5th South American Conference on Industrial Engineering and Operations Management
Bogota, Colombia, May 7-9, 2024
Publisher: IEOM Society International, USA DOI: 10.46254/SA05.20240210
Published: May 9, 2024

Implementation of Lean Manufacturing Smed and Value Stream Mapping Tools to Increase Productivity in a Bakery Company

Jimmy André Cárdenas Peña and Jhoel Oswaldo Veliz Veliz
Universidad de Lima
Industrial Engineering Lima, Peru
20130235@aloe.ulima.edu.pe ; 20174022@aloe.ulima.edu.pe

Abstract

The objective of this research is to use the "Lean Manufacturing" methodology to increase productivity in the production area of a company in the bakery sector. For the analysis, one shift (morning shift) of the two daily production shifts was considered. The problem in the bakery is the lack of follow-up in each process performed by the baker. This results in a greater use of resources, generating higher costs for the company. It also limits the response to higher production demands. The current productivity of the company is 63.56%. The VSM was used to analyze the current state of the bakery, the different variables and main factors involved in bread production. Of the different tools of the Lean Manufacturing methodology, the SMED tool was chosen because it is one of the best working tools that help reduce the changeover time and configuration of a product or batch. In this case, will be applied to reduce the time of any process by more than 30%. The time of each process was calculated with the use of a stopwatch. After applying the methodology, a new VSM and a production design model were designed, resulting in a productivity increase of 80.23%.

Keywords
Bakery, Lean Manufacturing, Small and Medium Enterprises, Productivity, SMED

1. Introduction
Bread is the main food for millions of people in Peru, of which French bread represents 50% of the income from its sale. In Peru, 35 kilograms of bread are consumed per capita and thanks to the operation of bakeries. Two hundred thousand people are employed and involved in the entire production chain. In recent years, the Peruvian bakery sector has been inconstant growth, defying all kinds of difficulties. This sector is quite dynamic and diverse because there is a diversity of breads, from traditional to sweet breads and cakes and variants. In addition, because there is good competition among bakeries, bakery chains and supermarkets. The innovation of bakers through the improvement of their production techniques and using local ingredients that provide quality food. As a result, consumer demand has been increasing. It is worth noting that the impact of the Covid 19 pandemic on the bakery sector was significant because it generated an increase in the purchase of bread for home consumption and at the same time helped to strengthen biosecurity elements and offer home delivery services. Nowadays companies in the bakery sector are starting to use agile methodologies in order to improve their processes and therefore be more productive, as is the case of the present work. The mypes that are in this sector are characterized by their traditional nature to make bread and are reluctant to change because they do not have knowledge of agile methodologies and are not trained by professionals with knowledge of process improvement. In relation to the last point, another important factor is the investment in time and resources since it is necessary to train all staff and reorganize existing processes.

1.1 Objectives
Research question:

- Is it possible to increase productivity in a bakery using Lean Manufacturing methodology?

Research objective:

- Implement Lean Manufacturing methodology to increase bakery productivity.
- Reduce standard bread production time by more than 30%

Research hypothesis:

- The implementation of Lean Manufacturing methodology increases productivity in a bakery.

2. Literature Review

According to García (2019), productivity is an indicator, which reflects how well the resources of an economy are being used in the production of goods and services. Then, productivity is the relationship between resources used and products obtained and denotes the efficiency with which human resources, capital, land, among others, are used to produce goods and services in the market. In the food industry, it is common to use Lean Manufacturing tools that help maintain high quality services. Tools such as SMED, 5s are among the most used. From this, the text seeks to reduce times, using SMED technology, this is related to reduce times by converting internal operations to external operations to reduce the work time of the baker to reduce the cost.

For Assad A. (2018), low productivity is detrimental to a company because it does not generate the desired profitability. It leads to a series of risks and serious results for a business such as economic losses, delays and errors in production. A decrease in labor productivity can be caused by various reasons such as: stress, conflicts, unclear objectives or a poor management structure. Low productivity derives from the composition of the productive factors in the country and is related to labor, economic and social conditions when together they fail to maximize and take advantage of human resources. To improve management, lean manufacturing tools are used to provide workers with facilities to perform their work faster and more efficiently. In this way, it will be possible to obtain a greater quantity of production in less time without losing quality.

According to Serrano, J. (2020), the implementation of the Lean Manufacturing methodology is of great helpfor any company that wishes to minimize the losses generated in any type of production in such a way that only the necessary resources are used to increase productivity. This methodology includes tools such as 5S, just in time, SMED,etc. Lean Manufacturing tools also include continuous analysis processes (Kaizen), advanced production (Kanban), elements and fail-safe processes (Poka Yugo) with the purpose of "doing things right" (Monozukuri). Productivity improvement is directly related to the quality of the product to be offered, in this case bread. From that, the text aims to minimize unneeded resources such as operations that can be done when the machine is working, to reduce production time and generation of new processes to reduce the cycle time of the product.

For Cini E.and Cappelli A. (2021), Pasta, bread and bakery products are considered worldwide as essential foods for human nutrition. In particular, ancient wheats and whole wheat flours, despite being able to provide health benefits through bioactive compounds, present important technological problems related to poorer dough rheological properties and final product characteristics. In addition, both the food industry and consumers are increasingly sensitive to environmental impacts, highlighting the urgent need for sustainable innovations and cradle-to-grave improvement strategies for all production chains, which motivates this review to improve productivity in bakeries. It also provides information on how to mill bread production inputs to improve productivity. From this, decrease the time. In addition, how inputs should be stored to extend their shelf life.

For Camara Valencia (2022), the Lean Manufacturing methodology is defined as a philosophy aimed at optimizing and improving the production process. It seeks to eliminate or reduce all those activities that do not add any value to the process. In addition, it is important to establish a continuous improvement strategy, so the company must be clear about the objectives to be achieved and the path to follow to reach them. The SMED method is a technique whose main objective is to reduce the time it takes employees to change the tooling of tools and machines.Thanks to it, small batches can be produced, which is a great advantage to adapt precisely to any kind of unforeseen event that may arise during the production process.

3. Methods

The tool used to meet the specific objective of reducing the processing time is the SMED, belonging to the Lean Manufacturing methodology.

The idea of this method is to change the sequence of bread production to eliminate operator downtime whilethe machine is working, so that both the baker and the machine are operational and thus reduce bread production time. This will be done on the basis of measuring the working time of the machines, as well as the workers procedures with the machine.

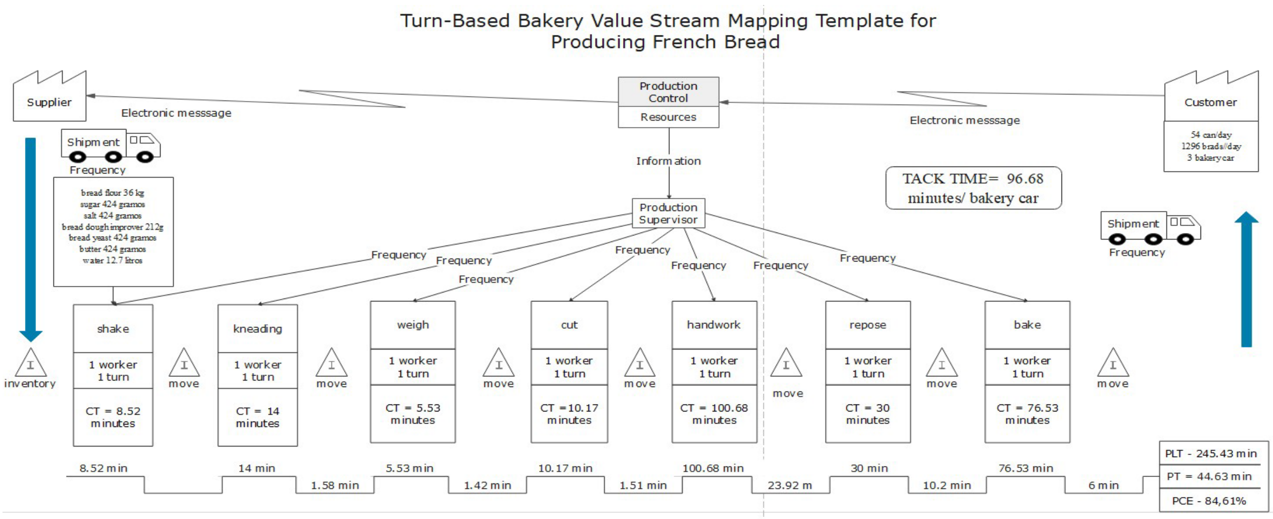

Figure 1**.** French Bread Turn-Based Bakery Value Stream Map Template

The Figure 1 detailed the tradicional process for making French bread. According to the objective of the SMED methodology, the aim is to reduce production process times, which will generate in the company a quick response to market demand, improve cash flow and therefore reduce business risk,among other benefits. The following scenario is presented for its application:

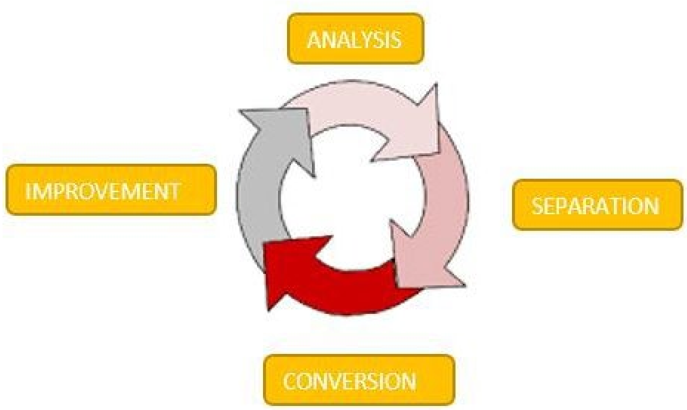

Figure 2. Development of the SMED methodology

The Figure 2 details the 4 continuous processes that have to be carried out with the SMED tool. As can be seen, the SMED tool aims at continuous improvement and in order to achieve this previous steps such as the analysis of the workplace. The division of the operational processes into two groups are carried out: The internal operations, which are those that need the machine to be stopped and that are performed during tool change. On the other hand, external operations, which are those that can be performed while the machine is in use.

The conversion is to minimize internal operations and transfer them to the external ones, thus causing greater efficiency in bread production and resulting in cost reduction.After applying the SMED tool in the present work, the results of the times will be verified through a rigorous comparison with the current times of the bread production process. According to the bakery's current data collection. The average production processing time is 290.06 minutes, and by using the SMED method it will be possible to convert internal operations to external ones, as well as implement machinery that exerts the same SMED dynamics. In this case, a dividing and rounding machine will be added. After the application of the tool, the bread productionprocess will be reduced by 98.53 minutes, which will benefit the bakery because it will be able to produce more breadsin less time, will have a smaller inventory of raw materials needed for production, and therefore will have more spacein the workshop to be used for other tasks. Likewise, the electrical cost of the machines and lighting in the workshop will be reduced as a result of the reduction in time.
Finally, there will be a constant monitoring of what was applied in the previous steps. At this stage, rules are established, in which the workers must follow the standard time calculated for each process of bread production, following an established work plan. Consequently, when a new type of bread is implemented in the bakery, this methodology can be used to achieve efficiency in your production time.

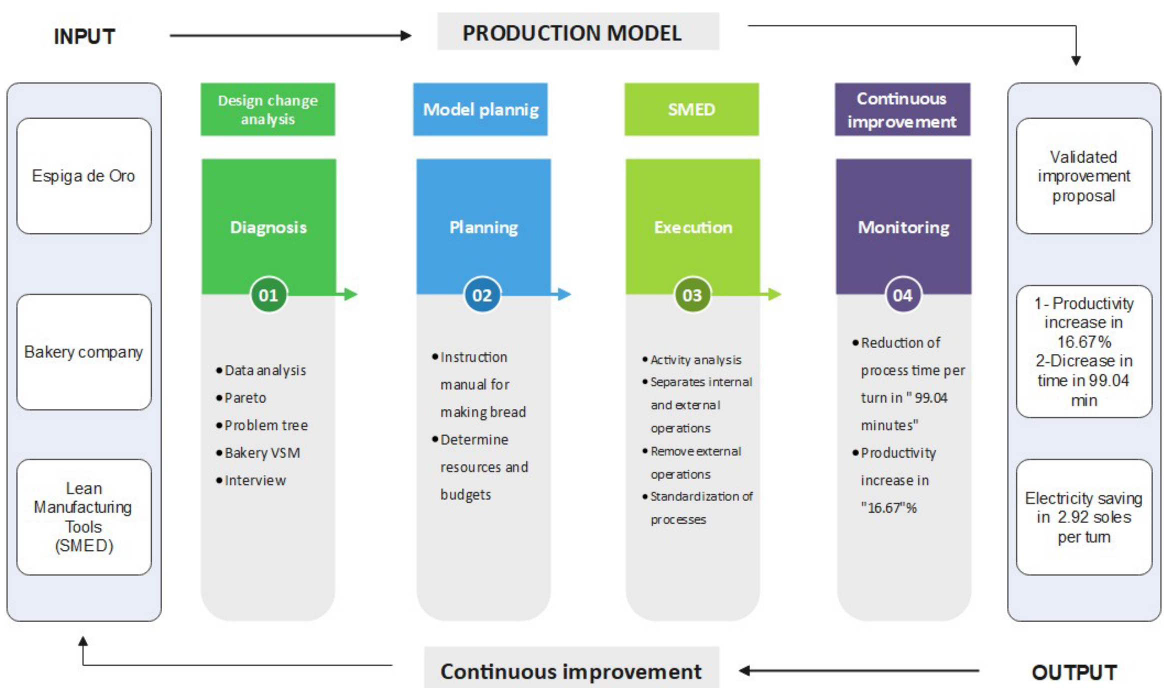

Figure 3. Model using SMED methodology

The Figure 3 shows the input and output elements, as well as the production process of the model.
In summary, in the above context, the use of Lean Manufacturing methodology tools had a great impact for the following reasons: Process Visualization: The VSM allows to visually map the processes involved in the production of bread and other bakery products, from the receipt of ingredients to the delivery of the produced bread to the customer. This provides greater process clarity to understand how value flows through the supply and production chain.

Waste Identification: As a consequence of a correct value flow map, the tool allows to easily identify the areas or processes of bread production where waste occurs, such as excess inventory, waiting times, leftover processes, etc. This helps the bakery to focus on specific areas for continuous improvement and waste reduction in order to have a faster and more profitable production.

Increased Flexibility: By decreasing changeover time in bread making, the bakery becomes more flexible in its ability to respond to new customer needs. The bakery can adjust quickly and, from that, meet that demand without significant delays.

Quality Improvement: By recognizing and optimizing value streams, the bakery can identify and address quality issues in the process. This can include standardization of work procedures, proper fermentation of the dough to develop the right texture, quality monitoring to verify quality: appearance, texture, flavor and scent, documentation and record keeping of recipes, methods identifying which work and which do not. From this, defects in the final products will be reduced.

Productivity Improvement: By reducing downtime associated with changes in bread production processes and the creation of a new process by joining two processes, the overall productivity of the bakery can be improved. From this, more breads can be produced in a shorter time, which can be interpreted into higher revenues and improved profitability for the bakery business.

Focus on Customer Value: VSM helps the bakery focus on adding real value for the customer. This is presented by eliminating activities that do not directly contribute to quality or customer satisfaction, reducing customer waiting time, as the processing time for French bread is less and competitively priced in the market. From this, it leads to better customer satisfaction and a competitive advantage in the market.

4. Data Collection

The type of design conducted in this research was quasi-experimental because it compares a group of people performing processes; these can be measured using measurement instruments at different times in order to achieve better results (16). The scope is explanatory, since it focuses on explaining why a phenomenon occurs, under what conditions itmanifests itself or the reason for the relationship between two or more variables.
The research approach is qualitative, because it studies concrete facts that take place in the bakery through interviews conducted with workers. This explains, describes, predicts the actions performed. It uses reliable data fromthe tools to test the theory.

It is oriented to understand the data collected in order to obtain an improvement in reality through research.
The following statistical formula was used to calculate the sample, since the population is finite and is less than 100,000 data. This represents a Z=95% (standard score), confidence level of 1.96, margin of error of 5%, probability in favor (p) of 50%, probability against (q) of 50% and a population of 365 data.

$$n = \frac{z^2 * p * q * N}{e^2 (N-1) + z^2 * p * q}$$

Statistical Formulation to Calculate the Sample Number

The figure shows the sample formula because it has less than 100,000 data.

$$188 = \frac{(1.96)^{\wedge}2*0.5*0.5*365}{(0.05)^{\wedge}2*(365-1)+(1.96)^{\wedge}2*0.5*0.5}$$

Application of the formula

In the figure application of the sample formula because it has less than 100,000 data. As a consequence, 188 samples from the population will be used, chosen using systematic sampling, as it allowsaccurate estimation of population parameters, reduces sample selection bias and is easy to implement and understand. Then, using the systematic sampling formulation, the K (sampling ratio) between the population and the sample number will be found. This K will be used to calculate the selected data that will form the 188 samples and the working times with the support of the SMED methodology. A start-up (A) will be considered as value 1 in the present work.

$$K = \frac{N(365)}{n(188)}$$

$$K=1.94$$

Formula for Finding K for Systematic Sampling. The figure shows how the constant "K" is found to calculate the sample.

After finding K, we will start to apply the formula. We will start with the bootstrap (A) which in our case is 1, and to the second sample we will add the bootstrap plus the sampling ratio (A+K), to the third A+K+K, to the fourth A+K+K+K+K and so on. A presentation of the first four samples selected from the 188 samples is given below (Table 1).

Table 1**.** Presentation of the selection of the first 4 samples
The figure shows the first 4 samples found with the constant "k" and as "A" equal to 1

A+K	SAMPLE	DAY
1	1	1
1+1.94	2	2.94
1+1.94+1.94	3	4.88
1+1.94+1.94+1.94	4	6.82

By means of Arena software, data will be obtained as a result of the simulation of the 188 samples. The minimum, maximum and average cycle time will be received, as well as the percentage of participation of the operator and the machinery. It should be noted that thirty replicas were used in its execution.

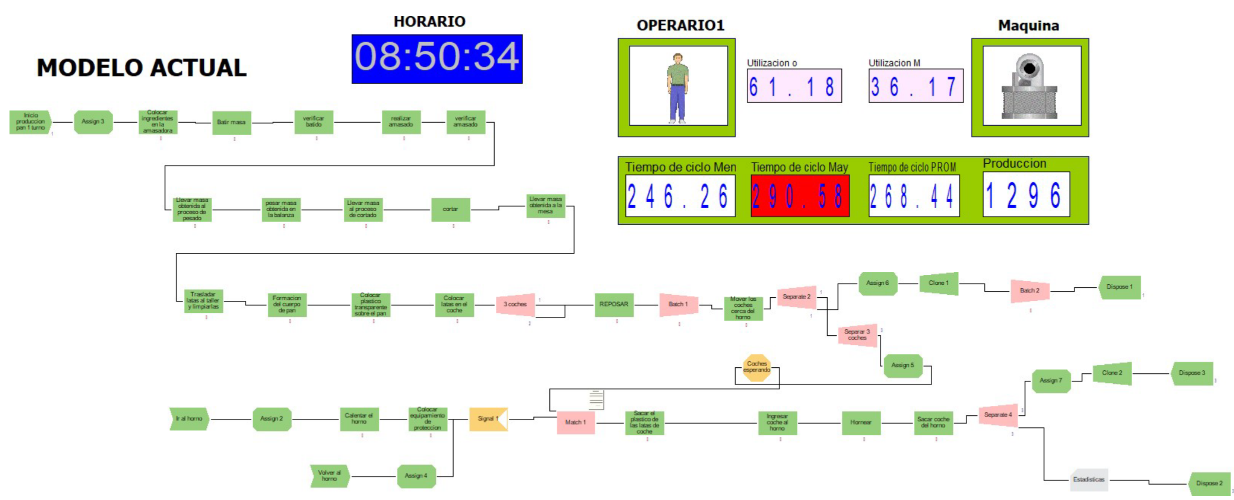

Figure 4. Sand Simulator

The Figure 4 shows all the processes and sub-processes that are carried out to make French bread.
After applying the SMED tool to the current process model, the following data will be obtained through the same software:

Table 2. Output current mode

The table shows the average amount made per bread in a replica of 30 shifts, as well as the maximum time of all the replicas and the minimum time for making French bread (Table 2).

Output	Average	Half Width	Minimun Average	Maximum Average
Bread production	1296	0	1296	1296
Maximum cycle time	289.43	1.24	282.85	295.58
Minimum cycle time	245.09	1.23	238.61	252.26
Average cycle	267.26	1.23	260.75	273.44

The Figure 5 shows the maximum cycle time, which refers to the total time that the process takes to produce French bread. On the other hand, the minimum cycle time is the time it takes to remove the first car from the oven. In the whole process, 3 cars of French breads are produced to make up the 1296 loaves.

		Time (MIN)
shake	PLACING INGREDIENTS IN THE MIXER	1.51
	WHISK DOUGH	6.01
	CHECK SMOOTHIE	1.00
kneading	KNEADING MACHINE	12.00
	CHECK KNEADING	2.00
	BRING THE DOUGH OBTAINED TO THE WEIGHING PROCESS	1.58
weigh	WEIGH MASS OBTAINED ON THE ANALYTICAL BALANCE	5.53
	BRINGING DOUGH TO THE CUTTING PROCESS	1.42
cut	CUT	10.17
	BRING THE DOUGH TO THE MANUAL WORKBENCH	1.51
handiwork	MOVING CANS TO THE WORKSHOP AND CLEANING THEM, AS WELL AS THE DOUGH SCRAPER	15.33
	FORMATION OF THE BREAD BODY	81.27
	PLACE PLASTIC WRAP ON TOP OF THE FORMED BREAD	4.08
	PUTTING CANS IN THE CAR	23.92
rest	REST	30.00
	MOVING CARS NEAR THE FURNACE	10.20
bake	HEAT THE OVEN	15.00
	DONNING PROTECTIVE GEAR	1.05
	REMOVE THE PLASTIC FROM THE CANS OF THE CAR (REPEAT THREE TIMES)	3.49
	ENTER CAR INTO THE OVEN (REPEAT THREE TIMES)	2.99
	BAKE (REPEAT THREE TIMES)	54.00
	TAKE CAR OUT OF THE OVEN (REPEAT THREE TIMES)	6.00
	TOTAL IN MINUTES 290.06	

Figure 5. Calculated time per shift in the bread production process (WITHOUT SMED*)*
In the sample, the total time in minutes of each process and sub-processes of making French bread.

The image shows the bread production process and its duration in minutes. The baking process is highlighted, since the sub-processes are carried out three times for the three bread cars. To classify the internal operations from the external ones according to the SMED method, the processes will be distinguished according to the color filling that contains it according to the table in Figure 5. The blue colored fillings are the operations carried out by the bakers without using any machine (internal operations). Those in pink are operations performed by the bakers with the use of machines, and finally the sub-processes filled in yellow are internal operations that are going to be converted into external ones, as established by the SMED tool. As a first application of this, in the process of manual work, the sub-process of transferring cans to the workshop and cleaning them, as well as the dough scraper, will be carried out while the mixer and kneading machine are working, that is, they will be carried out in parallel. The total time between the

kneading and beating process is longer than mentioned above. In this way, an internal sub-process will be converted into an external one, thus reducing minutes in bread production. Secondly, sub-processes will be selected from the resting and baking process to reapply the tool. In this case, moving the cars close to the oven, as well as heating the oven and color protection equipment respectively. The three sub-processes will be carried out while the bread dough is resting, so that the baker can take advantage of the resting waiting times and thus be more productive. As a result of the above, the processing time will be reduced by 26.25 minutes.
Third, the slicing and manual work processes will be eliminated, creating a new process called Bread Forming, by means of a machine that performs the kneading and rolling functions. This process will reduce the breadmaking time by 56.95 minutes. This machine was proposed and accepted by the head of the bakery, since it drasticallyreduces the time from the cutting process to the manual work and will have greater accuracy in the divisions that are made to the dough.

5. Results and Discussion

5.1 Numerical Results

As shown in the image, the total new time using the SMED methodology is 191.53 minutes. This has been decreased by changing the 4 internal operations to external, as well as the new operation (bread forming), eliminating the cutting and manual work processes.

		Time (MIN)
shake	PLACING INGREDIENTS IN THE MIXER	1.51
	WHISK DOUGH	6
	CHECK SMOOTHIE	1
kneading	KNEADING MACHINE	12
	CHECK KNEADING	2
	BRING THE DOUGH OBTAINED TO THE WEIGHING PROCESS	1.58
weigh	WEIGH MASS OBTAINED ON THE ANALYTICAL BALANCE	5.53
	BRINGING DOUGH TO THE CUTTING PROCESS	1.42
SLICING/FORMING BREAD	USE OF DIVIDING MACHINE TO PRODUCE BREAD BODIES	36
	PLACE PLASTIC WRAP ON TOP OF THE FORMED BREAD	4.08
	PUTTING CANS IN THE CAR	23.92
rest	REST	30
bake	REMOVE THE PLASTIC FROM THE CANS OF THE CAR (REPEAT THREE TIMES)	3.49
	ENTER CAR INTO THE OVEN (REPEAT THREE TIMES)	3
	BAKE (REPEAT THREE TIMES)	54
	TAKE CAR OUT OF THE OVEN (REPEAT THREE TIMES)	6
	TOTAL IN MINUTES	191.53

Figure 6. Calculated Time Per Shift in the Bread Production Process (With SMED*)*
In the Figure 6, the total time in minutes of each process and subprocesses of making French bread with the SMED methodology.

The hypothesis stated at the beginning of the work indicates that it is possible to increase productivity in a bakery by using the Lean Manufacturing methodology through the SMED tool. This was satisfactorily supported by following the parameters established by the tool. The initial productivity was calculated as the quotient of the quantity of breads produced per shift (1296 loaves) by the price of bread (25 cents) between the total cost of production per shift, which resulted in 63.56% and the productivity after the application of the SMED tool is 80.23%.
The monthly salary of a baker is 1,800 PEN. In addition to producing French bread, he makes a variety ofother breads. The time the baker spends per shift making bread is 4.83 hours, but using the SMED tool reduces it to 3.19 hours. Thus, the cost per shift for French bread production is 29.93 PEN.
The cost of light per 8-hour shift is 14.29 PEN, of which 4.83 hours are used for the production of French bread, so the cost of producing bread per hour amounts to 8.63 PEN. After using the SMED tool, a decrease in bread production time was obtained, which also resulted in a decrease in the cost per hour of 5.70 PEN (33.95% less).

The Table 3 shows the total costs of the French bread operations, labor cost and electricity cost, as well as the productivity of profit per bread

Table 3. Table of Costs and Results

SAMPLE TIME			USING SMED METHODOLOGY	
PEN	144.14	COST OF INPUTS PER SHIFT	PEN	144.14
PEN	45.32	LABOR COST PER SHIFT	PEN	29.93
PEN	8.63	ELECTRICITY EXPENDITURE	PEN	5.7
PEN	198.1	TOTAL SPEND	PEN	179.77
PEN	0.15	COSTO PER LOAF	PEN	0.14
PEN	324	TOTAL INCOME FOR THE PRODUCTION OF 1296 LOAVES	PEN	324
PEN	198.1	TOTAL COST FOR THE PRODUCTION OF 1296 LOAVES	PEN	179.77
PEN	0.25	SELLING PRICE OF BREAD	PEN	0.25
	63.56%	FINAL PRODUCTIVITY		80.23%
	1.64	PROFIT PER UNIT SOLD		1.8

.

To find the productivity, we used the income received by the bakery over its expenses. Revenues will be calculated based on the number of loaves produced times the selling price of each loaf, divided by the expenses included in its production. Using the SMED tool, productivity will increase from 63.56% to 80.23% in relation to its economic return on investment per unit of bread.

The Table 4 shows the average amount made per bread in a replica of 30 shifts with SMED methodology, as well as the maximum time of all the replicas and the minimum preparation time for French bread. The utility of the baker and the machines were also put in place.

Table 4. Cycle Time and Operator Utilization Table

Indicator	**Independent Confidence Intervals**	**Statistical conclusion**
Cycle Time	Current : (288; 291) Minutes Proposal: (190;191) Minutes	There are significantdifferences, the cycle time is shorter in the proposed model
Operator Utilization	Current: [61.1; 61.5) %. Proposal: (71.6; 71.7) %.	There are significant differences. Operator utilization is higher in the proposed scenario

The following Table 4 shows the comparison between the current situation of the bakery and the results after the application of the SMED tool. In this way, statistical conclusions can be drawn.

5.2 Graphical Results

As visualized in the VSM diagram, two processes were eliminated: manual work and slicing, to unify them in a new operation which is bread forming. From this, the processing time will be reduced due to the conversion from internal to external operations (Figure 7).

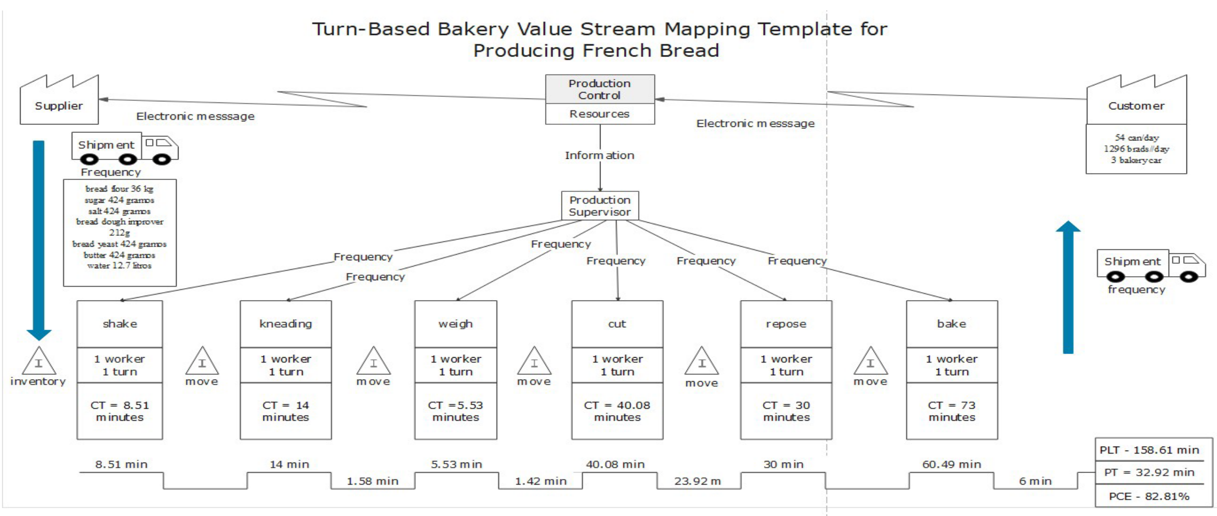

Figure 7.VSM using SMED tool

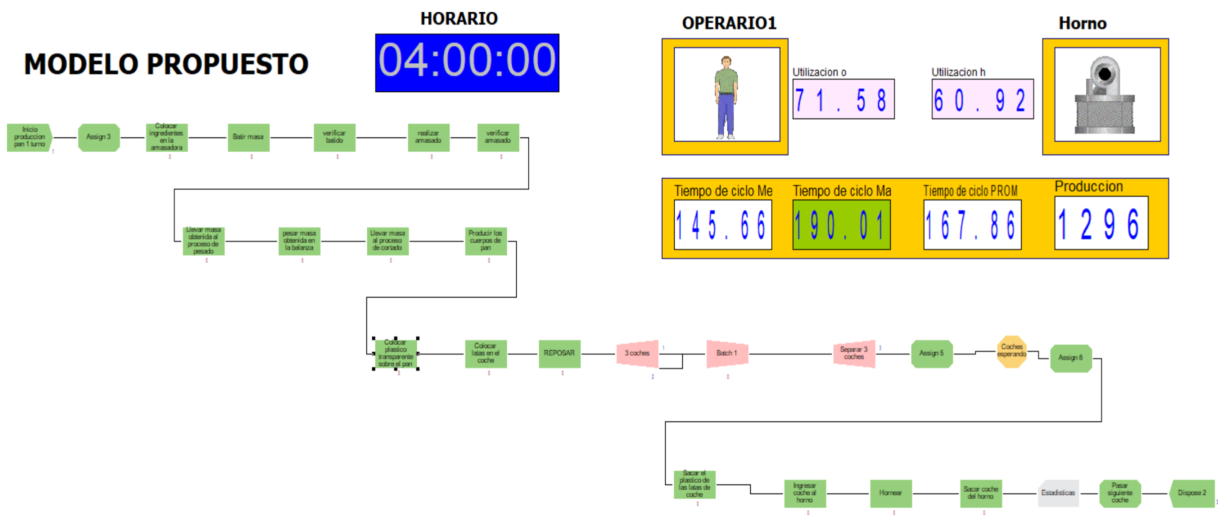

Figure 8. Arena simulator with SMED tool

The Figure 8 shows all the processes and sub-processes that are carried out to make French bread using the SMED methodology.

As can be seen in the picture, there is a change in the processes of French bread manufacturing, the percentage of baker and machine utilization. On the one hand, two processes (slicing and manual work) are combined to create a new operation called bread forming, as well as the modifications of 4 internal operations that will be changed to external ones. These no longer appear in the Arena software. On the other hand, the baker's activity will increase since, in the kneading, beating and resting operation. He will do in parallel the internal operations that were changed to external ones, having less dead time, changing the baker's utilization time from 61.18 % to 71.58 %. The utilization of the machines is also affected because the processing time has been reduced, but the machines keep working the same time.

Table 5 shows the quantity in a replica of 30 shifts with SMED methodology. The use of the baker and machines, as well as the average time of the entire process.

Table 5: Proposed model output

Output	Average	Half Width	Minimun Average	Maximum Average
Bread production	1296	0	1296	1296
Maximum cycle time	190.32	0.49	188.35	192.71
Minimum cycle time	146.05	0.5	143.95	148.5
Average cycle	168.19	0.49	166.17	170.59
Operatir use	71.62%	0.07	71.33%	71.98%

In the graph shown, it is visualized that the standard time for a simulation of 30 replications is 190.32 minutes for the production of French bread using the SMED tool. In this case, the process ends when the 3 cars come out of the oven. The operator utilization is the proportion of time in which the operator is working in relation to the bread processing duration.

5.3 Proposed Improvements

The bakery under study has an intermittent production system and produces a wide variety of products. The most demanded types of bread have been selected, which are called "pan labranza" (French bread, mica bread, mollete bread and marraqueta bread). Among them, the French bread with the highest sales was selected, to which the productivity improvement proposal will be made through the SMED tool to reduce processing time and, as a consequence, generate a reduction in production costs. In relation to the improvement proposals, through the SMED tool it is proposed to modify the design of the current bread production process to reduce the processing time from 290.06 to 191.53 minutes in two main steps. On the one hand, four internal operations were converted to external operations, reducing the time by 42.28 minutes. On the other hand, after a market study of machinery in the bakery sector, a new machine was acquired that will help speed up the production process. As a result, two bread-making processes were combined to form one and the time was reduced by 56.22 minutes. As a consequence of the improvement proposals, it is deduced that the bread processing time decreased by 98.5 minutes, decreasing labor and electricity costs, generating a higher income for the bakery.

5.4 Validation

The input data were validated through the following statistical tests in each sub-process of bread production. Taking into consideration the following:

Goodness-of-fit test:
Ho= The time to perform sub-processes **x** fits a Beta distribution.
H1= The time to perform sub-processes **x** does not fit a Beta distribution.
According to the above, the data in each sub-processes fits a beta distribution.
Chi square Test = Validation was performed in each bread production sub-processes, validating that the P-value > 0.05. According to the above, the data in each sub-process fit a beta distribution.

Kolmogorov-Smirnov Test = Validation was performed in each bread production sub-processes, validating that the P-value > 0.05. According to the above, the data in each sub-processes conform to a beta distribution.

As a final validation, it is concluded that the null hypothesis is not rejected and the duration times in each bread production sub-processes conform to a beta distribution.

Example of data validation in the sub-processes "placing ingredients in the mixer".

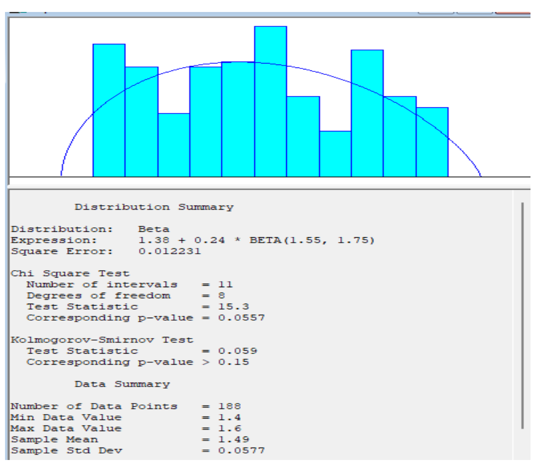

Figure 9. Input Analyzer data retrieval of placing ingredients in the mixer

The image provides the data provided by the ARENA software, to validate the data that was generated (Figure 9).

Goodness-of-fit test

Ho= The time to place ingredients in the mixer conforms to a Beta distribution.

H1 = The time to place ingredients in the mixer does not fit a Beta distribution.

Chi square Test = (P-value>0.05). The p-value =0.0557, therefore, is greater than 0.05 and according to this test, the data fit a beta distribution.

Kolmogorov-Smirnov Test = (P-value>0.05). The p-value >0.15, therefore, is greater than 0.05 and according to this test, the data fit a beta distribution.

Conclusion: The null hypothesis is not rejected and the duration time to verify kneading conforms to a Beta distribution. 1.38 + 0.24 * BETA (1.55, 1.75)

6. Conclusion

After the application of the SMED tool in the following work, the following conclusions were obtained:
It is feasible to use Lean Manufacturing methodology to improve bakery productivity.

It is demonstrated that the use of the SMED tool reduces the processing time per shift by 98.53 minutes, making it anacceptable practice for reducing food productions times. As a consequence, labour and electricity costs are reduced. Through the application of the SMED tool, an increase in the man-hour unit of the work performed by the operator on bread production is evidenced. It is possible to make an additional car of bread as long as there is an additional consumption public to the one that exists the bakery.

It is essential to have protective equipment throughout the production of bread, because there are processes in which without the use of these it is not possible to perform them.
Another contribution was to be able to provide flexibility to adapt to changes in demand, respecting the time limits. In this way it will be possible to obtain an immediate response to any new situation.
The impact of the following scientific article will be of help to many small and medium sized companies in the bakery sector to improve their bread production processes because the research is focused on this target audience that do not have the necessary resources to acquire more modern machines and have limited budgets for personnel. From the following research, the use of the baker's man-hour and machine-hour estimation unit of the machines will be optimized, thus decreasing the bread production time, labor and electricity costs. In addition, this model will be able to meet variations in customer demand without affecting the productivity of the bakery. To take advantage of the work presented, it is important to collect the exact time taken by each baker in a bread production shift and validate it through automation and event simulation software. In this way, the application of any Lean Manufacturing tool will have more accurate results, for the desired improvements. It is important to always receive feedback from the customer to know their experience in the service provided if it meets the expectations and thus identify areas for improvement and process readjustments.

References

Assad, A. Quality index , https://www.cuidatudinero.com/13108654/efectos-de-la-baja-productividad-en-el-lugar-de-trabajo /. Accessed February 01, 2018

Derya , C. , Gufte , C. and Yakup ,D. The effect of safety climate in workplaces on productive organizational energy of employees: a research in textile industry. *International Journal of Quality & Reliability Management,*vol 41, no 1, pp 42-59 , 2024

Bao-Guang , C., Kun-Shan ,W. and Chieh-Wen , C. Productivity Change and Decomposition in Taiwan BakeryEnterprise-Evidence from 85 degrees C° Company. *Sustainability* , 11(24), 2019. .https://doi.org/10.3390/su11247077

Valencia, C. Have you heard about the lean manufacturing trend?. Available: https://ticnegocios.camaravalencia.com/servicios/tendencias/las-herramientas-mas-importantes-en-lean- manufacturing/,Accesed 2024.

Cappelli, A., Oliva, N. and Cini, E. A systematic review of gluten-free dough and bread: Dough rheology,bread characteristics, and improvement strategies. *Appl. Sci.* , 10(18), 2020 . .https://doi.org/10.3390/app10186559

Car, G., Flores, G., Campoverde , J. and Coronel, K. Bakery small business in Azuay (Ecuador) and their productivity. *Challenges . Journal of Management Science and Economics* vol.7, n.14, pp.167-188, 2017 https://doi.org/10.17163/ret.n14.2017.09.

Castro, M . and Arrieta , J. Implementation of lean manufacturing techniques in the bakery industry in Medellin. *Gestão & Produção* , vol. 26, no. 2, pp 1-9, 2019 . https://doi.org/10.1590/0104-530X-2505-19

Cini , E. and Cappelli ,A. Challenges and Opportunities in Wheat Flour, Pasta, Bread, and Bakery Product Production Chains: A Systematic Review of Innovations and Improvement Strategies to Increase Sustainability, Productivity, and Product Quality. *Sustainability* , *13*(5), 2021 . https://doi.org/10.3390/su13052608

Domínguez, R. , Espinoza , M., Dominguez , M. and Romero , L. 'Lean 6s in food production: HACCP as a benchmark for the sixth s "safety"', *Sustainability*, 13(22), p. 12577., 2021 .https:// doi:10.3390/su132212577.

Duarte, B., Goncalves, A. and Santos, L. Optimal Production and Inventory Policy in a Multiproduct Bakery Unit , *Processes* , vol 9 ,no 1 , pp 101 , 2021 https://doi.org/10.3390/pr9010101.

Garcia, A. Quality Index . https://www.eleconomista.com.mx/capitalhumano/Que-significa-que-un-pais-tenga-baja-productividad-laboral-20190210-0005.html / Accessed February 02,2019

Gil, M., Sanz, P., Benito, J. and Galindo, J. Definition of a methodology for a practical application of SMED, 1er Edition, Técnica Industrial, España, 2012.

Gómez, C. Internalization of the Naturissimo brand. University of Guayaquil. , vol 1, no 1 , pp 19-190, 2016.

Esan Connection . Heijunka: the tools to implement this methodology in a company. Esan. Available: https://www.esan.edu.pe/conexion-esan/heijunka-las-herramientas-para-implementar-esta-metodologia-en-una- empresa. August 31, 2021.

Hecker, F., Hussein, W., Paquet Durant, O., Hussein, M. and Becker, T. A case study on the use of evolutionary algorithms to optimize bakery production planning. *Expert Systems with Applications.* vol 40, pp. 6837-6847 , 2013 . https://doi.org/10.1016/j.eswa.2013.06.038

Huchet, V., Pava, S., Lochardet, A., Divanac'h, M., Postollec, F. and Thuault, D. Development and application of a predictive growth model of Aspergillus candidus as a tool to improve the shelf life of bakery products. *Food Microbiology ,* vol 36 , no.2 , pp 254-259, 2013.

Huila, M. Study of times and movements to improve the production process of steel profiles in the company Ferrotorre S.A. Guayaquil :Universidad de Guayaquil, vol 1, no 1, pp 16-148, 2017.

Jurado, N., Fernandez ,I., Quiroz J. and Cardenas , L. Lean Inventory Management Model to Reduce Defective Products in Peruvian Baking SMEs. *2021 10th International Conference on Industrial Technology and Management ,* pp 46-50 , Lima , Perù , March 26-28 , 2021. DOI: 10.1109/ICITM52822.2021.00016

Kapelko, M. Measuring productivity change taking adjustment costs into account: evidence from the food industry in the European Union. *Annals of Operations Research*, vol.278, no.12, pp. 216-234, 2019. DOI 10.1007/s10479-017-2497-0.

Kumar, S., Abdulla, S. and Singh, C. Productivity growth in the Indian bakery manufacturing industry. *Journal of Agribusiness in Developing and Emerging Economies,* vol. 12, no.1 , pp 94 – 103 , 2022 . DOI 10.1108/JADEE-12-2019-0204.

Maria, P., Williams, S. and Naim, M. Six S: Creating a more efficient and safer work environment. *Total Quality Management and Business Excellence*, vol. 25, no.11, pp 1410-1428, 2014 DOI 10.1080/14783363.2012.704281.

Nagyova, A., Pacaiova, H., Markulik, S., Turisova, R., Kozel, R. and Dzugan, J. Design of a Model for Risk Reduction in Project Management in Small and Medium Enterprises,*Symmetry*, vol 13, no.5, 2021 DOI 10.1111/ijfs.13505.

Naji-Tabasi, S., Shahidi-Noghabi, M. and Hosseininezhad, M. Improving the quality of traditional Iranian bread by using sourdough and optimizing fermentation conditions. *SN Applied Sciences*, vol. 4, no.5, 2022 . DOI10.1007/s42452-022-05034-8

Pedone, L., Schultz C. and Walter, F. Applicability of the production effort units method in a bakery: an evidence from a case study. Systems & Management, vol 12, no 1, pp 38-48, 2017.

Purseys, J. Biotechnology-inspired solutions to further increase sustainability and wholesomeness in the bakery market. Cereal Food World, vol 65, no 6, 2020

Quintana, L., Ariasb, C., Cordoba, J., Moroy,M., Paudillo, J. and Ramirez, A. Ergonomics, automation and logistics: practical and effective combination of methods of work, case study of a company bakery, Work 41, Bogota, Colombia, 2012.

Serrano, J. How to apply Lean Manufacturing in your company. Blog, Light up your business. Avaliable: https://sixphere.com/blog/aplicar-lean-manufacturing/, 2020.

Tursunbayeva, S.,,Iztayev, A.,Mynbayeva, A.,Alimardanova, M.,Iztayev, B. and Yakiyayeva, M. Development of a highly efficient ion-ozone cavitation technology for accelerated bread production. Vol 1 Ep 1,1-12,2021

Zgodovova, K., Bober, P., Majstorovic ,V., Monkva, K., Santos, G. and Juhaszona, D. Innovative Methods for Small Mixed Batches Production System Improvement: *The Case of a Bakery Machine Manufacturer.* Vol 2, E 1.pp. 1-20, 2020

Biographies

Jhoel Veliz Veliz: Bachelor of Industrial Engineering from the University of Lima with a specialty in the areas of Logistics and Supply Chain. With two years of experience in sales through retail stores, wholesalers, ecommerce and sales in own stores. He has taken courses in Workplace Safety, Finance and Business Management. Jhoel is currently taking Import Management courses with the purpose of improving the purchasing processes of product containers in companies.

Jimmy Cardenas Peña: Bachelor of Industrial Engineering from the University of Lima with a specialty in the areas of finance and business. With three years of experience in the banking sector and capital markets. He has taken specialized courses in finance for commercial management and agile methodology. Jimmy has experience as a general manager of a bakery in the city of Lima. He knows all the internal and external operations of the bakery. Jimmy is currently taking SCRUM courses in order to continue improving processes in areas of any sector.