International Journal of Advance Industrial Engineering
E-ISSN 2320 –5539

Available at http://inpressco.com/category/ijaie/

Review Article

Cycle Time Reduction using Lean Principles and Techniques: A Review

Mihir R. Prajapati†* and Vivek A. Deshpande†

†Department of Mechanical Engineering, G H Patel College of Engineering & Technology, Vallabh Vidyanagar, Gujarat-388120, India

Accepted 18 Dec 2015, Available online 20 Dec 2015, **Vol.3, No.4 (Dec 2015)**

Abstract

In this economical world, any company has to fulfill its customer needs to survive in the market. Cycle time reduction plays a vital role in improving the customer demands. When several workplaces are required to process a job, the machining and moving of the parts between the workplaces can be very time consuming unless it is suitably planned. From the point of view of production planning and control the basic bulldog blocks in the production system are WIP (work in process), Takt time and Balancing of line. In this particular study more focus on lean tools and techniques with their principles. The significance of this study is to identify the best possible tools and tools and techniques with respect to the problems. After this study the decision says that few tools and techniques can be applied and it is more preferable. It also discusses the methodology generally adopted, tools and techniques used and benefits obtained.

Keywords: *Cellular manufacturing, Lean production system, Kaizen, VSM, SMED, Takt Time and Assembly line.*

1. Introduction

In the current era of globalization, industries are adopting new tools and techniques to produce goods to compete and survive in the market. The most discouraging issue faced by manufacturers today is how to deliver their products or materials quickly at low cost and good quality. One encouraging method for addressing this issue is the application of lean management principles and techniques.

The Toyota Production System (TPS) was developed in Japan by Ohno and Shingo in 1940s and forms the basis of lean manufacturing (Herron, C. *et al*, 2008). The mass production system existed in USA could not affordable by Toyota so they focused on decreasing waste in all aspects of its operation by using many techniques and tools including Kaizen, cellular manufacturing, poka-yoke, etc. (Herron, C. *et al*, 2008).

Lean Production has emerged as methods to eradicate the bad sides of Mass production. However, most adopted Production methods in Palestine are very far from mass production since they target local markets. The Palestinian industrial sector (and to some extent in the Middle East) is mostly based on family businesses that are characterized as small and medium enterprises (Zain, M. *et al*, 2012).

The objective of this work is to help job shop production corporations adopt and benefit from Lean production ideas by suggesting a practical tool that can be effectively implemented.

*Corresponding author **Mihir R. Prajapati** is a ME Scholar (Industrial Engineering) **and Vivek A. Deshpande** is working as Assistant Professor

It should be known that the economic situation in Palestine is very difficult for industrial corporations to compete at an international level. Due to the Israeli occupation of the West Bank/Gaza, consumer power is heavily fluctuating causing a very variable demand, supplies of raw material and equipment can be heavily delayed and heavy competition from Chinese and Israeli producers (Zain, M. *et al*, 2012). All these factors make the adoption of Lean Production philosophy essential for their survival and to achieve economic sustainability and excellence.

This work presents an actual case study on one of the local elevator producers in Palestine. Their method of Production is heavily based on manual assembly with coupled with some machining operations. Products produced are fully customizable based on requests from the customer (It can be classified as engineering-to-order).

2. What is Lean manufacture?

Lean Manufacturing, also called Lean Production, is a set of tools and practices that aims for the continuous elimination of all waste in the production process. The main benefits of this are lower production costs; improved output and shorter production lead times. More precisely, some of the goals include:

2.1 Defects and wastage: Reduce defects and terminated physical wastage, including excess use of raw material inputs, needless defects, and costs related with recovering faulty items and avoidable product features which are not necessary by customers.

2.2 Cycle Times: Reduce manufacturing lead times and production cycle times by reducing waiting times between processing stages, as well as process grounding times and product/model conversion times.

2.3 Inventory levels: Minimize inventory levels at all stages of production, particularly works-in-progress between production stages. Lower inventories also mean lower working capital necessity.

2.4 Labour productivity: Improve labour productivity, both by reducing the idle time of workers and ensuring that when workers are working, they are using their effort as productively as possible (including not doing unnecessary tasks or avoidable motions).

2.5 Utilization of equipment and space: Use equipment and manufacturing space more efficiently by eliminating bottlenecks and maximizing the rate of production though existing tools, while decreasing machine downtime.

2.6 Flexibility: Have the ability to produce a more flexible range of products with minimum changeover costs and exchange time.

2.7 Output: So far as reduced cycle times, increased labour productivity and elimination of bottlenecks and machine downtime can be achieved, firms can generally expressively bigger output from their existing facilities.

3. Principles and Practices of Lean Manufacturing

Lean production is a multi-dimensional approach that integrates a wide variety of management practices, including just-in-time, quality systems, work teams, cellular manufacturing, supplier management, etc. in an integrated system researchers identified ten fundamental lean principles (Table 1) on the basis of exhaustive literature review and authors industrial experience, which further used for analysis of lean implementation (Shah, R. *et al*, 2003; Yadav O. P. *et al*, 2010).

There is not a fixed standard method for lean applications; however researcher (Hines, P. *et al*, 2004). given the Womack and Jones's framework for the lean leap (Table 2) defines a "one best way" which, containing a good deal of functional advises.

Table 1: Lean manufacturing principles

Lean manufacturing Principles	What it means?	Enablers
1. Standardization	Consistent work procedure to do mundane and monotonous tasks to improve efficiency and quality.	Standard work procedures, Design blue prints.
2. Simple and specified pathways	Flow of work to the right device or person in the right form at the right time at the lowest cost with the highest quality possible which reduces production lead time.	Kanban system, JIT
3. Teaching and learning	Through incessant effort of managers and supervisors acting as enablers or advisor in solving problems.	Scientific methods of problem solving
4. Socialization	An atmosphere of trust, respect and common purpose in which work is performed to improve efficiency and productivity.	Consistency, consensus and communication
5. Continuous improvement	Research by the people at every level toward improving their own work systems.	Kaizen, TQM, Six Sigma, JIT etc.
6. Supplier-customer relationship	Supplier-customer relationship postulates the form and quantity of the goods and services to be provided, the way requests are made by each customer, and the expected time in which the request will be met.	Long term cooperative relationship
7. Coordination through rich communication	Coordination through rich communication is required to develop the idea into an innovation.	Involvement of suppliers early during PD
8. Functional expertise and stability	Every company depends on highly skilled engineers, designers, and technicians to bring a product to the market; it is about emerging standard set of skills.	Job rotation policy
9. Pursuit for perfection / striving for ideal goal	It is a common sense of what the ideal system would be, and that shared goal motivation to make enhancements beyond what would be compulsory merely to meet the current needs of their customers.	Sharing a common goal
10. Cultivating organizational knowledge	It shows the faith of association that the skills and knowledge generated will pay off later.	Knowledge sharing practices

Table 2: Time Frame for the Lean Leap

Phase	Specific steps	Time frame
Get started	1. Find a change agent, 2. Get lean knowledge, 3. Find a lever, 4. Map value streams, 5. Begin kaikaku, 6. Expand your scope	First six months
Create a new organization	1. Reorganize by product family, 2. Create a lean function, 3. Devise a policy for excess people, 4. Devise a growth strategy, 5. Remove anchor-draggers, 6. Unstill a "perfection" mind-set	Six months through year two
Install business systems	1. Introduce lean accounting, 2. Relate pay to firm performance, 3. Implement limpidity, 4. Initiate policy deployment, 5. Introduce lean learning, 6. Find right-sized tools	Years three and four
Complete the transformation	1. Apply these steps to your suppliers/customers, 2. Develop global strategy, 3. Changeover from top-down to bottom-up improvement	By the end of year five

(Source: Hines, P. *et al*, 2004)

Table 3: The applications, strengths and limitations of LPS tools and techniques

Tools/techniques	Applications	Strengths	Limitations/ Problems
Cellular Manufacturing	Shop floor.	Uninterrupted movement of materials, overhead cost reduction, enhances flexible manufacturing.	High set up cost.
Just-In-Time	Supply chain, manufacturing.	Improves productivity and profitability, reduces inventory, costs and lead time.	Leads to losses sometimes due to stoppages in production as a result of suppliers failures.
Value Stream Mapping	Supply chain, manufacturing.	Provides information and material flow, reduces cost and lead time.	Does not incorporate management of human resources and the development of products.
Five-S Practice	Shop floor	Ensures neat shop floor, improves productivity, and reduces waste.	Requires constant work and updating.
Single Minute Exchange of Dies	Machines	Set up time reduction, increase in productivity and flexibility, reduction in inventory and wastes.	Requires High set up cost.
Takt Time Analysis	Manufacturing processes	Synchronizes demand and manufacturing, reduces wastes.	Difficult to apply in the manufacturing of diverse products.
Kaizen	All production processes	Reduce wastes and inventory, improves productivity, quality of products and flexibility.	Results to flow disruptions.

4. Tools and Techniques of Lean Production System

There are many tools and technique for Production System, the application of these techniques assists in starting improvement processes, incremental the overall responsiveness of quality and also enhances the change of attitude of employees. In his study (Dale, G. *et al*, 2003) explained that tools and techniques are used to "aid quality planning, listen to the 'voices' of the customer, capture data, control processes, make improvements, solve problems and improve people."

However, the various tools and techniques will not achieve the desired results if they are no utilized; this is because LPS is not just the application of a bunch of tools but rather a completely different approach of manufacturing. This was pointed out by (Lang, J. *et al*, 1995) as they argued that "although a lot of techniques and tools have been associated with the concept of Lean design and manufacturing, they prove to be futile unless they are integrated with thorough understanding of the manufacturing processes, redefinition of the currently adopted processes and multidiscipline teams assigned to implement changes."

Some of these tools and techniques which include Just-in-time, Cellular manufacturing, Single minute exchange of dies, Kaizen, Total productive maintenance, Value stream mapping, Five-S practice, Takt time analysis etc. The applications, strengths, and limitations of the various LPS tools and techniques are listed in (table 3).

4.1 Cellular Manufacturing

Cellular manufacturing can be defined as a tool and technique of LPS where machines and equipment are properly arranged in order to enhance the steady and continuous movement of materials and tools through the process of production without slowdowns and time wastage. In their study (Levinson W. *et al*, 2002) observed that it is "only by relating each machine with the others in such a way that production will follow in straight lines without confusion, can the highest economy operation be attained."

The main benefit of Cellular Manufacturing is that it assists organizations to reduce the overhead cost, as an individual worker can monitor and manage series of machines and equipment in a production channel.

4.2 Just-in-time

Just-in-time (JIT) production which involves the identification and tackling of problems, as well as production cost elimination is one of the most widely used tools. According to one researcher, Just-in-time means ensuring the manufacturing of the right item at the right quantity and also at the right time. In their study (Albino V. *et al*, 2001) listed the three sub goals of JIT as:

- "Quantity control, which enables the system to adjust to daily and monthly demand fluctuations in quantity and variety;
- Quality assurance, which ensures that each process will supply only defect-free units to subsequent processes; and
- Respect of the worker, which is the base to increase human resources productivity necessary for attaining the system's cost objectives."

Also, as Lean companies have no inventory to fall back on, the application of JIT sometimes leads to losses due to stoppages in production as a result of supplier's failures.

4.3 Value Stream Mapping

VSM is an effective LPS tool that involves the use of paper and pencil, and assists in the understanding and monitoring information and material flow in a manufacturing plant as materials flow across the value stream from raw material to shipping. Its implementation assists an organization to improve the quality of its products, reduce the cost of manufacturing and lead time (Dinesh, S. *et al*, 2005).

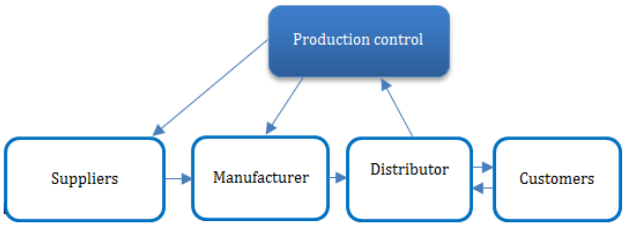

Figure1: An example of a Value Stream Map Source

As shown in figure 1, VSM provides the information and material flow in a manufacturing plant; it also shows various production processes, as well as the rate of defects, and set up time. VSM while focusing on fulfilment of orders and incorporation of the supplier processes pays no attention to major processes like the management of human resources and the development of products.

4.4 Five-S Practice

Five S is a tool of LPS which is aimed at increasing productivity by sanitizing as well as ensuring a neat and well-arranged shop floor; it also adopts the use of visual signs to ensure greater benefits. The five-S which were originally Japanese words are:

- Seiri (Sort): Isolate and get rid of all materials that are not useful;
- Seiton (Straighten): Systemize the important materials and arrange them correctly for better retrieval when they are required;
- Seiso (Shine): Clean-up the entire shop floor to maintain an encouraging environment for manufacturing;
- Seiketsu (Systemize): Maintain a constant cleaning of the surroundings.
- Shitsuke (Sustain): Involve all the employees and ensure that the constant cleaning is maintained.

The first task in transforming a company to Lean production according to (Skinner D. *et al*, 2003) is to adopt the Five-S practice to properly structure and arrange the shop floor. He observed that it leads to the reduction of wastes inherent in waiting, unnecessary movement, inventory as well as wastes in other manufacturing processes.

4.5 Single Minute Exchange of Dies

Single Minute Exchange of Dies (SMED) is a productivity improvement LPS tool and technique aimed at waste elimination through setup time reduction. SMED plays a prominent role in Lean manufacturing as achieving setup time reduction is very important in transforming a company from mass production to Lean production (Shingo, S. *et al*, 1985). Also the application of SMED enables manufacturing companies to be more competitive by achieving the following: a decrease in lot size production, setup time reduction, decrease in planning and scheduling overhead, waste elimination, and more efficient utilization of material resources, thereby leading to the production of high quality products that meets the customer's requirements.

4.6 Takt Time Analysis

Takt time is the rate with which products flow through the line of production, it can be achieved by synchronizing the production rate to the rate of product demand. Its knowledge and application is a very important aspect of LPS.

Takt time which is calculated as the (available time) divided by the (demand required) is applied in LPS to ensure that the customer's requirement are met through timely provision of products, thereby ensuring that excess manufacturing of products which translates to waste is avoided (Page, J. *et al*, 2004).

The limitation of Takt time analysis technique is the difficulty that are always encountered whenever it is applied where machines and equipment are employed for the manufacturing of diverse products.

4.7 Kaizen

Kaizen which is a Japanese word for continuous improvement is a very efficient tool and technique of LPS which is aimed at the adoption of creativity and innovation to detect and reduce non-value-adding work, and also affect the changes within the shortest possible time, thereby increase productivity. Here efforts are made to apply and maintain little but incremental changes continuously in order to achieve an identified improvement (Ortiz, C. *et al*, 2006).

The adoption of Kaizen techniques by organizations is one of the most efficient ways of beginning a continuous improvement approach that will lead to positive achievements and production of high quality and innovative products. For Kaizen to be successfully implemented in a company, it requires full commitment and contribution of an entire company's workforce. However, some manufacturers are reluctant to adopt the LPS technique as they argue that it does not allow for easy flow of materials due to disruptions which may hamper the smooth operation of a company.

4.8 Types of Assembly Line

An assembly line can be classed into three classifications based on numbers of prototypes assembled on the line and according to the line pace which are:

4.8.1 Single Model Line: A single – model line can be described as a line that assembles a single model. This line produces many units of one product with no variation. The tasks achieved at each station are same for all units. Products with high demand are intended to this line**.**

4.8.2 Mixed –Model Line: Mixed – model line is producing more than one model. They are made simultaneously on the same line. Once one model is worked at one stations, the other product are made at the other positions. Thus, every station is equipped to achieve various tasks needed to produce any model that moves through it. Many consumers product are assembled on mixed – model line.

4.8.3 Batch Model Line: This line produces each model in batches. Usually workstations are set up to produce required quantity of the first model then the stations are reconstructed to produce other model. Products are often assembled in batches when medium demand. It's more economical to use one assembly line to produce several products in batches than build a separate line for each model. The research will be carried out in industry which applied a mixed model line.

5. Lean Implementation

Implementing the lean concept in any organization can gain many advantages over the operational performance. According to the empirical literature of (Rahman *et al*. 2010) and the study done by (Anand G. *et al*, 2009) have demonstrated that the implementation of a lean manufacturing system resulted in superior organizational performance compared to the other practices namely flexible manufacturing systems and computer integrated manufacturing systems. This has currently caused to create new trends in lean implementation. (Iarnien R. *et al*, 2012) have described the model of lean implementation process with three major steps.

1. Planning the change: It needs to define and pre identify the required change expected through lean implementation and to get the assurance of the management to do that change. Then the processes should be well identified to apply the lean concept.

2. Identifying success factors: All people should be made aware of the expected change and should involve with the process of implementation. Then the superiors should provide required tools, methods and job security to these people.

3. Implementing and measuring progress: The progress and the effectiveness of this implementation should be assessed to ensure the success. The authors suggested five dimensions to measure this progress. They are; elimination of waste, continuous enhancement, continuous flow and pull driven systems, multifunctional teams and information systems.

The study done by (Kovacheva, A.V. *et al*, 2010) has identified the following factors to be the most significant in lean implementation according to the literature.

1) Management commitment in the implementation process and communicating the vision of the improvement program
2) Necessary changes in the organizational culture
3) Employees involvement
4) Network relationships
5) Holistic strategy for integrating the system
6) Willingness to learn

Therefore in implementing the lean concept and in its operation, these factors should be collectively considered.

There is a criticism among rank-and-file workers saying that, the lean practitioners are highly focusing on the lean tools and the respective methodologies, so that they fail in the implementation process due to the poor focus on the lean philosophy. In some cases, the

lean implementations look good but fail to improve. (Hopp W. *et al*, 2008) have explained this situation seeing as a pitfall saying that management decides what solution to use without understanding the true problem and without consulting shop floor personnel.

Conclusion

Lean manufacturing has a long history which was initiated in Japan. This concept was originated with thinking of waste reduction evolving with the Ford's production philosophy and the Toyota Production System. The related literature supported to map the current knowledge in lean manufacturing with its real-world applications. Thus many researchers have studied in this area and have found the positive impact of the concept on the organizational performance.

The adoption of the tools and techniques also makes manufacturing to be highly profitable, as a result of fast production of goods and products; also the considerable reduction in lead times and production costs enable organizations to immediately sell their products, beat their competitors and also increase the rate of turnover, thereby maximizing profit.

However, the various tools and techniques will not achieve the desired results if they are not properly utilized; this is because LPS is not just the application of a bunch of tools but rather a completely different approach of manufacturing.

References

Albino, V. and Okogbaa, G. (2001), Computer-Aided Design Engineering & Manufacturing Systems Techniques & Applications, *Optimization Methods for Manufacturing* Vol. (4), pp 22-27.

Anand, G. and Kodali, R. (2009). Selection of lean manufacturing systems using the analytic network process – a case study. *Journal of Manufacturing Technology Management*. Vol. 20 (2), pp 258-89.

Dale, G. (2003) Managing Quality Blackwell Publishing, *Oxford*, UK.

Dinesh, S. and Vaibhay, G. (2005) Application of value Stream mapping for lean operations and cycle time reduction: An Indian case, *study Production Planning and Control,* Vol. 16, iss. 1, pp. 44-59

Gamage KGDAS, Piyanka WPGT, Jayathilake LPCB, Perera HSC, Gamage JR. (2012). Challenges and Potential Impact of Applying Lean Manufacturing Techniques to Textile Knitting Industry: A Case Study of a Knitting Factory in Sri Lanka, *Proceedings of 3rd International Conference: Engineering, Project and Production Management* (EPPM2012), Brighton, UK.

Hines P. (1998) Value Stream Management *International Journal of Logistics Management*, Vol. 9, Iss.1; pp 18-25.

Hines, P., Holwe, M. and Rich, N. (2004), Learning to evolve: A review of contemporary lean thinking, *International Journal of Operations & Production Management*, Vol. 24, No. 10, pp. 994-1011.

Herron, C. and Christian, H. (2008), the transfer of selected lean manufacturing techniques from Japanese automotive manufacturing into general manufacturing (UK) through change agents, *Robotics and Computer-Integrated Manufacturing*, 24, pp. 524-531.

Hopp, Wallace; Spearman, Mark. 2008. Factory Physics: *Foundations of Manufacturing Management* (3rd ed.), Mc-Graw Hill, New York, NY.

Ihueze, C., and Okpala, C. (2012) Application of Taguchi Robust Design as Optimized Lean Production System in Manufacturing Companies *Research Journal in Engineering and Applied Sciences* 1(1), pp 45-50.

Kovacheva, A.V. (2010). Challenges in Lean Implementation: successful transformation toward the lean enterprises. *Master Thesis. University of Aarhus.*

Iarnien, R. And Vienaindien, M. 2012. Lean Manufacturing: Theory and Practice*. Journal of Economics and Management.* Vol. 17(2), pp 726-732.

Lang, J. and Hugge, P. (1995) Lean Manufacturing for *Lean Times Compendex Journal*, Vol.33, Iss. 5; pp. 7-12.

Levinson, W. and Rerick, R. (2002) Lean Enterprise: A Synergistic Approach to Minimizing Waste *ASQ Quality Press,* Milwaukee, USA

McCarthy, D. and Rich, N. (2004) Lean TPM: A Blueprint for Change *Elsevier Butterworth-Heinemann*, London

Ortiz, C. (2006) All-Out Kaizen *IIE Solutions Journal*, Volume 38; Iss. 4, pp 21-30

Page, J. (2004) *Implementing Lean Manufacturing Techniques Gardner Publications*, Ohio, USA

Rahman, Shams, Laosirihingthong, Tritos and Sohal, Amrik S. (2010). Impact of lean strategy on operational performance: a study of Thai manufacturing companies. *Journal of Manufacturing Technology Management.* Vol. 21(7), pp 839- 852.

Shah, R. and Ward, P. T. (2003), Lean manufacturing: context, practice bundles, and performance, *Journal of Operations Management*, 21, pp. 129–149.

Shingo, S. (1985) a Revolution in Manufacturing: *The SMED System Productivity Inc.* USA

Shinkle, G. Gooding, R. and Smith, M. (2004) Transforming Strategy into Success: How to *Implement a Lean Management System Productivity Press*, New York

Singh, B., Garg, S. K. and Sharma, S. K. (2010), Development of index for measuring leanness: study of an Indian auto component industry, *Measuring Business Excellence*, Vol. 14, No. 2, pp 46-53.

Skinner, D. (2003) 'Lean and Clean' A Better Way to Run Sheet Metal Shops, *Books Say Snips. Troy*, Vol. 72, Iss.7; pp 48-56

Yadav, O. P., Nepal, B., Goel, P. S., Jain, R. and Mohanty, R. P. (2010), Insights and learnings from lean manufacturing implementation practices, *Int. J. Services and Operations Management,* Vol. 6, pp. 398-422.

Zain, M., & Kassim, N. M. (2012). *Strategies of family businesses in a newly globalized developing economy*.