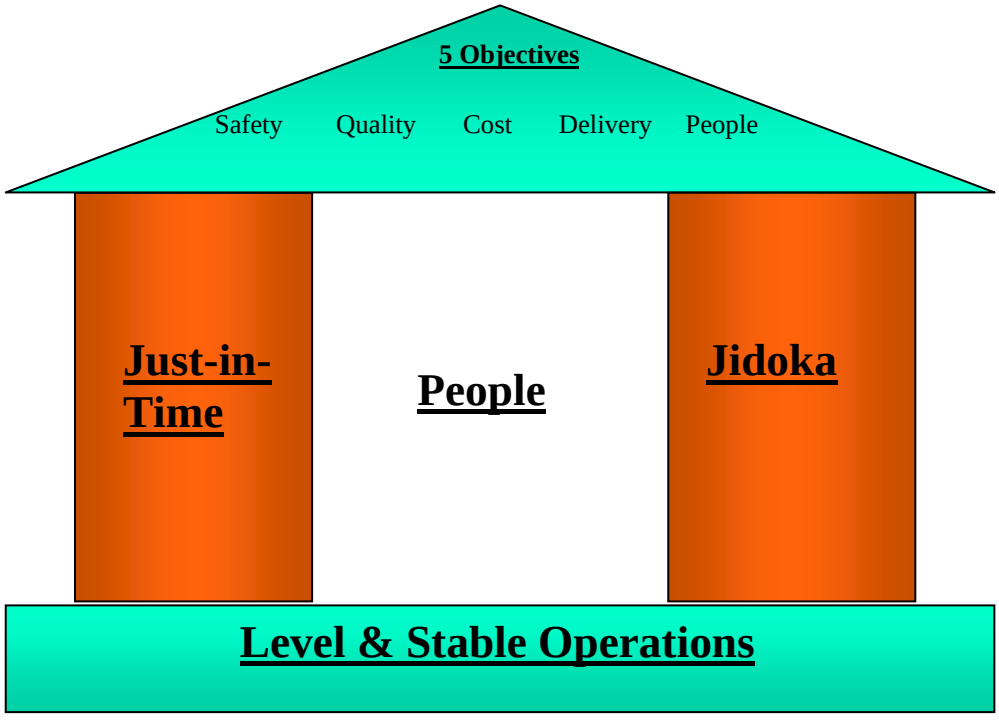



**Figure 1: The House of Lean**

are safety, quality, cost, delivery, and people development. And finally, people are the most important element in a lean system, as it is a culture of continuous improvement and organizational learning that provide the true sustainable competitive advantage.

Casual observers of TPS will likely become enamored with any number of lean "tools." However it is the thinking behind the tools that is what sets TPS apart. Coaters who develop their people and leaders in lean thinking and not just the tools will likely have a much better result.

## The Meaning of "Jidoka"

Jidoka is a word borrowed from Toyota that roughly means "automation with a human touch." It best describes the lean approach to achieving zero defects in everything we do. The three elements of Jidoka that we employ are:

1. STOP when a defect is discovered
2. PREVENTION of mistakes that could lead to a defect
3. SEPARATION of people from machines

The goal is ZERO DEFECTS. The thinking is that quality begins at the source with 100% source inspection, however even with 100% source in place this is not enough because no system is perfect. Therefore additional "layers of quality" should be considered to ensure a zero defect outcome. Ideally, there are five layers of quality that should be in place for a given process.

**Layer 1: Error Prevention**

The first layer is ***error prevention***. This is sometimes called *source inspection* because it is applied at the source of a problem – making sure the operation is carried out correctly in the first place. The idea in error prevention is to allow only one way – the right way – for a process to be done. We want to prevent a mistake altogether, or at the very least, alert the operator *very quickly* so he can *quickly* correct the error *before any part of the process executes. Poke-yoke, or "mistake proofing" devices are ideal for this layer.*

**Layer 2: Defect Detection**

The second layer is "Defect Detection." This is also called self-checks. These are things which, if a defect is produced, immediately bring it to the attention of the Team Member, and prevent the defect from being passed to the next operation. *Poke-yoke, or "mistake proofing" devices are also ideal for this layer.*

**Layer 3: Process Control**

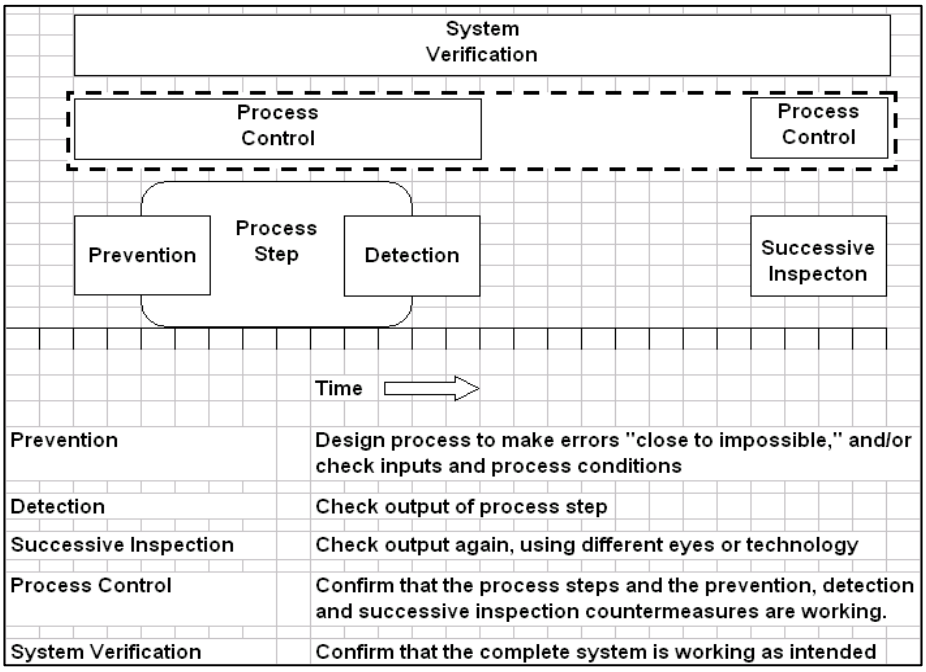
The third layer is called Process Control. At Level 3 a statistically valid process is being used to assure process control. This does not *replace* the 100% process checks being done in layers 1 and 2. It is simply a *check* that nothing unusual is happening. These verification checks must be done frequently enough that any suspect product produced since the last good check can still be contained, checked and if necessary corrected.

**Layer 4: Subsequent Checks**

As primary checks may not be 100% effective to assure 100% product quality, additional subsequent checks might be warranted. This check should be independent of the primary checks – that is if the primary check process (Error Prevention and Defect Detection) were to totally fail to operate, the subsequent check would still be performed.

**Layer 5: Process Verification**

The fifth layer verifies the quality system is operating as intended and appropriate confirmation checks are occurring throughout the system. How and how often this is done depends on how critical the process is.

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| Prevention | Design process to make errors "close to impossible," and/or check inputs and process conditions |
| Detection | Check output of process step |
| Successive Inspection | Check output again, using different eyes or technology |
| Process Control | Confirm that the process steps and the prevention, detection and successive inspection countermeasures are working. |
| System Verification | Confirm that the complete system is working as intended |

Figure 2: Layers of Quality

## Just in Time (JIT) in a Continuous Process Environment

For a lean system, the vision is one-piece flow of materials with no interruption through a value stream at a rate equal to the average customer demand. Flow is achieved by developing flexible manufacturing systems that balance the use of people and equipment to meet the customer demand in a standardized process using the least-waste methods presently known. Flow also provides opportunities to identify waste in the system (barriers to flow) that drives continuous improvement activity.

In the real world, and especially in coating and converting operations, many barriers to one-piece flow exist. For example, physical geography of a coating supply chain often dictates that raw material chemicals be shipped overseas in large batches. Or, the manufacturing batch size for a specific chemical will likely far exceed what is required to produce one coated roll of customer product. A lean supply chain will manage and control these situations with a goal of continuous improvement in leadtime and inventory. An effective tool to do this is called the “Components of Inventory.””

**Components of Inventory**

The purpose of inventory within a lean system is to buffer problems and enable flow. The structure of this inventory is defined as the “components of inventory. By making the causes for the inventory visibly accountable, the “owners” have the opportunity to remove the issues that cause the inventory. There are at least eight reasons for inventory to exist in a coating and converting supply chain, namely:

a. Geography: distance between operations or plants
b. Supply variability: inventory needed to buffer an unreliable supplier
c. Demand variability: inventory needed to meet customer demand fluxuation
d. Shipping Lot size
e. Shipping frequency
f. Transportation variability
g. Manufacturing Lot size
h. Information flow time

By understanding the specific components of inventory in a supply chain, it is possible to assign a specific number of kanban signals to each. For example, if there is a one-day travel time between plants, and the demand rate is 1000/day, then kanban worth 1000 units would be designated for geographical travel time. This provides an excellent tool to achieve structured inventory and leadtime continuous improvement.

**Takt: Setting the pace of the system to the needs of the customer**
At the beginning of each manufacturing period, the upstream supplier and downstream customer enter into a process to define the rate of manufacture and supply for that period. This definition of the production rate takes place within the current manufacturing month x days before the new manufacturing period commences. These agreed upon takt rates are then used to make the necessary kanban adjustments based on the above-described "components of inventory."

The purpose of the process is to allow the customer to confirm the manufacturing demand for the coming period and for the supplier to check the demand against manufacturing capacity.

**Logistics**
The flow of product between facilities should be continuous with the smallest lot possible. Maximization of the truck though co-mingled product on milk runs should be encouraged to reduce shipping costs.

Packaging and loading specifications through the standard operation of cross-docks should form a fundamental part of supply agreements. These specifications should be defined prior to the formation of any manufacturing agreement and specified product by product.

The number of trucks, shipping lot size, and the amount of inventory in the lane can be specified in line with the eight components of inventory. The flow of information is by physical Kanban or eKanban wherever possible.

**Escalation:**
The structure of the system results in a supply chain with minimal levels of inventory. This requires that problems become apparent quickly. Therefore there must be a structured escalation process in place with clear communication and responsibility. Standardized reporting and communications are critical to quick escalation and resolution of problems.

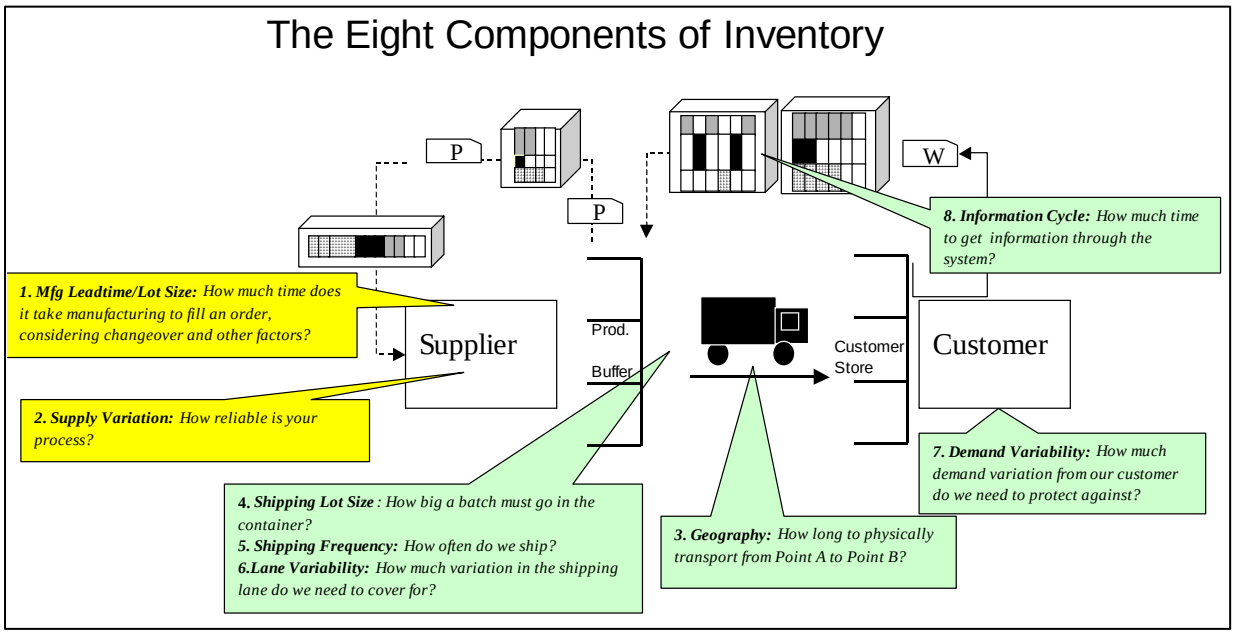


**Figure 3: The Components of Inventory**

## Stability: The Foundation of Lean

### 5S & Visual Controls

The foundation of lean is a stable process, and this foundation begins with 5S.
5S is a method of telling us whether things are operating the way we expect them to. It is a foundation of management by PDCA, which is the foundation of safety and quality. Excellent 5S requires excellent visual controls. Visual Controls should be simple and visual indicators that enable our people to visually detect at a glance normal from abnormal.

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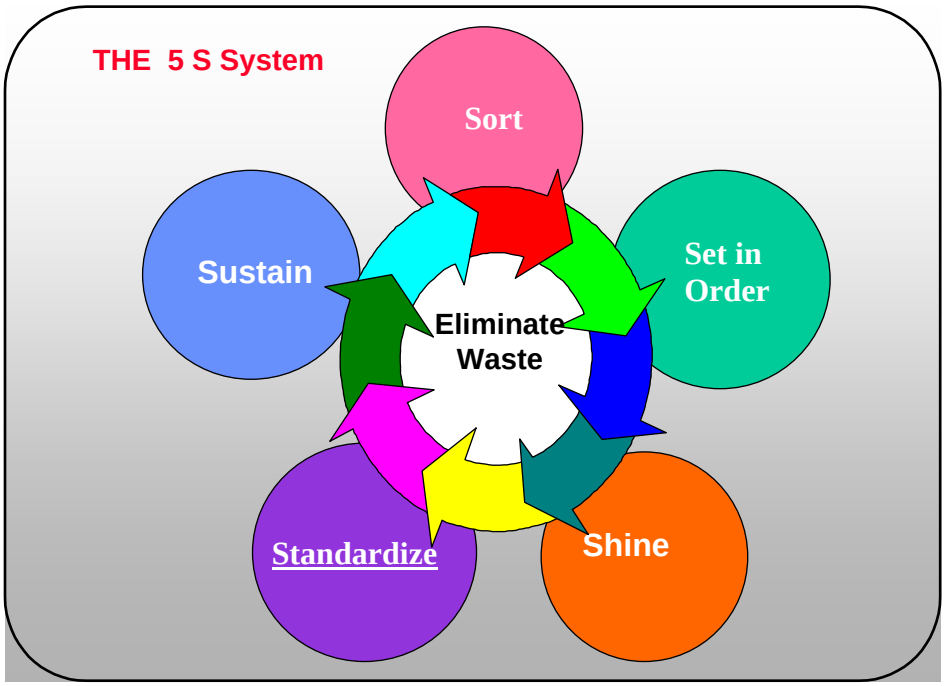


When we are becoming consistent about how we do things, and especially when we add the element of *time* ("when" and "how long") and specify the tools and materials, we are coming close to having *standard work.*

It is leadership's role to lead and drive the 5S & Visual effort whether it be in the office or on the production floor.

**Standard Work**

Standard Work is the basis on which continuous improvement is performed. There can be no kaizen without first having sufficient standardization in place.

All tasks are specified in terms of their content, sequence, timing and outcome.
There are verification checks built into the work for safe and correct execution as well as intended outcome. Ideally these checks are linked with the Layers of Quality approach described earlier. All verification checks trigger immediate escalation that restores the standard condition and carries out problem solving so the system can be improved.

In repetitive work environments we define these things by having three elements:

- A repeating work sequence. (Content, sequence, outcome)
- A standard amount of work-in-process inventory. (part of a verification check)
- The element of *takt time* (A verification check as well as defining the "timing.")

Documentation of standardized work is normally done using the "Standard Worksheet" and "Job Element Sheets." When performing kaizen, we often use Standard Work Combination Sheets (SWCS); Production Capacity by Process Sheets, Operator % Loading and Machine % Loading Charts.

**Kaizen**

Kaizen begins with standardized operations----without standardization in place, attempts at kaizen will be illusionary and not sustainable.

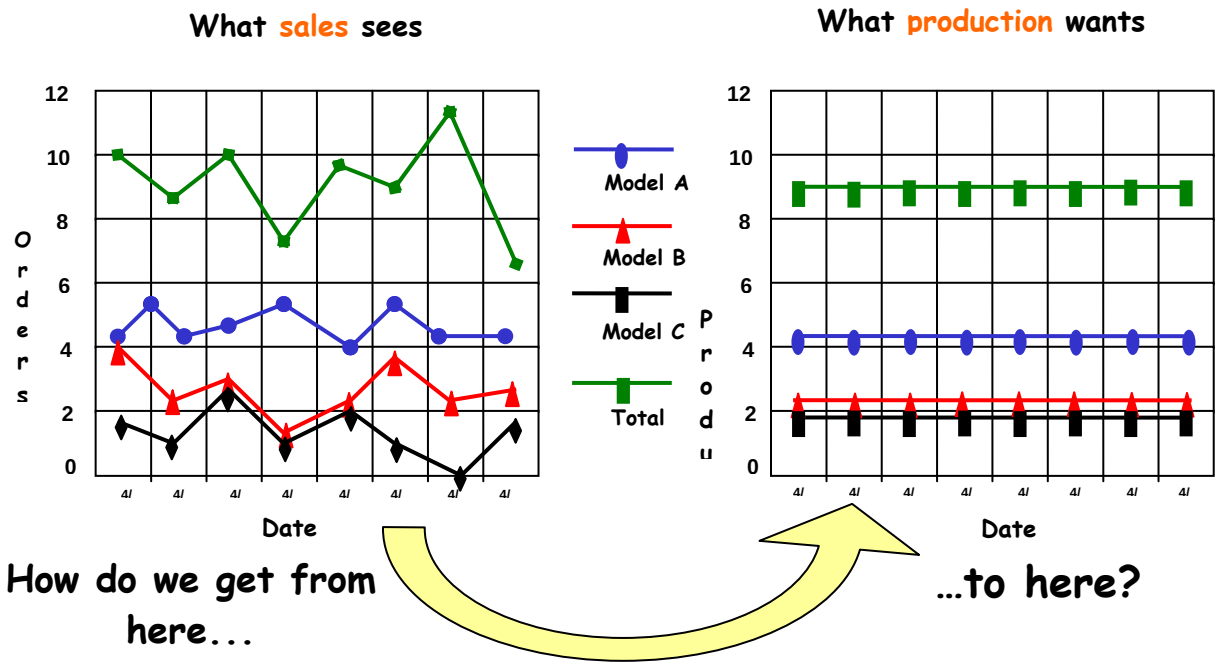
There are many different forms of kaizen activity, including:

a. Kaizen Events: Focused, intensive, kaizen events lasting 2-5 days. Events are generally driven by management and are used where breakthroughs are needed.
b. Problem Solving Kaizens: From one to 8 hours in length. May deal with specific operational issues, or develop out of management requests.
c. Employee Suggestions: Employee ideas for elimination of waste are solicited at all times and handled through a structured suggestion system.

Whatever the form of kaizen, the basic thinking is the same: Everyone is responsible for continuous improvement every day.

**Leveled Production**

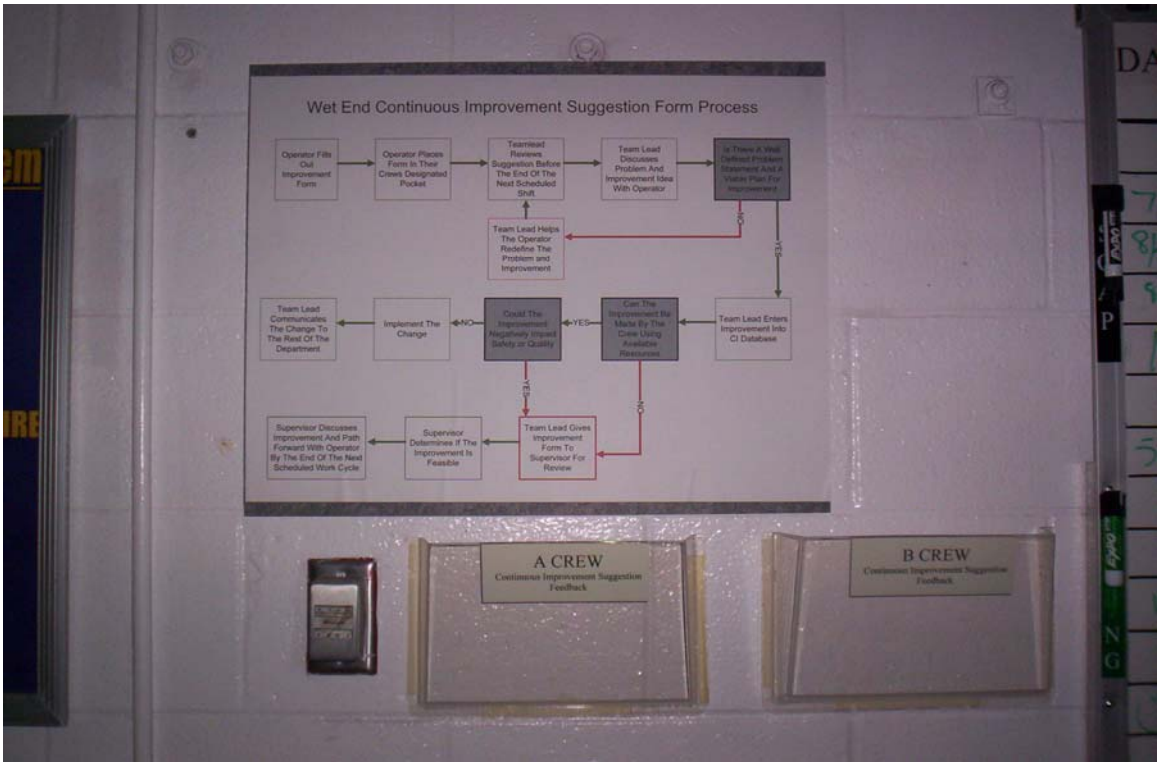
Production leveling will likely be needed in a lean system in order to reduce waste, unevenness, and overburden in the process.




## Lean is about people

People must be at the heart of any lean implementation. Above all "respect for people" must be sincerely practiced. Safety and well-being of employees must be first priority in order to create an environment of trust and empowerment. While many tools can be used here to encourage employee involvement, one that is particularly important is the suggestion system. Following is one example of such a system that is visual and easy to use. For suggestion systems to be effective they must be simple, non-bureaucratic, easy to use, and most importantly, employees should have confidence their ideas will be seriously and promptly considered and that they receive prompt feedback.

Many other tools fall into this area including gainsharing, kaizen teams, employee recognitions, wellness activities, training and development, and most importantly, good and frequent communication of objectives, plans, and business results.




## Conclusion – Getting Started

For those already involved in lean implementation, hopefully this paper provides several ideas that can be useful during the journey.

For those just beginning or considering implementing lean, do not try and implement everything at once. It is recommended to pick a point to initially focus the effort and get started. This is a learn by doing process, so avoid the temptation to study things to excess. It would be a good idea to enlist the help of someone who has done it before, especially in a continuous process environment. And finally, management support and involvement is essential at every step of the way. Lean should not be a sideline program….it needs to be embedded in every aspect of an operation to be most successful.