Implementing Automation After Making Lean Improvements

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1. Introduction

The transition from functionally oriented batch and queue manufacturing operations to Flow Manufacturing is challenging our traditional view of automated production equipment. Many times a company plans to automate a part of the production process without considering the effect on the entire process flow. Engineers will implement automation to reduce cycle time and to increase output instead of considering lower cost Lean Manufacturing alternatives such as setup time reduction, cellular manufacturing, kanban, or maintenance improvements. Automating a single process operation to achieve higher output without considering the effect on the downstream operations can result in creating a new bottleneck that eventually limits flow. In addition, inappropriate automation can "lock in" poor material flow and make change very costly. A company needs to understand its operation thoroughly prior to implementing automation to achieve the greatest benefit. Lean Manufacturing concepts should be considered before automating operations. Perhaps cellular manufacturing should be implemented to link production operations and to reduce material handling. Reduced equipment setup many be required to provide greater flexibility and shorter cycle times. This presentation addresses how to incorporate automation after implementing lean improvements. The automation concepts that are developed after implementing Lean Manufacturing will be significantly different than if automation is considered as the only option. The new "Lean Automation" becomes the intersection of lean manufacturing and automation concepts as shown in Figure 1.

The concept of lean automation is also applicable to an organization that is using lean manufacturing techniques and needs to reduce human variability or cost within a process or cell. In this case, lean automation may replace repetitive motion operations, inspections, or material handling.

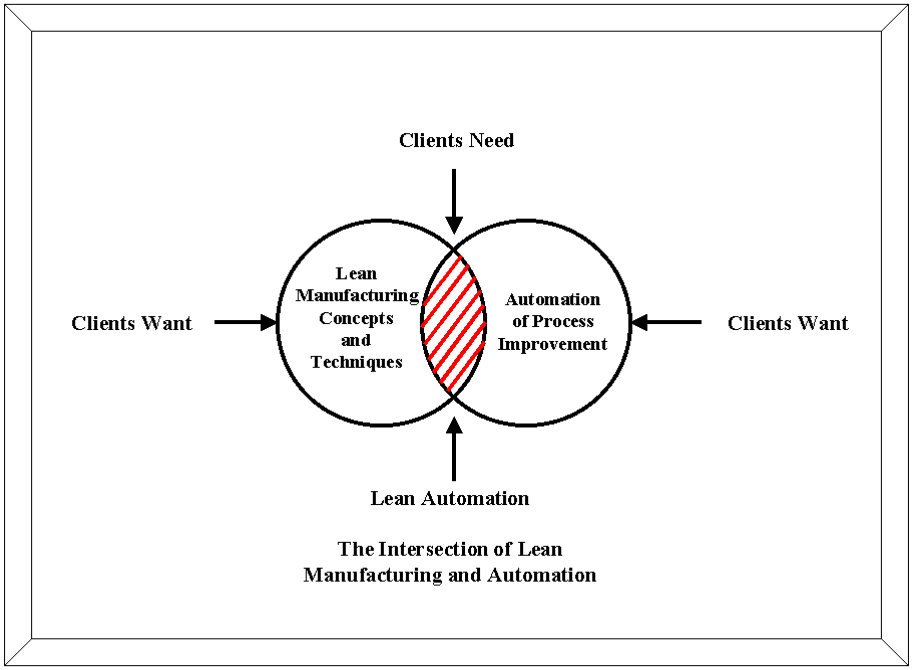

Figure 1

2. Working Towards Lean Automation: Use of Lean Concepts & Methods

A number of Lean Manufacturing concepts and methods should be used prior to implementing automation. The basic approach to cost reduction that we propose is as follows:

- Analyze the operation using lean concepts and techniques
- Implement Lean Manufacturing solutions
- Design and implement Lean Automation.

This approach will solve a majority of the material handling, lead time, and labor cost problems prior to automation. The automation will then be focussed on solving specific setup, line balance, variability, and ergonomic problems that are limiting cell output and cycle time.

2.1 Lean Concepts and Techniques

Lean Automation is based on the fundamental principle of Lean Manufacturing which is as follows:
any activity or action which does not add value to the product is a form of waste and must be eliminated or minimized. Value is added any time the product is physically changed towards what the customer is planning to purchase. Value is also added when a service is provided for which the customer is willing to pay (i.e. design, engineering, etc.). If we are not adding value, we are adding cost or waste. The goal of Lean Automation is to make the value adding steps flow faster with less labor and material handling. At the same time, waste related to inventory, inspection and rework, extra motion, and underutilized people will be reduced.

The techniques that have been found to be the most useful prior to automation are as follows:

- Value Stream Mapping
- Setup Reduction
- Visual Workplace
- Cellular Manufacturing
- Layout Improvement
- Batch Size Reduction

In order to understand where to start the implementation of lean concepts, one of the most useful tools is the *value stream map.* The value stream is the set of all specific actions, both value added and non-value added, that are needed to take a product through the information and production flows of a manufacturing operation. The value stream map is the assessment tool that follows the production path from beginning to end and shows a visual representation of every process in the material and information flows. It shows how the shop floor currently operates and serves as the foundation for the future state changes. The process of developing the value stream map forces you to understand your product families and the interaction of the production processes. The value stream map is the road map that reveals the opportunities for reducing waste through the use of other lean techniques. The focus becomes the improvement of the production process and flow and not just automating one operation. A concept value stream map is shown as Figure 2. (1)

Another useful lean technique is *setup reduction*. Analyzing the production operations to eliminate setup time will make the development of Lean Automation less complex. In fact, automation maybe required take the final labor components out of the setup. The following steps should be used: (2)

- Document the current changeover
- Consider a team approach
- Analyze the changeover and identify ways to reduce it (Convert internal setup to external)
- Implement improvements & monitor results
- Standardize the changeover
- Consider lean automation in the form of fixtures, automated handling, etc.

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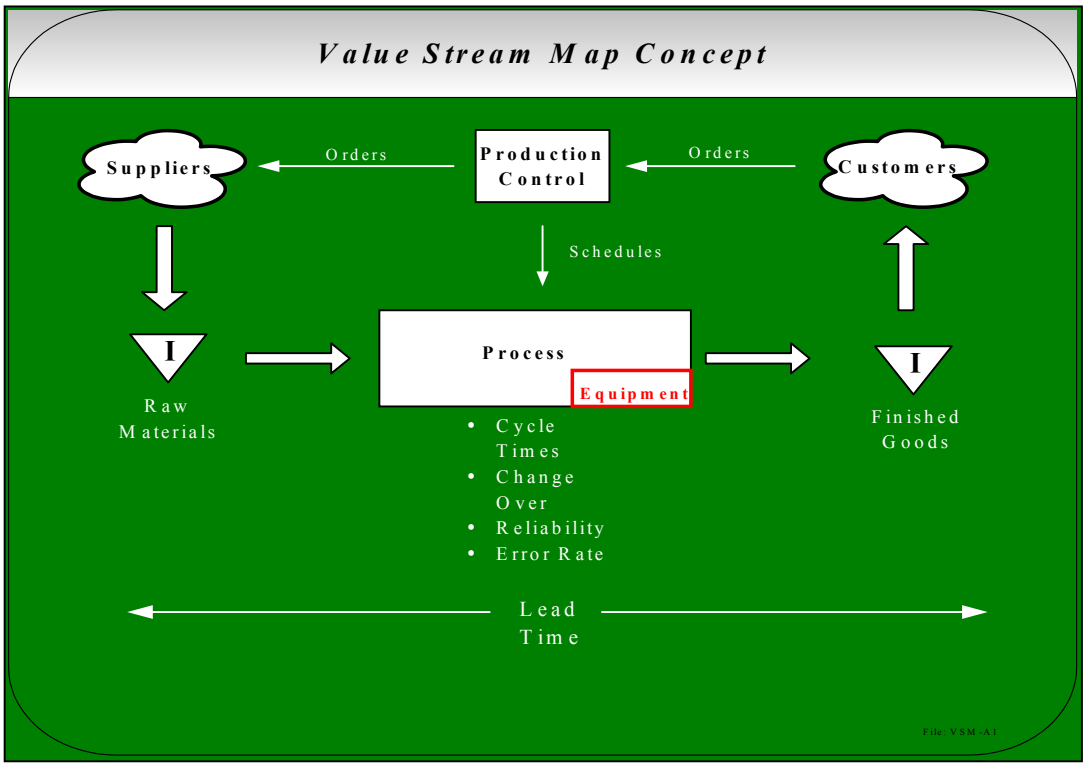

Figure 2

Visual workplace involves setting up a work area that is self-explaining, self-regulation, and easy to understand. (3) Simple visual controls such as organized staging areas, machine status lights, and color coding can significantly reduce automation complexity.

One of the most important lean techniques that can radically affect the automation concept is *cellular manufacturing*. A cellular approach re-arranges production operations to improve flow and to reduce handling and cycle time. Shifting from a conventional functional production layout to a cellular layout will significantly reduce the scope and complexity of machine automation.

Layout improvement is used along with cellular manufacturing to improve material flow and to reduce waste associated with material handling. A flexible, lean layout will many times eliminate the need to for costly automated material handling such as conveying systems.

Batch size reduction, implemented along with cellular manufacturing and setup reduction, can result in simpler production machines that are easier to operate and maintain. The entire production process will be more responsive to customer demand and work in process will be reduced.

Other lean techniques that that are important prior to developing automation are *total productive maintenance* and *quality systems improvement.* Total productive maintenance is useful for establishing a maintenance program that makes it easier to design automated equipment for maintainability. An effective quality system insures that process capabilities are related to required product specifications and tolerances and that data tracking is in place to provide feedback on performance. This provides the quality data needed to design automation that will have the process capability to produce satisfactory product.

2.2 Use of Lean Techniques for Automation

Now that we have reviewed lean techniques that are useful to developing Lean Automation opportunities, how do we use them? We have found that the following steps work:

- Assess the operation using a Value Stream Map (Develop product families & required production data)
- Evaluate the layout
- Identify lean improvements without using automation
- Implement lean improvements
- Identify Lean Automation opportunities
- Design and implement Lean Automation
- Start the cycle again!

The implementation of lean automation also can start in a mature lean environment. For example, if a company has implemented manufacturing cells, more analysis of cell operations will be required to identify the automation opportunities. Analysis techniques such as the use of process flow diagrams line balancing, and cycle time analysis may be required to identify problems. Quality data will have to be reviewed to determine sources of variation that maybe caused by manual operations. Operators should participate in the analysis to assist in identifying opportunities and potential solutions. This approach will insure the automation is focussed and will be as simple as possible.

The key is not to do it once! The goal is continuous cost reduction and lead time improvement. Figure 3 shows the process.

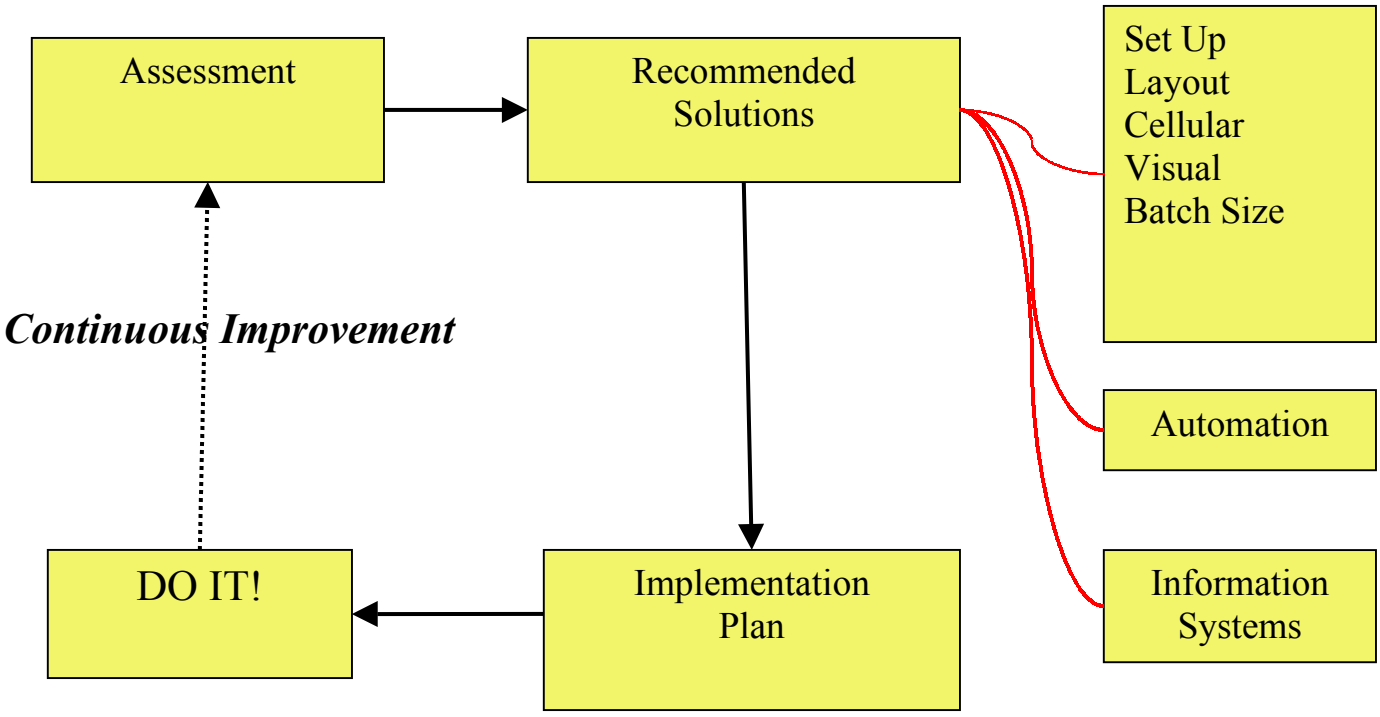

Figure 3

3. Lean Automation in Action

In order to understand Lean Automation, it is helpful to review a few actual applications.

A complex and expensive material handling system was planned to move components within a functionally laid out bearing assembly operation. The company was experiencing long setups of up to 9 hours, had large amounts of

work in process, and had batches of up to 1,000 bearings. Instead of designing the material handling system and locking in poor material flow, the following lean techniques were used first:

- Product family value stream map
- Setup time reduction
- Cellular manufacturing and layout

Instead of the new handling system, manufacturing cells were developed and implemented. Along with the cells, automated quick changeover chucks were installed to reduce setup time. After the cell was in operation, a custom "Lean Automation" loader/unloader was designed and installed on one of the grinding machines to balance the cell and reduce the cell manning from 3 to 2 operators. The lean implementation followed by Lean Automation improved the productivity of the cells to the point where one shift could produce the output that previously required three shifts. In addition, the Lean Automation eliminated the need for a $1 million conveying system. The new cellular layout is shown in Figure 4. The new auto loader is installed on machine #1138.

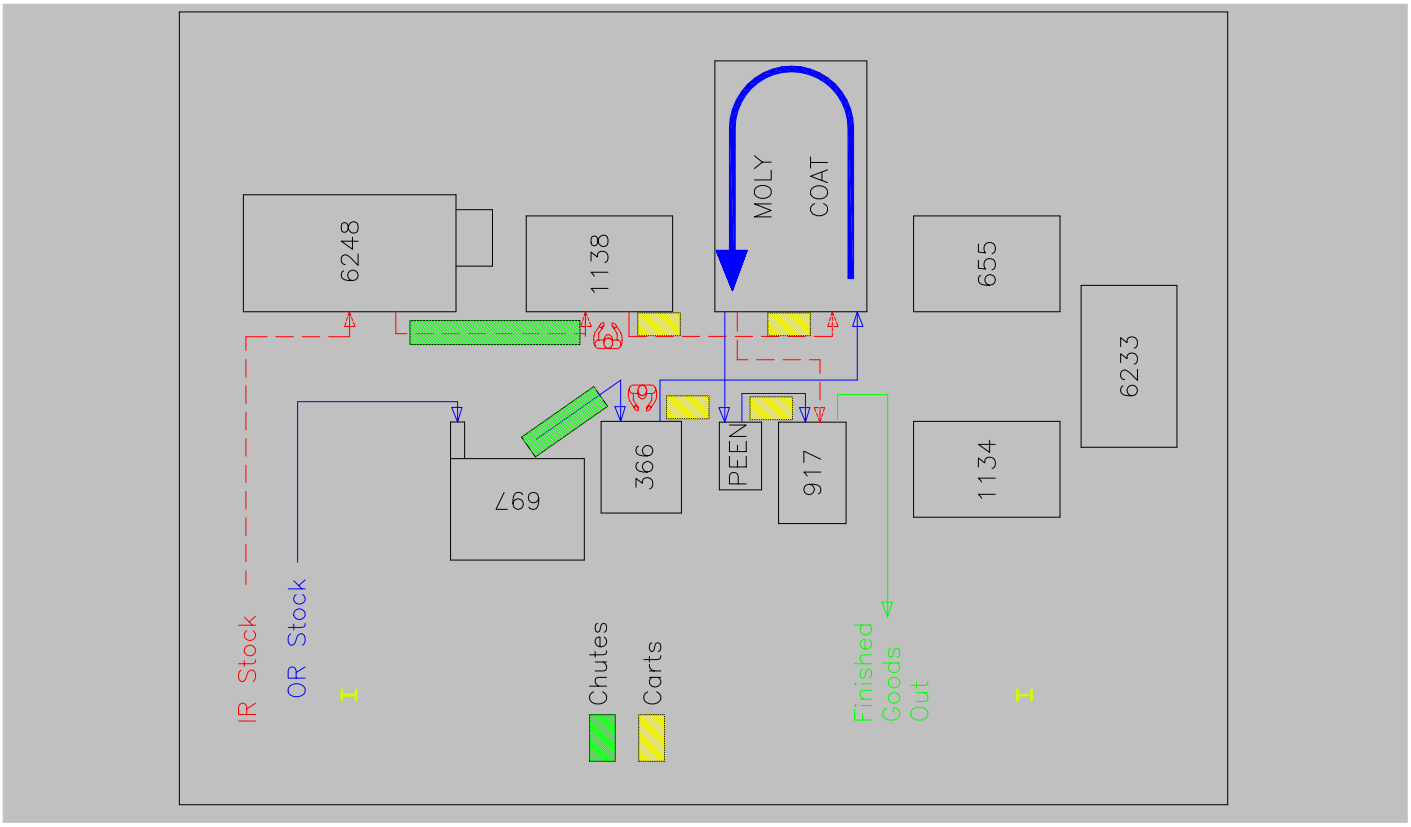

Figure 4

A manufacturer of electric drills was experiencing long lead times and low productivity in the assembly operation. Manual assembly of the pin carrier subassembly had the following characteristics:

- 40 second cycle time for 2 parts.
- 3 different assemblies
- 12 "machines" (Four tooled for three assemblies)
- 24 operators on two shifts

The company wanted to solve the problem by building one large automated assembly machine. Again, instead of designing the "big machine", the company was convinced "to go lean first' and then review the automation concept. The "big machine" would be very expensive, would be difficult to setup and maintain, and could actually reduce output! The following lean techniques were used first:

- Product family process flow diagrams

- Batch size reduction
- Visual workplace

A new "Lean Automation" pin carrier system was designed which resulted in the following benefits:
- 3 semi-automated machines vs 1 BIG ONE!
- Each machine runs one of the 3 product families
- No changeover
- 3 second cycle time per carrier vs 40 seconds
- 3 operators on 1 shift
- Capability to run small batches

The Lean Automation pin carrier system also had a capital cost that was $1,000,000 less than the original concept. Other examples of Lean Automation will be shown and discussed in the presentation.

4. Summary

Automation of production operations performed along with the use of lean manufacturing techniques can result in more flexible and cost effective concepts. Lean Automation provides the following benefits:
- Provides lower cost solution that are quicker to implement
- Faster acceptance and shorter pay back
- Greater flexibility for setup and material flow
- Better use of floor space

Our experience has shown that It is much easier and less costly to automate production operations in which the material flow has been improved through effective layout and cellular organization. This is not the conventional approach taken by engineers, and many changes have to occur to make Lean Automation a common way of thinking including:
- Becoming knowledgeable of Lean Techniques
- Getting design engineers to think differently
- Getting the work force involved as part of the design team
- Questioning automation assumptions
- Implementing Lean solutions first…then automate
- Establishing a cycle of continuous improvement

As lean manufacturing becomes a way of life in most companies, the concept of Lean Automation will become the next step for the lean enterprise.

Biographical Sketch

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Mr. Garcia, a registered professional engineer, served seven years in the U.S. Navy submarine force after graduation from the U.S. Naval Academy. After completing his military service, he obtained his Master of Engineering in Industrial Engineering from the Rochester Institute of Technology. In addition, he has 13 years of varied industrial experience in engineering, quality assurance, and operations management. He has worked for Mobil Chemical Company, Burroughs Corporation, Spectra Graphics, and the Department of Defense. His experience includes planning and implementing plant expansions in manufacturing, warehousing and materials handling systems. He has been responsible for Quality Assurance and Customer Service for multi-plant operations; engineered, justified and installed major manufacturing equipment systems; and has successfully managed manufacturing operations with staffing into the hundreds.

As a manufacturing engineering consultant for the past 12 years, Mr. Garcia has worked and managed projects involving material handling improvements, plant layouts and relocation, packaging line design and installation, and quality improvement. He has been involved with many lean manufacturing implementations involving setup reduction, cellular manufacturing, and value stream mapping. He has assisted in the development of manufacturing improvement strategies for national and international companies. His projects have been in the chemical, food, pharmaceutical, electronics, defense, and consumer products industries.

Mr. Garcia is a senior member of the Institute of Industrial Engineers (IIE) and American Society for Quality (ASQ). He is also a certified Systems Integrator (IIE), Quality Engineer (ASQ), and Quality Manager (ASQ).

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