

## **An Approach to Teach and Implement Lean Manufacturing**

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### **Introduction**

Companies have adopted lean manufacturing principles as a way to reduce costs, reduce lead times, improve customer satisfaction, and increase productivity. Lean manufacturing is a culture and philosophy for an entire enterprise. The process of becoming lean may mean transforming oneself from one's existing style of operations to an entirely different one. The process may require significant changes in the functions of the company.

Even though there are many examples of companies that have become more competitive and successful by adopting lean manufacturing principles and practices, there are many more examples of those who have not been as successful. Many organizations are not clear about what does it take to become lean. To convert from mass production to lean, they relate lean manufacturing to kanban system, or reduction of lot sizes to single-piece flow, or making a U-shaped cellular layout.

Many published articles in this area also, do not completely describe the process of going through the gradual and painful progress towards lean manufacturing. For example, there have been several articles that consider MRP and JIT as separate methodologies and others do not consider the linkage between basic inventory management principles with lean manufacturing.

This paper presents an approach to implement lean manufacturing from the existing condition of mass or batch production. The implementation consists of series of activities or projects that need to be done from start to finish and repeated again. Some projects have to be done before others can start. The paper also shows how some important principles of lean manufacturing can be taught using inventory management concepts.

## Teaching Lean Manufacturing

Generally lean manufacturing is taught as a stand-alone concept starting with any technique of interest to the instructor or depending on the needs of the industry. However, there exists a natural transition from basic inventory management principles and the development of the concepts of lean manufacturing. There is model normally taught in undergraduate production management course, called Economic Production Quantity (EPQ) model. Details of this model can be found in any text production or operations management text book (Heizer and Render 2004). Figure 1 gives a typical quantity versus time graph for this model. The EPQ is calculated by the square root equation given in the figure where,  $S$  = Setup cost per setup,  $D$  = annual demand in units,  $i$  = inventory carrying %/year,  $P$  = production cost/piece,  $d$  = demand rate of the item, and  $p$  = production rate of the item.

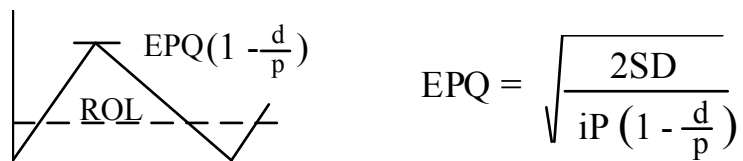


Figure 1. Basic Economic Production Quantity (EPQ) Model in Inventory Management.

The maximum inventory that can be reached in this situation is  $EPQ(1 - d/p)$  which can be rewritten as = total production during lead time – demand during lead time. Maximum inventory can be then determined by the relationship,

Maximum inventory =  $(p - d) \times LT$ , where  $LT$  = lead time.

It is a well-known principle in inventory management that inventory increases if  $p - d$  increases.

In lean manufacturing, the Takt time is the customer demand rate, thus, Takt time =  $d$ . One of the major principles in lean manufacturing is that the production rate should be made equal to the customer demand rate to eliminate the inventory build up.

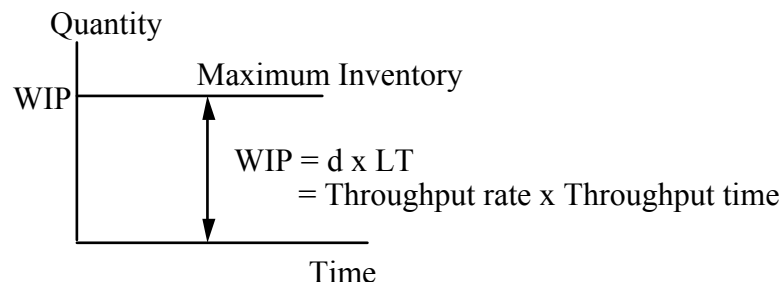


Figure 2. Relationship Between Work-in-Process and Lead Time.

Secondly, another well-known relationship is that Reorder Level (ROL) is given by demand during lead time, that is,  $ROL = d \times LT$  (Heizer and Render 2004). Figure 2 shows that the least maximum inventory that a company can have is in the work-in-process (WIP) when  $p$  has been made the same as  $d$ .

Therefore, to reduce WIP, the company should concentrate on reducing the production lead time. This is again a very important principle in lean manufacturing. The techniques of lean manufacturing are geared to highlight where the lead times are excessive and should be reduced.

Third, there is a direct relationship between inventory carrying cost and setup cost known as changeover in lean manufacturing. The bell-shaped inventory cost curves show that the total cost is the sum of the setup cost and inventory carrying cost (Heizer and Render 2004). Before inventory carrying cost can be taken up for potential reduction, it is the setup cost curve that needs to be brought down to reduce the total cost. In other words, the production batch size should not be arbitrarily reduced without reducing the changeover time. The goal of one-piece flow of lean manufacturing can only be achieved when the changeover time is reduced to, say, within 5 minutes.

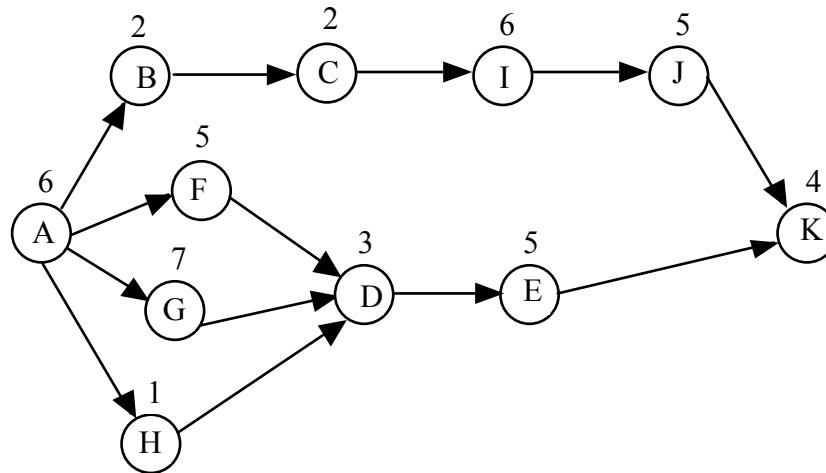


Figure 3. A Line Balancing Example with activity times given in minutes.

Lastly, in assembly line balancing technique, students work out ways to allocate assembly activities among a given number of workstations or determine the number of workstations required for a given output. As part of their solution to such problems, students can be asked to draw a load chart that shows the load at each workstation. Load chart is one of the common charts used in lean manufacturing to show graphically the load at workstations and the

corresponding Takt time. Figure 3 shows an example that students can use to indicate their arrangement of the workstations to meet the customer demand of 60 assemblies in 480 minutes. By drawing a load chart with Takt time line on it, they can suggest improvement in the arrangement. One of the possible improvements is that the entire work of activity J can be redistributed to activities I and K.

## **Implementing Lean Manufacturing**

Studies have shown that a lean manufacturing environment requires half of the hours of human effort spent on production, one-third of the hours of human effort spent on engineering, half of the factory space to produce the same output with a significant reduction in WIP inventories and defect rate.

In most companies, opportunities to apply lean concepts are abundant. Most companies learn to identify these opportunities by mapping the value stream for each major product type (Rother and Shook 1999). The value stream consists of all those activities, from forecasting and planning through invoice collection, required to deliver products and services to customers. The value-stream-mapping process will likely reveal that, from the customer's perspective, a significant amount of non-value adding activities are embedded in the current processes. These are the activities that consume financial and human resources and extend throughput time without adding to the economic value of a product or service.

By mapping value streams, identifying non-value adding activities and focusing on those processes likely to benefit most from the application of lean principles, a firm can begin applying lean concepts. However, value stream mapping is just one of the tools in lean manufacturing and after it is successfully applied, companies often find out that there are numerous areas that need improvement.

The sad fact is that the majority of U.S. manufacturers have not adopted lean principles. A recent survey by Industry Week indicates that only about one-third of these companies consider lean manufacturing as their primary improvement program. In fact, industry experts estimate that fewer than 5% of US manufacturing firms are truly lean (O'Brien 2003).

Even though lean manufacturing has proven time and again to work, why are not companies lean? Two major reasons that have been given and rightly so, will be discussed next. First reason is that the most important part of implementing lean principles is having an organizational commitment to improve (Hancock and Zayko 1998). All will agree that without commitment of

the management and the involvement of the employees no improvement can be brought about in a company. Second reason is that lean thinking is counterintuitive to what management is taught. Lean manufacturing while proven, does not fit comfortably into the business philosophies that most westerners have been taught. Using economies of scale, people know that more is better. The idea is that if you make large batches of product you have used your equipment more efficiently while if you make small batches with time consuming changeovers. In this the focus is on machine and operator efficiency. While in lean manufacturing the focus is on value-added activities and the efficiency of the workflow as a whole. More is not necessarily better. The focus is on to synchronize operations so the entire workflow produces product that customer needs it and in the amount the customer needs it (Conner 2001). The focus is on the overall system and how the system generates value.

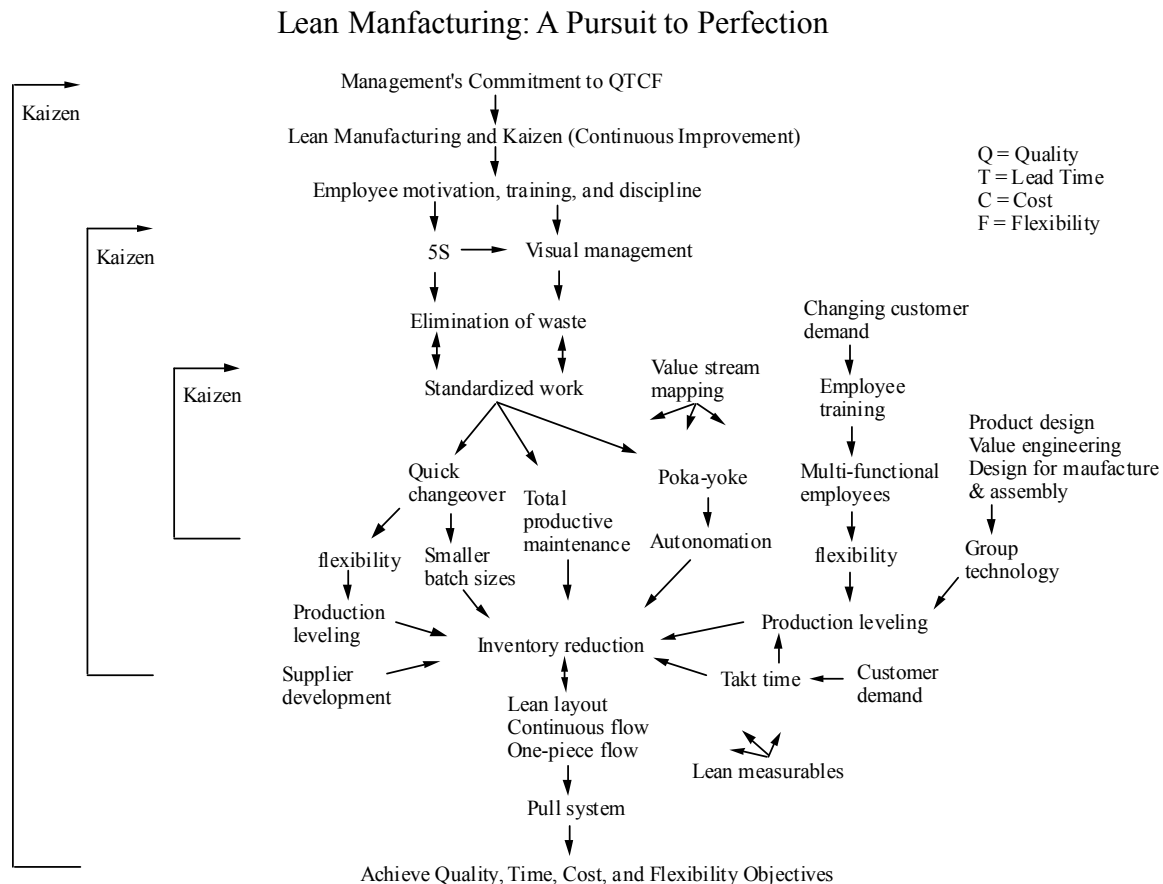


Figure 4. Lean Manufacturing Techniques and their Logical Flow of Application.

In this paper, another reason for the lack of application of lean manufacturing concepts is introduced. Even though the management is committed to improve, and the employee

involvement is high, but valuable resources are wasted in using the right technique in incorrect sequence. Figure 4 shows most of the lean manufacturing tools in their logical flow of application. Generally, in discussions of implementing lean manufacturing, tools such as inventory reduction, lean layout, pull production, or kanban come up first. According to figure 3, these attractive tools cannot be used in the beginning unless some pre-requisite tools have been successfully applied.

Often times in lean manufacturing literature, statements such as “four key principles of lean manufacturing are value, value stream mapping, pull production, and continuous flow” or similar ones can be found. But again, pull production is counterintuitive to thinking. Various techniques are thrown at a problem situation hoping that some will work and give the benefits that many companies have reported. The obvious result is that the company people who have no time to delve deep into the theory do not achieve the desired results and either abandon their effort or bring to a virtual stop.

In this paper, the author proposes based on experience two important tools or concepts that firms can begin their journey towards lean manufacturing. They are:

- (1) Setup reduction or quick changeover, and
- (2) Multifunctional employees.

### **Setup Reduction**

It was seen before that before inventory or production lot size can be reduced or before lean layout of one-piece flow can be achieved, it is important to reduce setup. Setup reduction is number one in the sequence of application of lean manufacturing tools. It is not the intent of the paper to get into the detailed step-by-step procedure for setup reduction which can be obtained from any book on lean manufacturing.

It is important to reduce setup in bottleneck operations first. Figure 5 shows the effect of setup reduction on bottleneck and non-bottleneck operations. In a bottleneck operation, time saved through setup reduction becomes run time. An increase of throughput rate at bottleneck increases capacity utilization in the whole system.

While in a non-bottleneck operation, time saved through setup reduction may have a tendency to add to the existing idle time. Therefore, an increase of throughput rate at a non-bottleneck should involve reallocation of resources from non-bottleneck to bottleneck operations. Once the

setup is reduced, production lot size can be reduced, and this cycle can be continued till desired level of production flow or benefits of lean manufacturing are obtained.

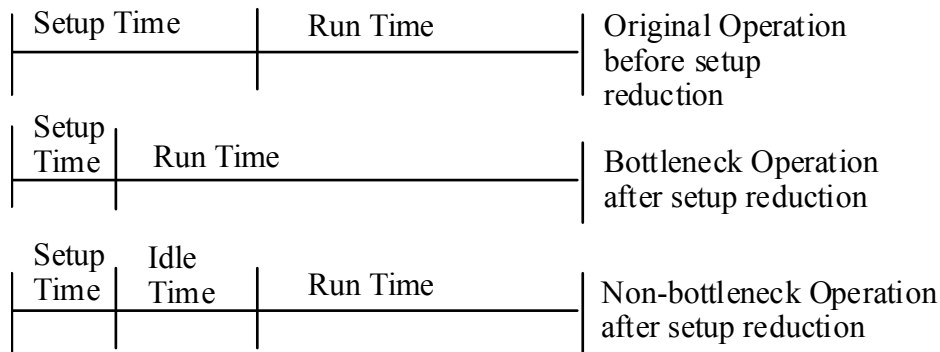


Figure 5. Effect of Setup Reduction on Bottleneck and Non-Bottleneck Operations.

One important consideration to remember is that the setup reduction should be applied to all the processes in the flow of a product. Otherwise, the reward will be partial to negligible as shown in Figure 6. This figure shows that only process 2 has gone through setup reduction project while other upstream or downstream processes have remain unchanged. In such a situation, the product cannot flow continuously, the inventory has not gone down, and the lean layout or pull production cannot be achieved.

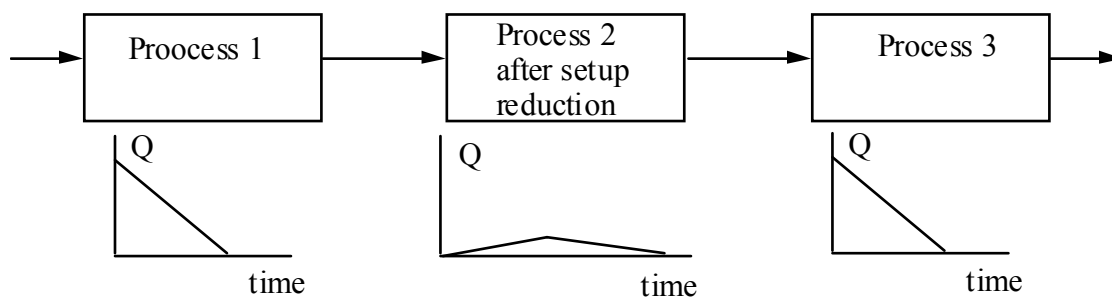


Figure 6. Need to Apply Setup Reduction in the Processes of a Product Flow.

Teams that have been successful in significantly reducing setup time challenge every activity. One very useful technique for doing this is known as the “5 Whys” from six-sigma methodology. By asking why an activity is performed, and subsequently asking why following each response, it is frequently possible to get to the root of the problem. Understanding root causes of all activities in a setup sets the stage for a successful setup reduction process (O’Brien 2003).

## Multifunctional Employees

Another important approach that companies can use to get immediate and long-term benefits is training their employees for multifunctional tasks. No company can become truly lean if the employees are not flexible enough to work on the current production needs based on customers' demand. Figure 7 shows that if employees are not trained to do the various production tasks when needed, the system generates either idle time or excess inventory both of which should be avoided by lean companies. It is important that firms use this concept of developing multifunctional employees early on in their lean manufacturing program.

Total productive maintenance and error-proofing have to be applied very closely to the two suggested above. As indicated in figure 4, these kaizen events need to be applied again to accrue full benefits of lean manufacturing.

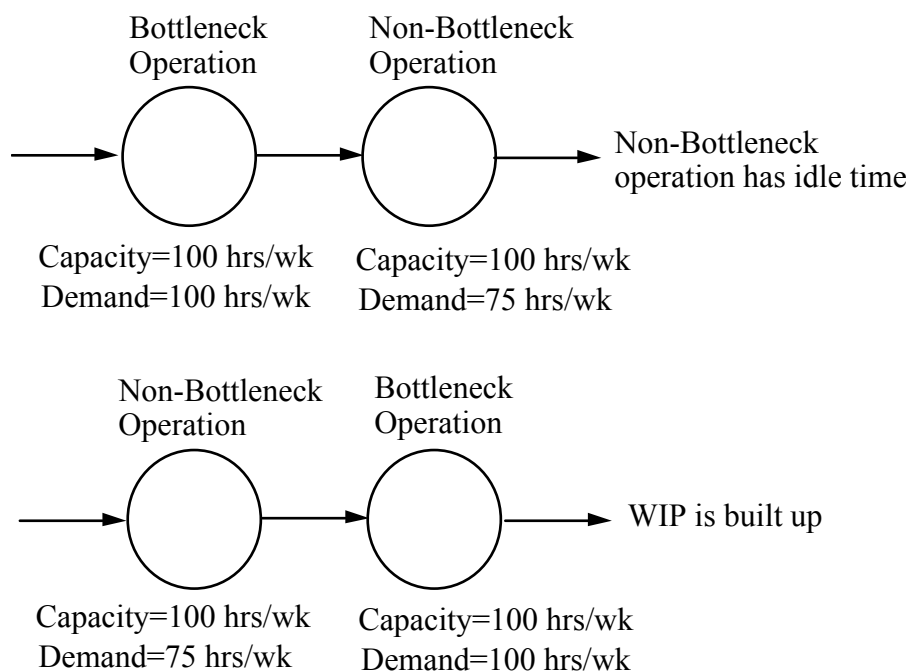


Figure 7. Need for Multifunctional Employees for Effective Production Leveling.

There are many tools available in lean manufacturing. Techniques such as pull production, error proofing, visual management and similar approaches can be applicable depending on the need of a particular situation. Experience will help determine which of these tools are most appropriate for each particular application.



## Conclusions

There is a misconception that lean must be implemented “from top to bottom” in order to generate meaningful results. Although company-wide implementation of lean principles is likely to produce the greatest long-term benefit, there are many significant gains to be made by identifying focused areas that will benefit from the application of lean concepts. Finding focused applications for lean principles, rather than company-wide initiatives, can help get lean manufacturing program off to a successful start.

Lean manufacturing can be rightly introduced as an extension of well-established inventory management principles and developed further by bringing in concepts of waste elimination, setup reduction and lead time reduction, the graduates will obtain a broader and better picture of the need for applying lean manufacturing concepts. Companies that hesitate to venture into lean manufacturing because of the vast array of tools available to use, can be motivated to take simple initial steps to get them going in the right direction.

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## Biography

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