PRODUCTIVITY IMPROVEMENT BY LEAN MANUFACTURING PHILOSOPHY

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Abstract: In the increasingly global marketplace, many manufacturers and service providers are applying lean manufacturing philosophy in order to optimize costs and quality gaining a competitive advantage. The paper summarises the advantages of application of lean philosophy in the manufacturing and service sectors, which focuses on value-added flow and the efficiency of the overall system. Lean manufacturing techniques and typical wastes are also detailed. The author describes the main general steps of a lean project completed in an industrial environment, and finally a case study is presented.

Keywords: lean production, lean techniques, lean project

1. Introduction

Lean manufacturing is a performance-based process used in manufacturing companies to increase competitive advantage in the global market.

Nowdays this philosophy is applied in many sectors including automotive, electronics, white goods, and consumer products manufacturing, etc.

The focus of the approach is on cost reduction by eliminating non-value added activities. Originating from the Toyota Production System, many of the tools and techniques of lean manufacturing (e.g., just-in-time (JIT), cellular manufacturing, total productive maintenance, single-minute exchange of dies (SMED), production smoothing, …) have been widely used in manufacturing [3].

Recently many manufacturers apply lean manufacturing tools in order to optimize quality and costs to gain a competitive advantage.

2. Mass production vs. Lean production

Mass production is a way of thinking that starts with the principle of economies of scale. Bigger is better and making large batches of parts makes more efficient use of individual equipment than small batches with time consuming changeovers. The focus on mass production is individual efficiency – efficient use of individual machines and individual operators [6].

Lean thinking focuses on value-added flow and the efficiency of the overall system. The goal is to keep product flowing and add value as much as possible. The focus is on the overall system and synchronizing operations.

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Lean manufacturing is a manufacturing philosophy that shortens the time between the customer order and the product build/shipment by eliminating sources of waste. *Waste* is anything that does not contribute to transforming a part to your customer's needs.

The results of the lean approach are illustrated in Figure 1. Lean manufacturing will take some waste out of the value-added activity shrinking it down as in the mass production approach, but more importantly, it reduces the pure non-valued added activities, which has the large impact on lead-time [6].

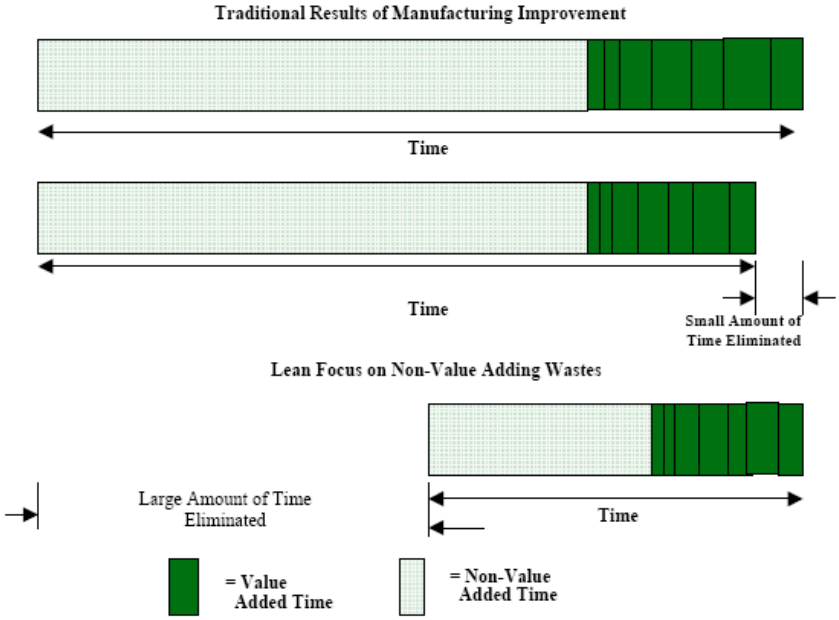

Figure 1. Lean manufacturing vs. traditional manufacturing [5]

Inefficiencies of mass production [6]:

- Long lead times due to inventory buffers.
- Imbalances in the timing of operations hidden - bottlenecks are hidden.
- Feedback from later operations (customers) to earlier operations is delayed. When a defect is discovered it is not clear when or why it was produced.
- Little motivation for improvement.
- When shifting to a new product (e.g., from A to B) there is a large buffer of parts to be moved and handled.
- Extra handling is necessary (potential damage).
- Extra floor space is needed.
- Extra inventory costs.

Advantages of lean manufacturing [6]: (over batch and queue)

- Production lead times are short.
- Imbalances in operation timing (bottlenecks) are apparent – improvement can focus on bottlenecks.

- Defects are immediately apparent and the underlying cause can be quickly determined.
- Constant motivation for improvement – problems have immediate production impact.
- Operations can quickly shift to a new product (e.g., A to B) without interrupting the flow, each operation makes just what is needed when it is needed.
- There is minimum part handling.
- Inventory holding costs are minimized.

3. LEAN principles and wastes

The challenge to organizations utilizing lean manufacturing is to create a culture that will create and sustain long-term commitment from top management through the entire workforce. There are many literatures in topic of lean production principles and application of it [1, 2, 9, 10].

Lean manufacturing techniques are based on the application of five principles to guide management's actions toward success:

1. Value: The foundation for the value stream that defines what the customer is willing to pay for.
2. The Value Stream: The mapping and identifying of all the specific actions required to eliminate the non-value added activities from design concept to customer usage.
3. Flow: The elimination of all process stoppages to make the value stream "flow" without interruptions.
4. Pull: The ability to streamline products and processes from concept through customer usage.
5. Perfection: The ability to advocate doing things right the first time through the application of continuous improvement efforts.

All of processes can be categorised into theree groups:

- value added activities (e.g. manufacturing, assembly, …),
- required but non-value added activities (e.g. exchange of die),
- waste is "any element that does not add value, or that the customer is not prepared to pay for" (e.g. over-production, transportation, …).

Seven types of wastes can be identified in processes [6]:

1. **Over production** – Producing more final products than is needed or before it is needed for the customer is a fundamental waste in lean manufacturing.
2. **Waiting** – Worker or machine is waiting for material or information. Material waiting is not material flowing through value-added operations.
3. **Motion** – Any unnecessary motion that does not add value to the product is waste.
4. **Transportation** – Moving material does not enhance the value of the product to the customer.
5. **Inventories** – Material sits taking up space, costing money, and potentially being damaged. Due to stocks problems are not visible.
6. **Over-processing** – Extra processing not essential to value-added from the customer point of view is waste.

7. **Producing defective products** – Defective products impede material flow and lead to wasteful handling, time, and effort.
8. **Other additional wastes** – Underutilized worker creativity and resource, application of non adequate equipments and systems, wasted energy and water, damage of environment.

These wastes appear in every manufacturing activity. The most important tasks of companies are to identify, manage, and minimize these wastes in order to become more competitive.

4. Main tools and technics of lean manufacturing

The main tools and techniques of lean manufacturing are for example Value Stream Mapping, JIT, One-piece flow, Takt–time analysis, Heijunka, Single Minute Exchange of Dies (SMED), Jidoka, Pull system, Kanban, Supermarket, Kaizen, Standardised processes, 5S, Total Productive Maintenance (TPM), 6σ, Cell design and layout for flow (Cellular production, U-shaped cells), Work group team error proofing, Zero defects (ZD), Station and operation process control, Error proofing (poke-yoke), Balanced flow-, Synchronous flow, Mixed flow lines, etc. .

Each of these tools and techniques focuses on certain aspects and areas of the manufacturing process in order to help improve costs and efficiencies at the company.

The lean manufacturing and a lean enterprise or business mean that the company is focused on supplying exactly what the customer wants, in the form they want it, free of defects, at the exact time that they want it, with minimal waste in the process.

5. Main steps of a Lean project in an industrial environment

The main steps of a lean project generally are the followings [11]:

Step 1: *Determination of goals and objectives of the project, identification of obvious problems with the management.*

At first the most important KPIs (key process indicators) should be defined which should be measured at the beginning and improved at the end of the lean project.

The measurement of processes and activities by KPIs provides a basis for understanding performance capabilities and improvement opportunities [7].

Step 2: *Choose the pilot pick of an important product, product family, or customer.*

Pareto Analysis has to perform by volume (qty.), or by sales value in euros, or by volume of scrap, by costs, by strategical customer, etc.

Based on pareto analysis 1 item should be chosen for study.

Step 3: *Study and evaluate the pilot process.*

Value Stream Mapping (VSM) is a very efficient tool of lean philosophy for visually representing where wastes occur in the process [8]. Value Stream Map helps to visualize the flow of information and product, helps to see wastes, shows the relationship between information and material flow, and forms the basis for prioritizing lean actions.

The first step in creating a *Current State Map (CSM)* is to group and identify product families. The next step is to walk the process, collect data relating to all of the manufacturing processes. The data relating to the different manufacturing processes should be collected and written into the map, inventory levels and process cycle times, along with changeover times also should be documented. Interview could be made by key people to identify key assumptions.

The following engineering studies can be performed: capacity analysis, labor analysis, takt-time analysis, methods analysis, handling analysis, space analysis and value engineering analysis.

Based on analysis of CSM bottlenecks and wastes can be identified in the process. After it brainstorm can be realized with key personnel, short and long-term improvements should be documented, recommendations can be made and savings and benefits can be quantified. The suggestions should be presented to management for approval.

A *Future State Map* is then developed for the system with lean tools. The process of defining and describing the future state map starts while developing the current state map, where target areas for improvement start to show up.

Step 4: *Operator Training*

Adequate key persons should be exposed to techniques of lean manufacturing. Expected savings and benefits should be emphasized.

Step 5: *Pilot implementation, establishment of core project team for implementation.*

Project team and team leader should be selected, the project should be scheduled.

Step 6: *Run pilot and refine*

Pilot project should be run for process validation, personnel should be trained, suggestions and changes should be achieved. Adjustments should be refineed and made if it is necessary. Opportunities can be identified for full implementation. Results of the project can be measured by the improvement of defined KPIs.

Step 7: *Full Implementation*

Pilot project should be integrated into the total Lean Program. Goals and objectives of the total Lean Program should be defined, improvement and study areas should be identified.

Expected savings and benefits should be defined and detailed engineering studies and analysis to include savings, benefits, costs and ROI (Return On Investment) should be performed. Current conditions and areas for improvement to eliminate "waste" should be documented, and the Project Team should be established and trained in the techniques and principles of Lean Manufacturing. Executive plan for each project should be developed, each project should be scheduled, monitored and measured after implementation. Necessary revisions and adjustment should be made to ensure success.

6. Case study for a lean project

A lean R+D project was completed for a company which produces household appliances.

The main manufacturing process steps are the followings: metal plate cutting, automatic welding of inner can of boiler appliances, cleaning (sand cleaning) and enamelling of inner surface of cans, heat treatment in a furnace, testing on high water pressure, foaming and final assembly, final testing and packaging.

The main steps of the project were the followings [4]:

Step 1: *Determination of goals and objectives of the project, identification of obvious problems with the management.*

In the R+D project the target KPIs were the followings: improve profit margin, decrease lead time to the customer, improve quality, reduce inventory and increase productivity. The identified risk fields and problems were the followings:

- risk of material flow,
- risk of production planning,
- quality risks,
- risk of production capacity (bottlenecks),
- risk of human resource.

Step 2: *Choose the pilot pick an important product, product family, or customer.*

Pareto Analysis was performed by production volume. Based on pareto analysis 1 item family was chosen for study in the pilot project.

Step 3: *Study and evaluate the pilot process.*

In the frame of the R+D project the Current State Map was prepared to visualize the flow of information and product, helps to see waste, shows the relationship between information and material flow, and forms the basis for prioritizing lean actions. The prepared Current State Map can not be showed because of the large size of it.

The problematic areas were showed and the reasons of these were explored by the CSM. Suggestions and recommendations were defined for the next risk areas:

- Component and raw material supply of technological processes:
  - component supply scheduling should be harmonised with production plans,
  - organization of fork-lift trucks should be improved,
  - supermarket (lean supermarket is a place between processes where a standard amount of inventory is stored - in order to supply a downstream process without interruption due to product variations and/or batch sizes) should be established close to the production area which can decrease the risk and lead time of component supply.
- Production planning by the ERP system:
  - technological parameters used during the planning process should be reviewed and refreshed,
  - data relating to semi-finished products, reworks and scraps should be entered into the ERP system.
- Product identification, real time electronical documentatition of material flow:
  - estalishmnet of an individual identification of each of products was recommended which can provide the real time moitoring of every product in the technological process,
  - due to the identification system the occurred problems can be retrieved and identified,

- delivery and acceptance of raw materials and components between the different technological processes can be documented,
- identification and documentation is also should be applied for human- and equipment resources.

– Review of quality assurance processes:
  - establishment of new testing and quality assurance stations was recommended to improve product quality and decrease the possibility of scraps and wastes,
  - application of lean tools was suggested which result quality improvement, e.g. jidoka (built in quality), andon system (signal for immediate help to prevent line stop), poka-yoke (idiot or fool proofing technique), TPM (Total Productive Maintenance), etc.

– Revision of manufacturing and technological processes:
  - modernisation of manufacturing technology recommended in some manufacturing phases,
  - standardization and documentation of work areas and processes can lead to reduced cycle times, greater cost efficiency, and reduced motion which directly affect the reduction of wastes of transportation and inventory,
  - storage and transport activities between manufacturing phases should be developed to eliminate the damage of semi-finished products,
  - application of a SMED (Single Minute Exchange of Dies) as an important lean tool is recommended in the manufacturing process, especially at critical points of the phases e.g. automatic welding machines, were the exchange of dies requires more than 4 hours. The benefits of SMED are: improved flow, lower inventories, better quality and reduction of waste times,
  - application of line balance method for equalizing cycle times to improve productivity.

– Improvement of visual management activities:
  - application of 5S as a lean tool is suggested which represents the establishment of a transparent and clean working area to improve productivity and reduce waste times,
  - visualisation of material flows and buffers in the plant (painting of different colored lines on the floor),
  - application of business information tables, application of KPIs.

  A future state map is under preparation.

Step 4-5: *Operator Training. Pilot implementation, establishment of core project team for implementation.*

Project teams for the lean action areas and team leaders were selected, deadlines for project steps were defined. Every team is consist of white- and blue-collar worker. Adequate key persons were exposed to techniques of lean manufacturing.

Step 6: *Run pilot and refine.*

Pilot project was started, recently the project is under realisation. All of the team members and the company management believe in the success of the lean project and lean actions. At the end of the project the results will be measured by the

defined KPIs. After a successful pilot project the Total Lean Program (Step 7) will be realised based on the experience gained in the implementation of the pilot project.

7. Summary

The paper summarises the advantages of the lean philosophy which is a performance-based process used in manufacturing organizations to increase competitive advantage. The author defines the most typical wastes (over production; waiting; motion; transportation; inventories; over-processing; defects; other) and emphasizes the importance of application of lean manufacturing, lean techniques and tools. Main steps of a lean project completed in an industrial environment were described generally (determination of goals and objectives of the project, identification of obvious problems with the management; choose the pilot pick of an important product or customer; study and evaluate the pilot process; operator training; pilot implementation, establishment of core project team for implementation; run pilot and refine; full implementation) and finally a case study was presented.

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