Production Improvement in SME's Enterprises Through Lean: A Case Study

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Abstract

The role of micro and small enterprises is very important for the economic development of the regions. This research work is an initial path towards a significant improvement in productivity, efficiency, lead time and waste in Peruvian enterprises that must to improvement production and efficiency, increase productivity and eliminating wastes to reduce total production cost. This paper presents a case study of a micro enterprise dedicated to the manufacture and assembly of wooden desks that are distributed to the regional and national market. Process times were taken to determine baseline indicators using the O-T diagram. The 5S methodology was implemented to reduce search times for materials and tools and movements of operators. Activities were grouped that allowed reducing downtime and increasing production. In this sense, production flow was optimized thus reducing non value added activities. The results showed that reducing waste time, would enable the enterprise to improve production.

Keywords
Lean, production, takt time, lead time, waste.

1. Introduction

SME's enterprises have gradually found in the different lean manufacturing methods opportunities to improve their productive and economic indicators, which allows them to maintain a presence in the current market characterized by

their dynamism and interactivity (Antony et. Al., 2018). The global market is forcing SMEs to achieve and maintain competitive advantages such as: production, productivity, service level, value flow, inventory minimization, etc., in order to remain in the economic system.
In Peru, the micro, small and medium (SME's) enterprises are the backbone of the economy and employing about 10 million persons (Core MYPE, 2018). Organization for Economic Cooperation and Development (OECD) reveals that 96.28% of the total are micro enterprises, 3.22% are small, while 0.10% are medium sized enterprises.
The SME´s have a yearly growth of 10% and it´s considered a prevailing tool to create employment. At the same time, external and internal markets are demanding products and services a low cost and high quality. SME's are facing a lot of resource constraints: cheaper prize of competitors, energy cost, delivery time to the market and the new rules about pollution (Valeria; Víctor, 2018).
In this sense, the Peruvian enterprises must to improvement production and efficiency, increase productivity and eliminating wastes to reduce total production cost. According to the Peruvian Institute of Economy - IPE, Lambayeque (at the north of Peru) is one of the regions with the highest economic growth and the sixth most competitive in the country, and according to the different economic activities the manufacturing sector contributed on average 10.70% at the regional economy, a percentage that is decreasing in the last five years (Macera, 2018). And the sugar mills offer an opportunity to improve local economy (Ulloa et al., 2020). The facts are based on the low values of competitiveness in which small and micro enterprises are incurring, a situation that requires the direct intervention of governmental and academic institutions to contribute in actions to develop strategies to eliminate waste (Phanindra; Shikanth. 2019).
Local enterprises need methods to cut down the cost and move towards a new operational culture based on lean methods. Hence the possibility of application of lean techniques in SME's enterprises is to be studied and identified (Matt; Rauch, 2013)
This paper presents a case study of a micro company dedicated to the manufacture and assembly of wooden desks that were distributed to the regional and national market. However, the increase in demand and tight delivery times has generated several problems in the delivery of orders, return of products and negative economic impact due to the payment of penalties for non-compliance. The aim of this study is to measure, analyze, and developing procedure to increase productivity by making reductions on waste time and adjustment on capacity flow.

2. Methodology

The first thing is to make a diagnosis of the production process, identify the waste, implementing 5S and improve the processes to reduce wastes. The absolute elimination of waste lies at the heart of the Toyota production system. Waste in a process (easier to understand with the labor productivity is you can think about wasting time), anything that is not contributing to the output is considered a waste. And it also results in inefficiencies. Waste reduces productivity. But what is more important for those involved in the operations and driving lean production is that the reduction of waste means understanding the operations.

2.1 Characteristics of selected enterprise

The company's selection criteria were: a micro enterprise in the manufacturing sector, having an interest and intention to implement lean tools, interested in a culture of continuous improvement, economic capacity and allow participation in decision making. The specific area where implementing lean methods is production.
Several local companies that meet the above criteria are evaluated. There is a positive response from two companies but one of them was unwilling to bear the costs of improved implementation.

2.2 5S principles

The 5S is the first step towards a lean culture to modify and clean the shop floor but at the same time is a potent tool to removal of wait time and no value added activity (NVAA) (Barcía; Hidalgo, 2006).

Table 1. The five steps of 5S (Agrahari; Dangle; and Chandratre, 2015)

Steps	Definition
Sort (Seiri)	Sort is the process of removing all the items not needed for current production from the workspace. An effective tool that will help you with your sort process: red tags (identify objects that need to be removed from the workplace)
Set in order (Seiton)	Set in Order is the process of putting everything in a place that is easy to get to. All items should be clearly marked so anyone can easily find its proper home
Shine (Seiso)	Shine means removing all the dirt and grime and keeping the workplace clean on daily basis. You want to get it clean and keep it clean
Standardize (Seiketsu)	Standardize creates a system of tasks and procedures that will ensure the principles of 5S are performed on a daily basis.
Sustain (Shitsuke)	Sustain gives your staff the commitment and motivation to follow each step, day in and day out.

2.3 Operation – time diagram (O-T)

The operation-time diagram allows to establish and identify indicators related to production lead time, wait times, efficiency and productivity (Cuatrecasas et. al, 2013):

- Lead time. Production lead time (or manufacturing lead time) is the amount of time it takes from the moment a customer places an order to the moment the product is out for a delivery (Lonnie, 2010):

$$\mathrm{LT} = \sum \mathrm{C} * \mathrm{N}$$

C: process cycle (m/units)
N: number of units

- Efficiency. Production speed of the process relative to the total time of the process:

$$\mathrm{Ef} = \frac{\mathrm{Tp}}{\mathrm{Tp} + \mathrm{Tw}}$$

Tp: Processing time
Tw: Waiting time

- Production. The production is the available time (or base time) relative to the process cycle time:

$$\mathrm{Pr} = \frac{\mathrm{Ta}}{\mathrm{C}}$$

Ta: Available time
C: Cycle time

2.4 Takt time

Takt time is the rate at which you need to complete a product in order to meet customer demand. The use of takt time can help to reduce wasted time and resources to improve workflow based off of customer demand (Deshkar, et. al, 2017):

$$\text{Takt time} = \frac{\text{Production time available}}{\text{Required unit of production (customer order)}}$$

2.5 Capacity analysis

The capacity analysis allows to calculate resource capacity in a process of one type of flow unit and then identify the process bottleneck and calculate the overall process capacity. This mean to determine the flow time and the flow rate of the process, and calculate process utilization and utilization of the resources in the process (Cuatrecasas, 2017).

2.6 Waste time to avoid

Lean manufacturing aims to eliminating waste from the manufacturing process. The waste in a manufacturing process can take many forms (Cuatrecasas, 2009):

- Wait-time: time when work-in-process (WIP) is waiting for the next step in production
- Over-Production: producing more than is needed and generate excess inventories
- Transportation: moving material around without adding value.
- Over-Processing: doing additional work.
- Inventory: more work in progress (WIP) and products in storage
- Motion: movement of people that does not add value
- Defects: production that needed to be repair or rework in order to satisfy customers

3. Case study

There are three employees working in the production area. Each one produces a desktop using the cutting, bordering, and assembly processes. The effective working day is 7 hours/day and a desk need about 50 pieces. The three main stages of the process were analyzed and the timing times for each stage were recorded: cutting 85´, bordering 65´, and assemble 110¨, a total time of 260 minutes.
Figure 1 shows that worker 1 builds a full desk, while worker 2 has an initial downtime of 85 minutes that doesn't add value to the process. At the same time, worker 3 has an initial idle time of 170 minutes. Considered in total, that 3 complete units were produced but it should be mentioned that worker 3 needed 10 more minutes to finish the product. At this time, worker 1 has a partially advance to the assembly process.
During the daily process, there is a total wait time of 520 minutes where the bordering stage being the one that takes around 190 minutes and the assembly stage constitutes the bottleneck.
The O-T diagram in figure 1 shows waiting times that are inherent in the enterprise's production model and allows to determine productive indicators (Table 2):

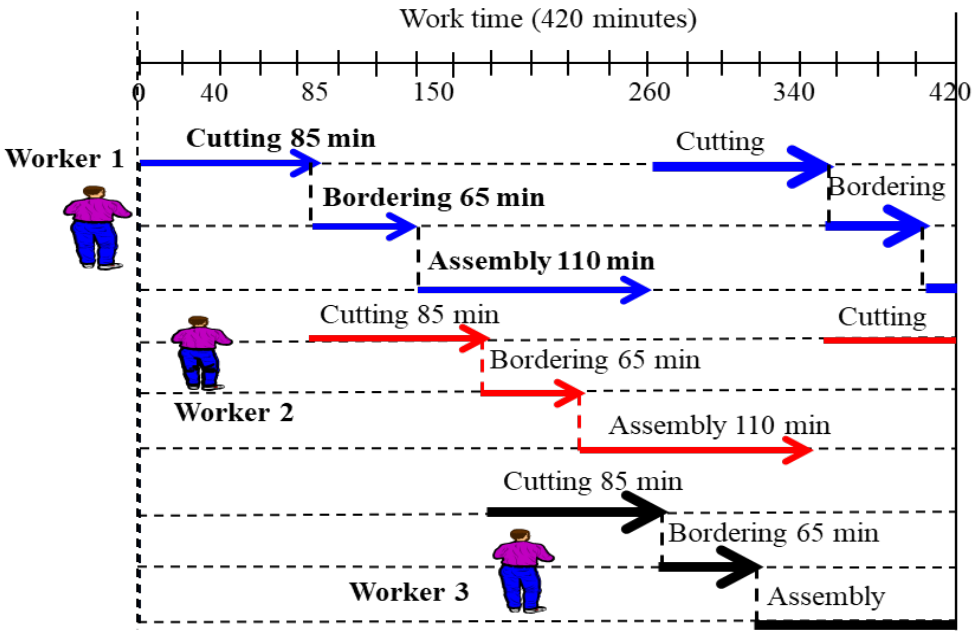

Figure 1. Productive process (three workers). O – T Diagram

Table 2. Efficiency and waiting time

Item	Cutting	Bordering	Assembly
Waiting time (m)	175	195	150
Processing time (m)	85	65	110
Efficiency (%)	23.69	25.00	42.30

The current production of three units per day is not enough to meet the average monthly demand of 180 units. According to the required demand, the estimated daily production must be 7.5 units/day:

$$\text{Production} = \frac{180 \text{ units/month}}{24 \text{ day/month}} = 7.5 \text{ units/day}$$

This means a takt time of:

$$\text{Takt time} = \frac{420 \text{ m/day}}{7.5 \text{ units/day}} = 56 \text{ m/unit}$$

The resource utilization is the flow rate over the resource capacity. The flow rate is equal to the process capacity and the process capacity is equal to the capacity of the bottleneck (assembly). So this means at assembly, our resource utilization is equal to the bottleneck capacity over the resource capacity or about 100%. The resource utilization is at the bottleneck. What does this mean, the bottleneck is working all the time? If there's enough input and enough demand, the process capacity is equal to the capacity of the bottleneck. And that assembly better keep assembling a 100% of the time in order to keep the process at least producing 3 units/day.

The difference between cycle time (110 m) and takt time (56 m) does not allow to meet the demand and deadlines established with the final customer. The process times were analyzed to identify in each operation their elementary activities (Table 3) that do not add value to the final product, and that are feasible to be minimized (Cuatrecasas, 2017).

Table 3. Elementary activities time

Operation	Elementary activities	Time (m)
Cutting	Verification measure	20
	Selecting piece	20
	Calibrated	15
	Cutting	25
	Delivery 1 (pieces)	5
Bordering	Ordering of pieces	5
	Adjust for bordering	10
	Bordering	30
	Control	10
	Delivery 2 (pieces)	4
	Transport	6
Assembly	Assembling 1 (drawers)	35
	Assembling 2 (sidepieces)	40
	Assembling 3 (desk)	35
Total time (m)		260

Evaluation of elementary activities determined that manual activities (Table 4) needed more time: cutting about 78.58%, bordering 53.85% and assembly 100%.

Table 4. Types of elementary activities

Operation	Elementary activities	Manual/Machine	Time (m)
Cutting	Verification measure	Manual	55
	Selecting piece		
	Calibrated		
	Cutting	Machine	25
	Delivery 1 (pieces)	Manual	5
Bordering	Ordering of pieces	Manual	15
	Adjust for bordering		
	Bordering	Machine	30
	Control	Manual	20
	Delivery 2 (pieces)		
	Transport		
Assembly	Assembling 1 (drawers)	Manual	110
	Assembling 2 (sidepieces)		
	Assembling 3 (desk)		
Total time (m)			260

Two improvement alternatives based on four factors were presented to the company's management: order, classification, training, grouping of activities. The first action was implemented is the 5'S methodology, and due to the order and organization already established in the company, the actions were facilitated. With the plant workers participation they applied the logic shown in Figure 2, generating a workplace more comfortable and cleaning (Figure 3). The results reflected a better workplace, reduced preparation times due to the rapid availability of components and tools. The improvement had a greater impact on the final assembly area.

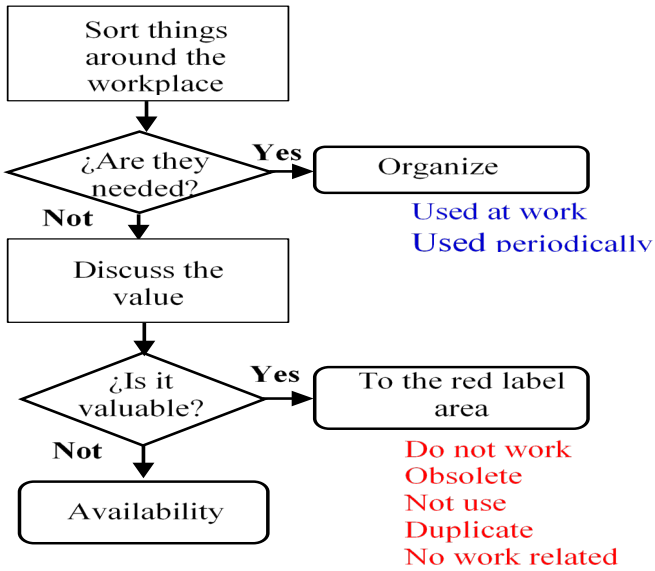

Figure 2. Work logic for production area (Santoyo, et. al., 2013)

Figure 3. Applying 5S: results

After several tests and adjustments in the process, the activities were grouped as shown in Table 5. The activity groups were the result of the interaction of four workers throughout the process that allowed to increase production.

Table 5. Grouped activities (four workers)

Operation	Elementary activities	Manual/Machine	Time (m)
Cutting	Verification measure Selecting piece - Calibrated	Manual	55
	Cutting	Machine	25
Bordering	Organized delivery 1 (pieces) Adjust for bordering	Manual	15
	Bordering	Machine	30
	Control Delivery 2 (pieces) - Transport	Manual	20
Assembly	Assembling 1 (drawers)	Manual	70
	Assembling 2 (sidepieces)		
	Assembling 3 (desk)		
Total time (m)			215

The lead time is about 215 minutes considering that the new cycle time is cutting operation (80 m). So, the estimated daily production must be 5.25 units/day:

$$\text{Production} = \frac{420\ \text{m/day}}{80\ \text{m/units}} = 5.25\ \text{units/day}$$

This means a takt time production of 80 m/units. The value of the takt time production is above the customer's delivery time (56 m):

$$\text{Takt time} = \frac{420\ \text{m/day}}{5.25\ \text{units/day}} = 80\ \text{m/unit}$$

Previous results are not enough to meet the demand. And this made necessary to evaluate a second alternative that allows a greater availability of time for workers. The second alternative implemented, considers additional worker participating in all manual high intensity operations, such as assembly and load- unload activities: three worker in initial activities (verification-selection-calibration), but the greatest contribution is in assembly, where all the workers only made the assembly labor. Table 6 shows the new times achieved with the inclusion of a new two workers:

Table 6. Grouped activities (six workers)

Operation	Elementary activities	Manual/Machine	Time (m)
Cutting	Verification measure Selecting piece - Calibrated	Manual	25
	Cutting	Machine	25
Bordering	Organized delivery 1 (pieces) Adjust for bordering	Manual	10
	Bordering	Machine	30
	Control Delivery 2 (pieces) and Transport	Manual	10
Assembly	Assembling 1 (drawers)	Manual	60
	Assembling 2 (sidepieces)		
	Assembling 3 (desk)		
Total time (m)			160

The lead time has been reduced to 160 minutes considering that the new cycle time is assembly operation (60 m). The estimated daily production must be 7 units/day:

$$\text{Production} = \frac{420\ \text{m/day}}{60\ \text{m/unit}} = 7\ \text{units/day}$$

This means a takt time production of 60 m/unit. The value of takt time remains slightly higher than the takt time of delivery to the customer (56 m):

$$\text{Takt time} = \frac{420\ \text{m/day}}{7\ \text{units/day}} = 60\ \text{m/unit}$$

Having added new workers to the process have a direct impact on cost production. Table 6 showed that production is increased, but it implies that the company must rethink its operating costs (new worker, a training program). Action implemented by reducing lead time are showed in Table 7 and these one have improved workflow (Verma; Sharma, 2017):

Table 7. Lead time: actions implemented

Actions	Improvement results
Production time reduction	Reduction and elimination of material search activities. Improved workspace. Visual control of product quality
Reduce component wait time	Synchronizing the workflow using an activity schedule and operator traffic map
Reduce of the batch time	Controlling of the wait times for work in process due to the availability of a single cutting and bordering machine
Process delay reduction	Delay times are caused by the availability of machinery. These are time-controlled not to increase lead time
Management of supply chain	Improved vendor delivery times and compliance with preventive maintenance plans.
Reduce transport delay	Reducing distances between workstations
Setup reduction	The specialization of the machines and their high level of functionality, have a planned buffer or safety stock

The production achieved does not fully respond to the demand established by the market. To achieve this, an economic investment is needed but the enterprise don´t want to incur in additional costs for additional machinery.

4. Discussion and conclusion

Changing the number of operators affects not only the production capacity, but also the manufacturing unit cost. In this sense, adding operators to the process increases the production rate, but the marginal rate decreases with each additional operator (Figure 4). With each additional operator, the operating cost of the direct labor of the process is increased by the operator's salary.

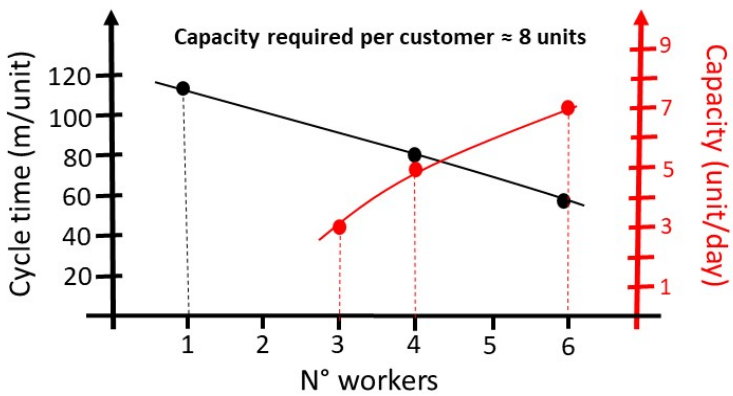

Figure 4. Increasing number of worker vs Capacity

In order to achieve the result of producing 7 units/day, it has implied identifying the processes of the machines and those carried out by the workers. In this way, activities of high labor intensity have been determined to assign a greater number of workers.

The total times obtained in table 5 considering four operators is achieved by incorporating two more operators for purely manual tasks, especially in the cutting stage: verification of measurements, selection of piece and calibration.

Adopting takt time as a guide in production system helped to develop a production scenario that allowed to meet market demand. The production system still need to improve the variability and dynamics of the system.

In the mentioned case study, it has been found that the reason for non-value added activities are due to wrong handling material, long distance to find a tool, defect product and waiting time.

The enterprise has a production of 7 unit/day with the participation of 6 workers but process times are very tight and it must be readjusted by to meet market demand. Nowadays, the company has invested in training and tools. He has not planned to buy another bordering machine in the next two years.

Micro and small enterprises are very important in the economic and sustainable development at the Lambayeque region (Ulloa et al., 2020). The case study in this paper showed that introduction of lean methods brought opportunities for improvements production and a best management. It can be concluded that O-T Diagram is an effective tool for identifying processing wastes.

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