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A Study on Identifying the Causes of Lean Manufacturing Waste and Eliminating them using Lean Tools

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Abstract : Lean Manufacturing was developed by Toyota Motor company to address their specific needs in a restricted market in times of economic trouble. These concepts have been studied and proven to be transferrable and applicable to a wide variety of industries. This paper aims to Identify the Causes of Lean Manufacturing Waste and Eliminating them using Lean Tools by various managerial operations, organizational culture, environmental management and various lean activities. We thoroughly describe the lean tools which Toyota production system uses for lean manufacturing and also their general principles. A tabular representation of lean activities is presented and their affect on the production optimization. Further we describe the tools i.e. lean tools which are set of operations which when Implemented on the problem area will be able to remove the non value adding process and thus increases the efficiency. For every problem which we encounter in the production system can have corresponding lean tools by which we can cure them and optimize the production.

Keywords: Lean, Lean Manufacturing wastes, Toyota Production System, Lean Tools,

1. INTRODUCTION

The core idea of lean manufacturing is actually quite simple…relentlessly work on eliminating waste from the manufacturing process. So what is waste? Waste is defined as any activity that does not add value from the customer's perspective. According to research conducted by the Lean Enterprise Research Centre (LERC), fully 60% of production activities in a typical manufacturing operation are waste – they add no value at all for the customer. The good news is that just about every company has a tremendous opportunity to improve, using lean manufacturing techniques and other manufacturing best practices. Techniques that enable you to deliver higher quality products at significantly lower costs.

Waste is defined as any activity that does not add value from the customer's perspective. The elimination of waste is the primary goal of any lean system. In effect, lean declares war on waste – any waste. Waste or muda is anything that does not have value or does not add value. Waste is something the customer will not pay for. The key is to spot waste and then stop waste.

MUDA, waste, can be defined in eight types, 7 defined by Toyota and 'non utilized skills'. These are: Defects, Overproduction, Waiting, Non-used Talent, Transport, Inventories, Motion and Excess processing. As Mnemonic device, the first letters of these wastes form the acronym DOWNTIME. There are numerous tools available to identify and remove waste from your process, which include Poke Yoke, Kanban, Takt Time, SMED and One-Piece flow.

1. DEFECTS are products or services that are moved to the next process step, but not confirm customer specs. In a production environment, a defect could be a product (part) that does not function properly, or a product that is incomplete when it arrives at the customer. A defect in an office environment could be a typo in an IT system, which prevents the process from continuing, or even sending a wrong attachment in an E-mail. Defects usually lead to rework and/or extra work, to make sure the customer receives the products or service he ordered.

2. OVERPRODUCTION means producing more than the customer needs at this point in time. This is a waste because resources are already invested in products or services, that will not be worked on after the current process step. One example in production is producing components that are needed further downstream of the workstation, but it is unknown when they are needed exactly. In the office environment, the input of electronic tickets for change requests for IT or engineering can be considered overproduction, when the resources the receiving department are restricted and it is uncertain whether or not they have the capacity to work on the request. The people who need the IT changes simply push the next number of requests into the system, hoping they will be implemented, spending time following procedures and filling out forms. Overproduction is sometimes referred to as ´the mother of all wastes´, because it leads to all other kinds of waste because the product or service moves through the entire process with both value adding as well as non-value adding activities.

3. WAITING is the third waste and includes parts, e-mails and SAP actions that are waiting to be completed on the shop floor, in somebody´s mailbox or in the ERP system. And what about all the

people that are waiting for one person at the start of a meeting? These are all non-value-adding times in the process, directly increasing the lead time and preventing flow. Waiting time can be interrelated to inventory. Whenever products are sitting in inventory, they are technically waiting to be processed. The same holds for E-mails waiting to be read or answered. This is why inventories on the value stream map are measured in waiting time.

4. NON-USED-TALENT includes employee knowledge and skills not being used to their full potential. For instance, a high skilled worker has to do work that is relatively easy, or is firefighting all the time instead of focusing on continuously improving on the long run. Another example is not inviting the expert of a workstation to the value stream mapping events and thereby failing to use his input to identifying the problems within that value stream. This could lead to an entire management team focusing on the wrong problems to solve, having to do it all over again at a later stage.

5. TRANSPORT includes all movements of product between workstations, paperwork between departments, or digital processes between multiple individuals. The product moves around without

actually being altered, which means it increases the lead time and even man hours when a physical product is being transported, without adding value to the customer.

6. INVENTORIES are the products or services that are waiting at a workstation, in an E-mail account or in the ERP system to be completed. There is a clear link with waiting here, since products are actually waiting to be worked on in an inventory. The more parts are waiting for the same operation, the longer one particular part has to wait its turn. Again, waiting times directly increase the lead time of a product or service and therefore make the organization slower in responding to customer demand. Next to that, physical inventory costs money: Material costs, depreciation costs, physical space costs, management costs, insurance costs, and the costs of possible redundancies or damage. Depending on the product, these costs together could sum up to an 18-35% on a yearly basis (Dominick & Lunney, 2012).

7. MOTION describes the movement of people and machines without actually working on the product or service. For instance looking for the right screwdriver to tighten a screw in production or searching for a document for 10 minutes on the local drive to send it in the attachment of an E-mail in an office environment. Next to the fact that it takes time to reach that part or click through multiple folders on your computer, motion has a clear link with overburden (muri) as well. Parts that are put high up a shelf or down near the floor lead to ergonomic challenges for the employee. Motion is one of the wastes that should not always be removed to zero. Taking out the most difficult motions of a person´s work cycle might be an improvement in terms of ergonomics, but taking out all movement might have a negative effect on health, which can lead to a lot of other problems with long absence as a possible result.

8. EXCESS PROCESSING, means doing extra things that the customer is not asking for. This could include building in product features- or adding more accessories that the customer does not really need, but also the rework that is necessary to repair defects. Adding packaging materials for internal transport (between different floors, departments or even sites) which are then removed again are also examples or excess processing. In the office environment, excess processing could mean adding more pages or text to a document than necessary or spending time in making an extra fancy layout for a presentation for your manager.

MURI, overburden, can result from Mura, and from removing too much Muda (waste) from the process. When operators or machines are utilized for more than 100% to finish their task, they are overburdened. This means breakdowns when it comes to machines and absenteeism when it comes to employees. To optimize the use of machines and make sure they function properly, preventative- and autonomous maintenance can be implemented. To prevent overworked employees, safety should be the focus of all process designs and all standard work initiatives.

MURA, unevenness, can be found in fluctuation in customer demand, process times per product or variation of cycle times for different operators. In production environments with low-volume, high product variation, flexibility is more important than in high-volume, low-product variation environments. When Mura is not reduced, one increases the possibility for Muri and therefore Muda. Mura can be reduced by creating openness in the supply chain, change product design and create standard work for all operators.

2. Toyota Production System

The Toyota Production System empowers team members to optimize quality by constantly improving processes and eliminating unnecessary waste in natural, human and corporate resources. TPS influences every aspect of Toyota's organization and includes a common set of values, knowledge and procedures. It entrusts employees with well-defined responsibilities in each production step and encourages every team member to strive for overall improvement.

It has been said that the two basic concepts in Lean thinking are to eliminate waste and create value (Murmanet. al., 2002). Emiliani (1998), based on Womack and Jones (1996) presents a more detailed framework with five basic steps:

- Specify Value: What do customers want? When and how do they want it? What combination of features, capabilities, availability and price will be preferred by them?

• Value Stream Analysis: A Value Stream is the collection of processes and activities required to bring a product to the customer, from beginning to end. The Value Stream is not limited by boundaries between companies; that is the reason to strive to integrate suppliers, manufacturers, distributors and even retailers in the efforts to recognize and analyze the Value Stream. Also, three main categories of activities are distinguished: a). those that add value; b). Those that do not add value but cannot be currently avoided and c). Those that do not add value and should therefore be eliminated.

• Continuous Flow: Companies should try to make value flow continuously, not in batches. In this paradigm, the term one piece flow has great appeal and is highly coveted. Also, traditional functional organizations do not help continuous flow, therefore a focused teams approach (closer to the product) is recommended.

• Customer Pull: A principle made popular by the JIT concepts; it states that companies should not push their products to customers, and rather let them pull "value" (products or services) and link all the production chain (even with suppliers) in such a way that materials are not released and activities are not done until they are needed. The discipline of pull is established and enforced by using kanbans, which are physical or electronic mechanisms to transmit the need for parts and subassemblies from one point in the process to the preceding one.

• Continuous Improvement: As the commercial slogan for the Toyota luxury brand (Lexus) puts it, it is "The passionate pursuit of perfection". It is the conviction that improvement efforts are never finished, and it is the consistency to keep the discipline for improvement in place (kaizen).

Essential Lean Tools

Lean Tools	Definition	How does it help ?
5S	Organize the work area: Sort (eliminate that which is not needed) Set In Order (organize remaining items) Shine (clean and inspect work area) Standardize (write standards for above) Sustain (regularly apply the standards)	Eliminates waste that results from a poorly organized work area (e.g. wasting time looking for a tool).
Jidoka (Autonomation)	Design equipment to partially automate the manufacturing process (partial automation is typically much less expensive than full automation) and to automatically stop when defects are detected.	After Jidoka, workers frequently monitor multiple stations (reducing labor and many quality issues can be detected immediately (improving quality).
Just-In-Time (JIT)	Pull parts through production based on customer demand instead of pushing parts through production based on projected demand. Relies on many lean tools, such as Continuous Flow, Heijunka, Kanban, Standardized Work and Takt Time.	Highly effective in reducing inventory levels. Improves cash flow and reduces requirements.
Kanban (Pull System)	A method of regulating the flow of goods both within the factory and with outside suppliers and customers. Based on automatic replenishment through signal cards that indicate when more goods are needed.	Eliminates waste from inventory and overproduction. eliminate the need for physical inventories (instead relying signal cards to indicate when more goods need to be ordered).
Kaizen (Continuous Improvement)	A strategy where employees work together proactively to achieve regular, incremental improvements in the manufacturing process.	Combines the collective talents of a company to create an engine for continually eliminating waste manufacturing processes.

Standardized Work	Documented procedures for manufacturing that capture best practices (including the time to complete each task). Must be "living" documentation that is easy to change.	Eliminates waste by consistently applying best practices. Forms a baseline for future improvement activities.
Single-Minute Exchange of Dies (SMED)	Reduce setup (changeover) time to less than 10 minutes. Techniques include: Convert setup steps to be external Simplify internal setup Eliminate non-essential operations	Enables manufacturing in smaller lots, reduces inventory, and improves customer responsiveness.
Takt Time	**It** is the maximum amount of **time** in which a product needs to be produced in order to satisfy customer demand.	Provides a simple, consistent and intuitive method of pacing production. Is easily extended to provide an efficiency goal for the plant floor (Actual Pieces / Target Pieces).
Poka-Yoke (Error Proofing)	A **poka-yoke** is any mechanism in a lean manufacturing process that helps an equipment operator avoid (yokeru) mistakes (**poka**).	Its purpose is to eliminate product defects by preventing, correcting, or drawing attention to human errors as they occur.
Value Stream Mapping	A tool used to visually map the flow of production. Shows the current and future state of processes in a way that highlights opportunities for improvement.	Exposes waste in the current processes and provides a roadmap for improvement through the future state.

METHODOLOGY

• Identify the problem ; because of which the defects are produce in the system

• Taking the observation on the problem; for checking its severity and in what way it causes in the system.

• Finding the root cause of the problem ;there may be multiple causes for the single defect

• Finding the solution on the problem ; using cause effect table , cause effect diagram , and some logical analytical skills

• Implement the Tool ; which is found from the above step and take the observation on the same for its proper implementation and result after implementation

• Continuous monitor and sign off; have continuously monitored on that part of the system so that the same problem would not cause because of the same problem and the sign from that task, switch to other tasks.

LITERATURE REVIEW

Muda

Wastes	Causes	Remedies
DEFECTS A defect could be a product (part) that does not function properly, or a product that is incomplete when it arrives at the customer.	unclear customer specifications incapable processes lack of process control unskilled worker incapable suppliers	At least two tools can be used to prevent defects from happening: **Poke Yoke** and **Standard Work**.
OVERPRODUCTION It means producing more than the customer needs at this point in time. This is awaste because resources are already invested in products or services, that will not be worked on after the current process step.	volume incentives (sales, pay, purchasing) high capacity equipment line imbalance poor production planning	This type of waste can be reduced using tools like **SMED** and **Kanban**. **SMED** is an abbreviation of *Single Minute Exchange of Die*, which basically means 'Quick Changeover´.
WAITING It is Man Idle and Machine Idle that directly increasing the lead time and preventing flow.	unsynchronized processes inflexible work force over-staffing unscheduled machine downtime long set-up material and manpower shortage or delay	Tools that help find waiting time in a process are **time studies**, **takt time** and **line balancing.**
NON-USED-TALENT It includes employee knowledge and skills not being used to their full potential.	Lack of managerial skill Relying on inspections	The tool to reduce this non-used-talent is **training**.
TRANSPORT It includes all movements of product between workstations, paperwork between departments, or digital processes between multiple individuals.	poor route planning distant suppliers complex material flows poor layout disorganized workplace line imbalance	To minimize transport of tools by people, **5S** can be implemented.
INVENTORIES It are the products or services that are waiting at a workstation	over-production big batch sizes local optimization large minimum order quantities JIT-incapable suppliers.	Tools that can help reduce the amount of inventory in production are the already described **work cells** and **Kanban**. A third tool to reduce inventory is creating **One-Piece-Flow.**
MOTION It describes the movement of people and machines without actually working on the product or service.	• poor lay-out and housekeeping • disorganized work place and storage locations • unclear, non-standardized work instructions • unclear process and materials flow	Tools which help you reduce the waste moving include the tools **Standard Work**, **5S** and **Spaghetti Diagrams.**

EXCESS PROCESSING It means doing extra things that the customer is not asking for.	• adding more accessories that the customer does not really need	The tool that can be used to systematically find non-value-adding activities is a **process map.**

MURA

MURA, unevenness, can be found in fluctuation in customer demand, process times per product or variation of cycle times for different operators. In production environments with low-volume, high product variation, flexibility is more important than in high-volume, low-product variation environments. When Mura is not reduced, one increases the possibility for Muri and therefore Muda. Mura can be reduced by creating openness in the supply chain, change product design and create standard work for all operators.

Main causes of Mura

- Uneven customer demand
- Inventory swings – from too much to too little
- Uneven production speed or changing production quantities
- Uneven quality of good parts
- Irregular or erratic working rhythm
- Uneven training of the workers
- Uneven distribution of the workload

Remedies

1. Modular product design. Allow the product to be produced uniformly and put together multiple ways i.e like ikea furniture.
2. Production leveling in production planning. Use Heijunka and other lean methods.
3. Building flow at the production level.
4. Standardized work.
5. Reduce the number of links in a supply chain. External warehousing or moving parts of a plant is not a good idea in this sense.
6. Reduce delivery times between links. Off shoring across the world? The possible six weeks of transport times are terrible for inventories and lead times in the chain.
7. Create transparency between links in the supply chain when it comes to orders. This will reduce the tendency to increase the order size at every link

MURI

Muri, or overburden, means that operators or machines are pushed through their natural limits, which leads to problems. The quality of the output suffers because of the state of the machine or person performing the output is in, which means muri leads to muda (Hines, Found, & Griffiths, 2011). **Eg.** Overheating the battery of an old car which leads to breakdowns (=defects), or using heavy software on your personal computer that does not have the memory power to do calculations quickly, which leads to waiting time.

Main causes of Muri

- Human causes
  - Working long hours
  - Heavy mental and physical lifting
  - Unsuitable posture or ergonomics
  - Noise
  - Tasks too difficult
  - Tasks too easy
  - Excessive stress
  - Anything that leads to burnout or repetitive strain injury
  - Insufficient Training
  - Humiliation
  - Excessive praise
  - Difficult, Dangerous, or Dirty tasks (the 3K in Japanese)
- Organizations
  - Requesting supplier demand without forewarning and planning
  - Using market power to economically manipulate suppliers or customers
- Machines and Materials
  - Pushing machines and tools leading to increased wear and tear
  - Skipping maintenance

o Mistreatment of materials; e. g., storing parts in inappropriate conditions o Loading a vehicle or container beyond its weight limits

Remedies

- For Machine environment
    - Preventive Maintenance
    - Autonomous Maintenance
- For Human environment
    - 5S
    - Jidoka
    - Standardize work

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CONCLUSIONS

During the manufacturing there are waste generated not only in the form of scrap but also waste in the form of under skill, management, accounting, operations etc. so the first aim of lean manufacturing is to remove the unwanted process which do not add any value to the production or the product. Further we describe the tools i.e. lean tools which are set of operations which when Implemented on the problem area will be able to remove the non value adding process and thus increases the efficiency. For every problem which we encounter in the production system can have corresponding lean tools by which we can cure them and optimize the production.

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