Productivity Improvement by Implementing Lean Production Approach

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Abstract – This paper aims to provide a better understanding of lean production approach in order to enhance productivity, reduce cost and maximize customer value while minimizing waste during the production processes. Lean tools enabling a company to differentiate value from waste and facilitate to maximize customer value while minimize waste. Although there are many key factors for this methodology but here author would be focusing on the Value Stream Mapping (VSM), Pull system (Kanban) and Dedicated Flow that are contribute to change the process by eliminating different kind of wastes (such as inventory) which slow down the process. Further lean method signifies balanced production plan and producing goods on time and in the right quantity and quality. A case from metal manufacturing company is taken into account that focus on lowering down the inventory (waste) levels with the help of lean tools.

I. INTRODUCTION

In today’s advance world the companies are striving to get better and better, the competitiveness in the world market has always existed and is a key element for improvements, because it forces people and companies to drive themselves in order to bring up new tools or methods and take stance in front of innovative gadget, lean approach is the way to achieve improvement either in manufacturing and service sector.

Problem – Nowadays, the problem facing by medium sized manufacturing companies is how to increase productivity and reducing cost in order to stay competitive in the market and satisfies customer. Specially, in Baltic region medium size manufacturers have a fear to losing competitiveness against other low cost manufacturing countries. Hence, they must be more effective to survive and in order to do this they are seeking for process improvement methods.

Purpose – The solution for above stated problem is to adopt lean production and the aim of this paper is to create awareness about lean production with the help of a simple model of manufacturing system alongwith recognition of deadly seven wastes of lean and some lean tools such as Value Stream Mapping (VSM), Kanban and Dedicated Flow to reduce wastes within the process and increase productivity.

Methodology/Approach – A thorough search of literature and a case study regarding lean implementation to enhance productivity by means of reducing inventory levels are used to find the solution of the stated problem.

Findings – Lean Production has been one of the most well-known methodologies to eliminate waste in the manufacturing and service industry. The emphasis of lean is to eliminating non-value-added activities and the goal has been a goal of industrial engineering i.e., to improve the efficiency of all processes. Many firms have been practicing lean production to improving productivity and as a process improvement approach, small-medium enterprise (SME) manufacturers also looking forward to get under the umbrella of lean production and in Baltic such companies willing to learn Lean and it can be achieved through Lean Lego Games, hence, there is also a need to build such kind of Lean Labs where companies can practice Lean.

II. REVIEW OF LITERATURE

In this section the contribution of lean concept and its background with principle will be discussed. Also effectiveness of lean will be the part of this section along with brief explanation of productivity as a competitive tool.

A. Brief History of Lean

In the beginning of 20th century, Henry Ford developed a new way of manufacturing, mass production, which has been a major evolution and first applied to the automotive industry, and then his philosophy has been applied in every kind of production plants. A second major evolution, which is nowadays considered as the best of way manufacturing has been developed by Toyota, during the second half of the 20th century is Lean manufacturing [1], describes this way of thinking and manufacturing in different books, which goes in the opposite way of mass production, where quality is preferred to quantity.

The approach of lean was first initiated by Toyota, Lean production is orginated from Janpanes manufacturing method known as TPS - Toyota production system [2]. The history of manufacturing and the introduction of Lean are summarized in figure 1.

The term “lean process” in the literature has many definitions. As lean is generally derived from TPS and the basic idea in TPS is to produce the kind of units needed, at the time needed and in the quantities such that unnecessary intermediate (work in process) and finished product inventories can be eliminated. Three sub-goals to achieve the primary goal of cost reduction (waste elimination) are quality control, quality assurance, and respect for humanity. These can be achieved through four main concepts: JIT, autonation (automation with human touch), flexible workforce, and capitalizing on worker suggestion and eight additional systems. The basis of TPS is the absolute elimination of waste; two pillars needed to support the TPS are JIT and automation (Jidoka). TPS can be described as an effort to make goods as much as possible in a continuous flow [3].
Lean production uses half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a new product in half the time. It requires keeping half the needed inventory, results in many fewer defects, and produces a greater and ever growing variety of products [2].

"Shah and Ward [5]" defined lean process as “an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer, and internal variability”.

"Calborg et al., [6]” suggests in their study of “A lean approach for service productivity improvements” that standardizing services and increasing reliability in service processes through lean principles can increase efficiency. Further, Lean principles can be beneficial in order to improve productivity in services with an appropriate approach in which customer satisfaction must be considered, otherwise the positive long term effects of a lean approach in services will be absent.

B. Productivity as a Competitive Tool

"Productivity is a relationship (usually a ratio or an index) between output (goods and/or services) produced by a given organizational system and quantities of input (resources) utilized by the system to produce that output” [7]. The input are usually classified as labor, capital, material (inventory) and energy. In this paper inventory as an input will be under consideration, during the case study the inventory reduction with the help of lean tools leads to improvement in productivity of a case company.

Productivity enhancement is a common factor in fulfilling producer demands and customer demands as well. In this area the potential for improvement is always high to certain extent. Some researchers and company managers in western manufacturing industries argue that there is a potential to increase productivity by 50 per cent in many western companies. The more obvious fact is that when productivity is too low, operations are transferred to low-cost countries. Nowadays, this threat is also a reality in operations outside manufacturing. The most probable reasons for moving operations to low-cost are usually due to lower wages that will lead to increased profitability and/or enhanced competitiveness. Even some customers asking their supplier to move their operations to low-cost countries in order to expected reduction in prices. Unfortunately, this kind of discussion disregards the fact that the probable gains in profit due to lower wage level are often eliminated by costs related to longer lead times, increased tied-up capital, poor control, increased transportation costs, etc. These are drawbacks that can be difficult to quantify in advance, but fair estimations need to reflect an entire view. There are certain factors that should be considered before operations are moved to low-cost countries.

However, the important concern about the potential for improvement in existing operation is lost. From a universal perspective the most productive operation is generally also the most competitive and profitable one in the long term. This means that if only some of the potentials increases in productivity are achieved, mostly decision never be made to operations to low-cost countries. Lean is an approach to operations that specifically aims at increasing productivity in order to attract customers as well as investors. Nevertheless, it is not a short term approach to cure the wound; it is a long term approach that eventually focuses on efficient resources utilization by eliminating waste, increasing workforce commitment and keeps an eye on customer expectations [8].

C. Effectiveness of Lean Effort

There is a real connection between lean and the competitiveness of the company’s parameters and such parameters that certainly affected by a successful lean effort are:

- Quality
- Cost
- Flexibility
- Delivery reliability
- Delivery time

Other factors that makes lean more effective and related to strengthening the workforce’s welfare, driving force, motivation and influence. Examples of such lean effects are:

- Reduced stress
- Increased competence
- Improved cooperation
- Reduced Frustration
- Improved customer communication
- Broader and more developing tasks
- Improved safety at the workplace
- Job Security

These positive effects can play a vital role in the long run to accomplish Lean; there is something in it for everyone [8].

D. Lean Principles

Lean is focus on steady striving to eliminate waste. It is achieved through continuous exercise to visualize and resolve the deviations in an operation. A deviation is something that deviates from what is normal and can be perceived as defined and specific waste. Perhaps every organization agrees that waste should be eliminated, but the question is how. Here Lean principles have an important task in providing guidance. In order to be successful in Lean effort it is necessary for an
organization that its values are aligned with the Lean principles.

Lean methodology has five principles according to “Womack and Jones [9]” and they are defined as:

i. Identify value from customer point of view
ii. Value stream mapping (process map)
iii. Create flow – redesigning processes to minimize waste and optimize customer service
iv. Establish Pull – produce when it is needed to fulfill customer demand
v. Pursue perfection – Zero Defects

III. METHODOLOGY

After reviewing the literature it is somehow obvious that a proper lean implementation is a basic need in current manufacturing industries and in this research focusing on more to the identification of indicators, practices or tools or techniques for the implementation of lean in manufacturing for productivity improvement. In this paper a simple model of input, process and output of manufacturing system is developed with the identification of wastes known as seven deadly wastes of lean in order to create awareness of lean in manufacturing system.

Further, the manufacturing system is an Input-output model generally. The system receives the input elements and then later undergoes a few processes in the transformation stage. Finally, the desired product is produced in the output stage. Quality and cost of the final output rely heavily on the factors that affect or control the system during the transformation process. The purpose is to get the right product at the right time and with right quality in order to gain profitability and stay competitive by continuing the sales growth [10]. The figure 2 is presented a system model shows the relations between lean dimensions and wastes. ‘Muda’ is a Japanese word for waste and “Ohno [11]” has identified seven kinds of waste that are: overproduction, waiting, transportation, unnecessary motion, poor processing, defects and inventory. Productivity can be improved by eliminating these wastes from the system by implementing lean tools effectively.

To achieve excellent efficiency in a process it is needed that it is designed in such a way that waste may easily be detected. This means that there are opportunities to eliminate, or at least reduce, waste. Waste includes activities which do not add value to customers and organizations. For them, waste is a cost that they are not willing to pay. It is important to increase the awareness of employees on the concept of waste, as well as on the ways to identify and reduce waste.

There are some critical success factors recommended by Anvari et al. [12], for effective implementation of lean approach, i.e., management and leadership, organization cultures, goals and objective, problem solving, skills, continuous improvement, financial capabilities, performance measure, change, education and plan. They proposed three implementation stages (preparation, design and implementation) but failed to establish a systematic methodology by which firms could identify wastes; evaluate existing performance; remove those wastes; recalculate the performance and use sustainable lean tool for continuous improvements.

<table>
<thead>
<tr>
<th>Input</th>
<th>Process (Transformation)</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier Relationship</td>
<td>Manufacturing Processes</td>
<td>Scrap</td>
</tr>
<tr>
<td>Inventory</td>
<td>Over Production</td>
<td>Defects</td>
</tr>
<tr>
<td>Waiting</td>
<td>Unnecessary Motion</td>
<td>Transportation</td>
</tr>
<tr>
<td>Personnel Force</td>
<td>Visual Information</td>
<td>Waiting</td>
</tr>
<tr>
<td>Unnecessary Motion</td>
<td>Product Development</td>
<td>Poor Processing</td>
</tr>
<tr>
<td>Waiting</td>
<td>Defects</td>
<td>Feedback</td>
</tr>
</tbody>
</table>

IV. DISCUSSION

VSM, Kanban and Dedicated flow are the three tools of lean production that are under consideration in this research and can be used to clean the system especially all kind of inventory waste and focus on productivity enhancement. This section discusses the above stated tools that how these lean tools play their role in effectiveness and influence on the improvement of a company.

A. Value Stream Mapping (VSM)

It is a map of process flow for better visualization, VSM is a mapping tool that is used to map a productive process or an entire supply-chain of a product. It maps not only material flows but also the information flows that signal and control production. Moreover, a value stream is a collection of all actions (value added as well as non-value-added) that are required to bring a product through the main flows, starting with raw material and ending with finish product to reached customer. The ultimate goal of VSM is to identify all types of waste in the value stream and to take steps to try and eliminate these wastes [13].

B. Kanban (Pull)

Kanban provides the same idea as pull system which means a ‘signal’, ‘signboard’ or ‘ticket’ that is used to activate demand of a product or service. It specifies when and where more material is needed for sake of better flow internally and externally both. These cards are used to control production flow and inventory. This system facilitates high production volume and high capacity utilization with reduced production time and work-in-process inventory [14].

C. Dedicated Flow

Dedicated flow is based on product families, the similar function products are divided into the same product category and this family of product proceeds according to their respective process machines or equipment that results in optimal routing of a product family. Furthermore, it facilitates to follow the First-In-First-Out (FIFO) mechanism in a proper way that leads to overcome unnecessary motion of products and on the other hand reduce waiting time.
V. CASE STUDY

A metal manufacturing company is selected for the case study and to implement the three tools for process improvement as discussed in above section. This company is producing copper strips by casting process followed by slitting and rolling mill processes, more precisely the company produces copper strips for automotive and electrical applications. But due to some downsizing in automobile manufacturing business along with higher competition in the market, have direct concerns to the company production facility and this economic recession leads to higher metal price, consequently company face new challenges. Moreover, demand of good quality products from customers also on upper levels and results metal manufacturer to look into new solutions.

By that time Company had some internal challenges such as lengthy transportation, low quality, a lot of scrap and excessive stock as well as high work-in-progress, and long manufacturing and delivery lead times. That makes the management to initiate the lean production improvement operation with the focus to increase the productivity by minimizing wastes (inventory levels) within the production facility, to concentrate on quality and reduce costs. The main problems in the production flow are:

- High Work-In-Process (WIP) Inventory
- Unpredictable process and time
- Long changeover time

The current (as-is) state of stream mapped from fetching of raw material to dispatch of finish goods. The current state was a mess and creates chaos due to bad handling of information and lack of communication with some wrong practices. As there was imbalance between casting and rolling processes with respect to production speed, a great amount of WIP inventory was present that creating queues and occupying extra space on the production floor. The work load on rolling and slitting machines was uneven that also creates buffer in terms of inventory (finish goods- FG) as shown in fig.3. It was because of variation in product mix and which was not handled properly, moreover, no grouping of product and dedicated flow of product with respect to machines (RM – raw material inventory).

The current inventory levels of all kinds of inventory are shown in the table 1. Lean tools implementation and their results along with future inventory levels will be discussed in the following section.

A. VSM Deployment

Figure 4 represents the future process map as an improved values stream map where the information flow is clearly identified and described along with material/product flow. The awareness of employees about this suggested improved process map also created. The VSM helps to develop a new alloy combination also to avoid certain quality issues and to cope up with scrap problem especially in foundry process. Supplier evaluation is also recommended with keep an eye on the effect of new combination (product mix) on customer demand through sales department.

Moreover, a new grouping of products is implied, products with similar characteristics would move in a particular path as a flow group to filter the complexity of the previous flow in rolling and slitting areas. Flow group of products also leads to avoid waiting time and extra transportation along with equal distribution of workload, while the concept of freezing window for product groups is taken into the account to minimize re-planning issues. In addition, a dedicated flow is implemented in rolling and slitting areas that means rolling and slitting machines are designated for particular product for better clarify flow and optimal planning of these production machines. In order to avoid and mitigate the problems (delaying in finish goods deliveries) that occurred due to unpredictable process, extra delivery day is taken into consideration to fulfill the commitment of customer and to abstain rescheduling deliveries.

The current levels of inventory (before lean)

<table>
<thead>
<tr>
<th>Inventory type</th>
<th>Quantity (ton)</th>
<th>Time (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Material</td>
<td>349</td>
<td>4.8</td>
</tr>
<tr>
<td>WIP</td>
<td>1026</td>
<td>14.3</td>
</tr>
<tr>
<td>Finish Goods</td>
<td>470</td>
<td>6.6</td>
</tr>
<tr>
<td>Total</td>
<td>1845</td>
<td>25.8</td>
</tr>
</tbody>
</table>

Steps that were followed during the analysis and improvement process are: first to create overall current production flow (mapping) through VSM, next step was to clean the process by implementing lean tools – Kanban and dedicated flow to reduce inventory levels and lead times. Third was to standardize the improved process by creating standard operating procedures with better developed process map (VSM).
B. Kanban Deployment

The Kanban replenishment system is successfully implemented that reduced the WIP remarkably and enhance the process performance. A kanban sticker/card is introduced that contains a product information – when, where and how much is needed to produce for the subsequent process as the signal from upstream has triggered. This means information flow and the material flow run parallel, this kanban (pull system) effectively control the buffer between casting mill and rolling mill processes.

The kanban method start from production machine in rolling area that generate a signal by means of card (contains information what they required), this card goes to the planner who plans casting production accordingly, casting produced that specific product (replenishment) and in the end demanding machine get the desired product (withdrawal). The process is shown in the figure 5. Although, there were some challenges to keep this system work properly and understand by everyone in the production area. This kanban approach is postponed twice during the transformation to lean implementation due to some issues in foundry management. But in the end this system start working and the WIP level has reduced from 1026 tons to 800 tons.

C. Dedicated Flow Deployment

In order to keep the flow continuous that leads to reduction in buffer time, a dedicated flow has been implemented – in this a group of similar products would be process through their designated machines. This result in clear and smooth flow along with waiting time (buffer) gets smaller and hence, transportation has also optimized with better utilization of machines.

The products are divided into different families according to the processes that would be performed on them. Product family A belongs to those products that have annealing point greater than 100 my and thick in dimension, likewise the products passes through annealing between 70 to less than 100 my with single pre-rolling correspond to family B and family C products are those that have annealing point less than 70 with double pre-rolling. The process can be seen in the figure 6. Furthermore, the challenges have been faced during this implementation is the mix of product (A, B, C) with no agreement with sales to fit customer demand to capacity. Lack of continuity on implementing these changes, but the long term results are quite significant like in reduction in buffer time that bounds the people (management) to follow this approach.

VI. RESULTS

The future inventory levels of all kinds of inventory after lean implementation is shown in table 2. The total inventory level is reduced to 1600 tons from 1845 tons that leads to productivity improvement of the case company. Aslo the number of days for inventory are reduced to 22 days as compare to 26 days at the start that consequently speed up the production process.

Moreover, the graph in figure 7 shows a comparison between before and after state of the production process in terms of all kind of inventory levels along with percentage change. The improvement achieved in overall inventory level is 13.3% after the implementation of lean approach. To sum-up this case study it has been obeserved that the lean approach is not a short term approach it’s a long term philosophy that required continuous practice to get bigger achievements. Although, we have seen improvements in the metal manufacturing company’s production process by means of reduction in inventory levels and smooth flow after lean implementation in a short period of time but it can be enhanced by doing more and more efforts in order to strive for perfection and lean area to see huge improvements.

<table>
<thead>
<tr>
<th>TABLE II: FUTURE INVENTORY LEVEL (AFTER LEAN)</th>
</tr>
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<tbody>
<tr>
<td>Inventory type</td>
</tr>
<tr>
<td>-------------------------</td>
</tr>
<tr>
<td>Raw Material</td>
</tr>
<tr>
<td>Work-In-Process (WIP)</td>
</tr>
<tr>
<td>Finish Goods (FG)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>
**VII. CONCLUSION AND FUTURE RESEARCH**

Lean tools and activities support stability. The tools – VSM, Kanban, Dedicated Flow improves safety and productivity. The impact of lean tools and techniques is quite noticeable as the case company had a big problem of high work-in-process inventory and it was consider to a fat that has been reduced by lean approach and lean implementation have shown improvement by reducing WIP inventory from 1026 tons to 800 tons while overall inventory level has fallen down from 1845 tons to 1600 tons. The aim of this paper was to find out how Lean production can be able to improve productivity in a manufacturing company. In today’s world where globalization is now everywhere, it is important for companies to continuously strive for improvements in order to stay competitive. The consequence of this study is that Lean is a very global and vast system, and it’s not easy to implement just a small portion, it is moreover, all or nothing.

The necessity to implement this dominant improvement tool will be increased for all types of organizations in the future in order to protect their business processes. Since lean is also renowned for not easy to implement in a short period of time. The company has to pick the right lean tools and techniques which are applicable and confers certain improvement by means of their desired goals; on the other hand companies should be prepared to make some sacrifices if they want a good impact on their business by following lean approach. From case studies it is depicted that the people want change in terms of improvement but they are not ready to spend appropriate resources to achieve it, lean does not support such way of working as it requires daily and continuous efforts. People must be ready to change the whole organization, not only production lines. Sales, Logistics, Marketing, Product development departments will be affected by this change and if one of them does not follow, Lean will not sustain.

One of the future researches could be the effectiveness and barrier of lean approach in SMEs; on the other hand research on lean effectiveness in service sector for service productivity improvement can also be a future research. Another perspective is to conducting comparative study about lean approach in manufacturing and service sectors so that to developed better understanding of lean in all business areas.

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**REFERENCES**


