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LEAN Model for Optimizing Plastic Bag Production in Small and Medium Sized Companies in the Plastics Sector

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ABSTRACT

The plastic industry in Peru has experienced considerable growth in recent years, primarily due to an increase in the national production of plastics within the country and the different factors that have contributed to this phenomenon. However, small plastic packaging manufacturers, due to the context in which they operate, often experience delays in production. Various factors contribute to these delays, such as a lack of raw materials, defective products and reworked products. Thus, lacking standardized methods or tools for production flow leads to delays in delivery times of the product to the client. It has been indicated that 41.67% of unpunctual deliveries occur in SMEs. In the present study, the current and proposed processes were simulated and modeled in order to reduce waste through the application of the proposed methodologies.

Keywords: Lean manufacturing, 5s, Jidoka, Kanban, waste reduction, simulation.

1. INTRODUCTION

In recent years, the plastics industry in Peru has fluctuating in behavior, with significant growth in 2007 (10.9%) and 2010 (19.1%), and with reductions in production in 2009 (-3.9%) and 2012 (-0.8%) according to the IEES (National Institute of Enconomic and Social Stuides) and the SNI (National Industries Society) (2014). The industry has not had a constant growth standard, so improvements necessary. One of the essential achievements for companies that want to improve competitiveness and remain active in the market is the need to produce efficiently without causing delays in the delivery of the product, which requires compliance with quality, quantity and delivery deadlines.

Due to this, manufacturing companies look for efficient and effective processes, in addition to the implementation of more efficient production systems.

There are several methodologies that lead to the improvement of processes. Japanese techniques have been an important reference; you can find an extensive bibliography that facilitates its knowledge and application in manufacturing that reduces waste without large investments of money.

The plastics sector has maintained a stable demand and typically avoids delays in delivery times. However, compliance with delivery times can be affected by various areas of waste in production, which has resulted in additional costs in overtime and penalties. Through analyses of the activities of this sector, the main problem has been identified as non-compliance with the delivery terms of the products. Therefore, among the different causes, shortages of materials, defective finished products and reprocessing stand out as the most significant.

After determining the primary issue and its main causes, we propose the implementation of a methodology that can benefit an organization. Therefore, based on the criteria considered to be important, the implementation of the Lean Manufacturing tools was decided through an evaluation of processes, among which are the 5s, Jidoka and Kanban. These techniques will be applied in order to reduce or eliminate the main causes analyzed.

In this study, a simulation was performed in two work environments: with and without implementing the Lean Tools using the Arena program as a simulation tool. The manufacturing processes for both cases are presented. Finally, the results are reflected upon for the proposed indicators, especially in the index of compliance of delivery terms.

2. LITERATURE REVIEW

This section reviews the current literature regarding the success stories of companies that have applied the LEAN methodology and its tools.

According to Rosnah & Othman (2012), a study was performed in a plastic molding SME company located in Malaysia, where production was below capacity, which led to losses within the industry. Each of the injection molding machines was dedicated to several customers. Therefore, the model change time and product delivery time played an important role in ensuring that the manufacturers were able to satisfy the demand of the customers in order to avoid dissatisfaction. By applying the Lean methodology, productivity increased by 94.1%, delivery achievements increased by 100%, the time of change was reduced by 38.5 minutes and the reduction in the total inventory equated to 2.86 days. Therefore, it can be concluded that the Lean Manufacturing methodology helped to obtain an improvement in the indicators related to waste.

Qian (2012) mentions that due to the higher orders from clients, the department in charge experienced difficulties in planning with precision due to a lack of information regarding the total real stock. They also had to check the status of each item twice a day. Therefore, they had an issue with inventories of high stocks and inefficiencies in control. A simulation model of the frequency of delivery for the replenishment process of the selected populations was developed to analyze the frequency of delivery of the provider upon implementing the Kanban system. Likewise, the average trend of actions before and after the implementation of Kanban was analyzed to compare the effectiveness of stock control between the Material Requirements Planning (MRP) and the Kanban System. This tool of Lean Manufacturing helps to control and maintain an efficient process, as it provides accurate information of stocks.

According to Puche & Costas (2012), a classic source of waste are defective products, which can lead to either a reworking to recuperate the piece of the production system or a reduction in the production system if that would more economical tan reworking or if there is simply an inability to remedy the problem. These case studies were intended to demonstrate the favorable effect of the implementation of Jidoka. The favorable effect of the Lean Manufacturing paradigm and positive impact of the use of the Jidoka principle on the reduction of defects in production systems was demonstrated by discrete simulation techniques.

Agrahari, Dangle & Chandratre (2015) indicate that global markets are continuously changing and demanding high quality products at low costs. In India, the survival and growth of the small-scale industry depends to a large extent on its ability to innovate, improve operational efficiency and increase productivity. Thus, many businesses have been trying to adopt new initiatives such as the 5S. Following the 5S methodology leads to significant improvements in safety, productivity, efficiency and cleanliness. It also intends to build a stronger work ethic within management and the workers who are expected to continue good practices. The objective of their study was to increase the storage by 30%, create and preserve the standards and service procedures specific to the workshop, reduce unproductive time by 10%, redefine access, work and storage spaces, and readjust location. The Lean Manufacturing tool used in this case study helped in different factors; however, depending on its application, significant improvements can be achieved in a company's entire process.

Anđelković, Radosavljević & Stošić (2016) carried out a study in a Serbian company that was experiencing issues in its warehouse. The Lean methodology was applied to improve not only all processes within the company that can produce waste, but also in warehouse operations. They demonstrated their analysis of the storage process before and after the application of the methodology. In addition, they indicated which parts of storage should be improved and the correlation between the different areas of storage, taking into account the opinion of employees in the areas of purchase, production and logistics. It should be noted that Lean tools are essential when it comes to waste reduction. In addition, it is very necessary to maintain control of a warehouse and information of everything going on inside it.

All case studies analyzed had applied various tools of Lean Manufacturing and proposed different applications. In the first case study, the authors noted that increases in productivity could be obtained; they also managed to deliver on time and achieved reductions in total inventories. It should be noted comparisons had to be made between different SMEs in their respective countries in order to have a clear idea of how to use the methodologies to obtain better results in the indicators. On the other hand, in the second case, it can be highlighted that with their simulation model of the delivery frequency for the replenishment process, they were able to control the stocks in order to make the process more efficient. It can be added that the author had to analyze not only the real stocks and the stock in the system, but also all factors that caused these problems so that this tool could help him to improve the processes.

Therefore, in the third case study, the authors utilized Jidoka as a tool for solving waste issues such as rework or defective products. This system reduced the defects in the production system; however, more waste could be reduced if another Lean Manufacturing tool is utilized.

In the fourth case, the authors indicated that the 5S tool was implemented to achieve a reduction of unproductive time, increase storage space and create standards to maintain order within the area. The authors also focused on the storage area and could expand this application throughout the company by identifying the processes most affected by this waste.

Finally, in the last case study presented, the application of Lean Manufacturing tools can be highlighted, which helped improve the processes within the warehouse. In contrast, the authors had to delve deeper into the issue of what tools would be used to improve warehouse operations and reduce waste in the warehouse.

3. PROPOSAL

In order to create the improvement proposal, it was necessary to analyze the tools that Lean presents for further study with each of the main causes that were found. Lean is a philosophy that focuses on eliminating waste in a business; therefore, the tool system that this methodology employs is focused on achieving this objective.

3.1.Implementation of Jidoka

With the Jidoka tool, the aim was to increase the quality of the product by reducing the number of defects in the activities. Therefore, it was necessary to change or improve the working methods so that they follow a proper flow and decrease the percentages of the defective final products, returns and reprocessing.

The implementation begins with training sessions addressing the basic principles of Jidoka when applied to all aspects involved in the processes. A document was delivered that included: *Jidoka: objectives, characteristics and benefits.* By these means, we identified one of the most frequent defects in the production line and implemented the general concepts of Jidoka, which seeks to develop a solution to said defect by using Jidoka. Then, the goal of Jidoka was written in terms of the company's processes, and each process was associated with the main desired benefit through the application of the tool.

The next step was to clearly define the specifications that each of the products made by the process must meet. For this, it was necessary to include technical charts that indicate the specific measures of each product. Subsequently, the specifications related to each area and its respective work stations that comprise it were defined. The impact of what is performed in each job in compliance with the specifications must be clearly established.

3.2. Implementation of 5S in a plastic production plant

When implementing the 5S, each workstation is expected to maintain order and discipline. Likewise, any objects that are not used by the machines or their operators as well as those objects cannot be used due to their deterioration and obsolescence are ideally removed from the workspace.

The implementation of 5S begins with training the involved personnel in the basic functions of the tool, its characteristics and its advantages. This training is developed in three steps. First, at the beginning of the training, each assistant turns in a brief document that contains the following information about 5S: What is it?; process objectives; process characteristics; and process benefits. Then, training is given in the first three areas of 5s (Organize, Order and Clean). This is first done by organizing a meeting where explanations are given, activities with applications throughout daily life (work, home, among others) are performed, and finally training in Standardization and Discipline is given. Lastly, those participating in the training describe in writing the objective of 5S in terms of the processes of the business and how they associate this process with the main benefit that is obtained through the use of the tool.

The first S, Organize, is based on the classification of different elements that are found within the workspace. In this step, the classification of materials, machine components, tools and other necessary and unnecessary objects should be performed so that nothing that in the area that is unrelated or useless is within the workspace during the process.

The unnecessary objects found should be labeled with a red 5S card so that the operator knows that this object should be removed from the area. In Figure 1, a format for how the red card should be used and filled out is shown.

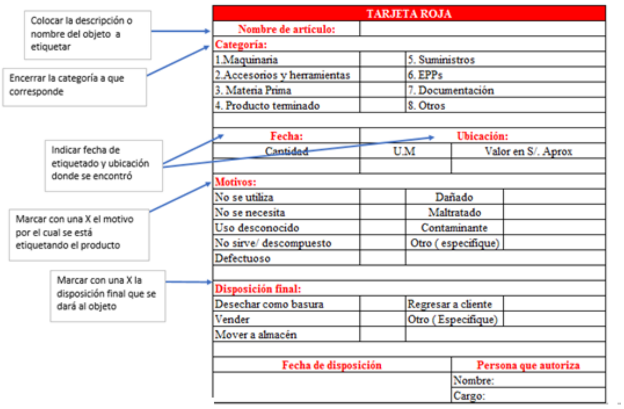

Figure 1. Red card informative chart

The second S, Order, involves ordering the elements within the work area so that an order for the use of materials and tools is established. To accomplish this, signs in different colors (red, yellow and green) for low, medium and high priority, respectively, should be placed on objects so that they can be rapidly identified by the personnel.

Figure 2 shows an informative table detailing the action of identifying the frequency of use of objects in the workspace.

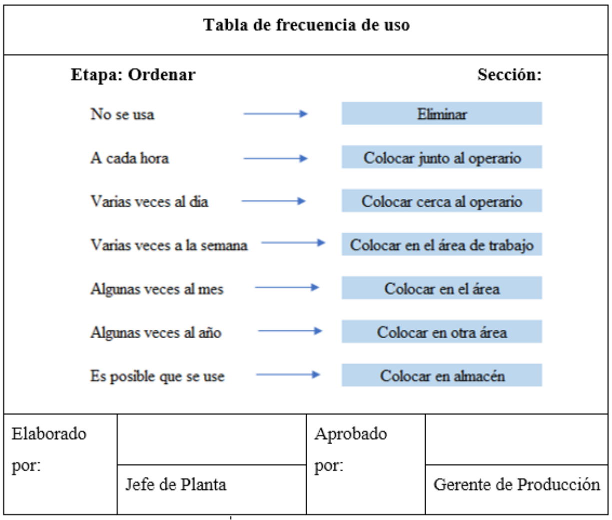

Figure 2. Use frequency chart

The third S, Clean, seeks to systematize cleaning in order to guarantee coordinated teamwork among those involved. In order to do this, it is necessary to establish a schedule with defined tasks, the time those tasks take, the tools used, and the people responsible for the completion of each activity.

In the next S, Standardize, the goal is to realize the previous 5S steps in order to develop a procedure for the implantation of the 5S program in the area of study. In this step, reference documents and table are elaborated in detail so that the machine operators and area supervisors can better understand how 5S is applied.

3.3. Implementation of Kanban

The idea of Kanban replenishment is established one the Kanban container no longer has any more items that emit a signal or alarm that indicates the need to replace a previously established quantity of an item, taking into account the time it takes a supplier to deliver new items and the rate of consumption.

In order to implement Kanban replenishment, the following points must be determined: analyzing the monthly consumption of the SKY, determining the lead time of suppliers, establishing the size of the Kanban, establishing the mechanism and way in which the replenishment signal is given.

Mara Plastics S.A.C. currently has a high index of defective products, machine stops, returns, reworking and material waste, all of which are the result of low operational performance and which thus reflect on the profitability of the business. The characteristics mentioned generate a delay in delivery times, which indicates a need to improve its operational efficiency. The ranges of delivery times that Mara Plastics S.A.C. is capable of, based on its objectives of operability, is established as between 15 and 20 days. However, given what has been observed and determined in practice, the delay experienced in delivering orders can vary up to 60 days.

According to a study of the registers from 2016, it has been possible to establish the annual average delivery times which indicated a lack of punctuality or delays in 41.67% of cases. This indicates that the index of untimely delivery orders is elevated.

It was also found that the business has an index of 18% of defective products, 7% of reprocessing already made products and 65% of replenishment of raw material. All of these indicators show the need to implement systems of production that are more efficient and help to fulfill the objectives of the organization. Lean Manufacturing is one of the initiatives that is focused on cost reduction as well as waste reduction.

The implementation of Jidoka in Mara Plastics S.A.C. begins with the training of involved personnel regarding the fundamentals of Jidoka and then with the drafting the objective of Jidoka within the business Mara Plastics. In this case, the objective was: "To ensure 100% quality products through a commitment of the workers to prevent defects during production." The benefit obtained during the critical point (Sealing) with the application of Jidoka is the following: Inspecting 100% of all products, increasing productivity, reducing the number of defective products and reducing the number of reworks.

Next, the specifications are defined that must be fulfilled by every product made at the plant. The business has a specification that they will produce around 10% more than what was ordered and that variation in the caliber, width and length cannot be more than 10% different from the specifications required by the client. Thus, the operator of each sealing machine must measure the width of the plastic when he inserts the spool and he must verify if the plastic fulfills the specific measurements of the seal order (I-03F-03) and that the product is within the permitted limits according to the aforementioned tolerance.

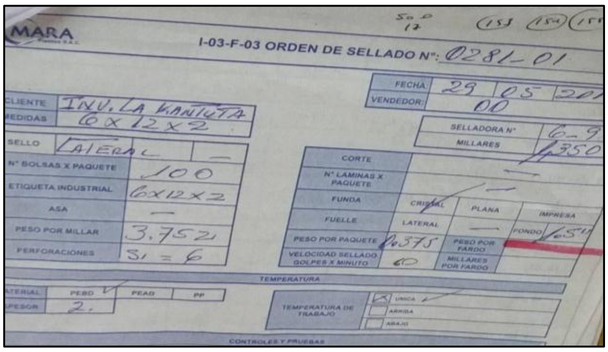
MARA
I-03-F-03 ORDEN DE SELLADO N°: 0281-01
FECHA: 29 05 20
VENDEDOR: 00
CLIENTE: INV. LA KANTUTA
MEDIDAS: 6 x 12 x 2
SELLO: LATERAL
SELLADORA N°: 6-9
MILLARES: 1350
N° BOLSAS X PAQUETE: 100
ETIQUETA INDUSTRIAL: 6x12x2
ASA: —
PESO POR MILLAR: 3.752
PERFORACIONES: SI = 6
CORTE
N° LAMINAS X PAQUETE
FUNDA: CRISTAL, PLANA, IMPRESA
FUELLE: LATERAL, FONDO
PESO POR PAQUETE: 0.375
PESO POR FARDO
VELOCIDAD SELLADO GOLPES X MINUTO: 60
MILLARES POR FARDO
TEMPERATURA
MATERIAL: PEBD, PEAD, PP
ESPESOR: 2.
TEMPERATURA DE TRABAJO: UNICA, ARRIBA, ABAJO
CONTROLES Y PRUEBAS

Figure 3. Seal Order I-03-F-03

Likewise, the related specification of each area must be defined (See Table 1) and the respective work stations must conform to these specifications.

The review of the completed products consists of a visual inspection, which takes the following points into consideration:

- Visual inspection of the bags, measuring the external seal as an initial assessment of seal integrity.
- Inspection of the package and seals for signs of seal runoff or rolling.

Table 1. Areas responsible for fulfilling specifications

Specifications	**Responsible Areas**
Spool dimensions	Extrusion
Clear and central print	Printing
Bag with uniform seal	Sealing

On the other hand, a work routine is proposed and an improved work method will be determined.

Work routine:

Before operating the equipment, the machinist must be familiar with its operation, components and the necessary safety considerations. For the heat sealing process to be carried out correctly, the operator must follow a certain work routine.

1. Ensure the equipment has been adjusted to the dimensions and other characteristics of the bags to be sealed.
2. Turn on the equipment. The ignition switch is located on the side of the digital controller.
3. Enter the sealing parameter values into the digital controller.
4. Proceed with the sealing operation(s).
5. Turn off the equipment.

Work method:

To seal a plastic bag, the operator must follow this method:

1. Place the spool on the roller of the sealing machine. The spool must be completely centered for the seal to be suitable.

2. Unwrap the spool and place it on the rollers, then ensure that the plastic is tensioned on each roller.
3. Check the width and thickness of the bag.
4. Initiate the sealing process by means of the switch.
5. The piston seals the bag with the parameters established in the digital controller.
6. Perform a quality control after every 50 bags, checking sealing, printing and thickness of the bag.
7. Remove the sealed bag. Ensure it meets the specified characteristics.

In addition, this process requires the assistance of a quality supervisor. Therefore, it is imperative to outline a position profile, to search for personnel with the necessary characteristics for the position.

For the implementation of the 5S, the following steps must be taken into account:

- Determine the person in charge: Define the coordinator for the implementation and monitoring of the 5S system, generate procedure, applicable area and responsible for these.
- Training and dissemination: Train the operators and head of the sealing area to follow good practices for environmental quality.
- Implementation of 5S: Classify, organize, clean, standardize and discipline.
- 5S Audits
- Corrective actions: Contingency plans to correct and prevent non-conformities.
- Follow-up: Check-ups and internal inspections of the area, closing of audits.
- Continuous improvement.

Firstly, the proposed steps and other representative texts of lean manufacturing are considered as a starting point, also taking into account the characteristics of the plastic bag manufacturing process, defects present in the product, and the organizational culture of the company Mara Plastics.

Having considered the implementation steps, we proceed to the training process, to identify restrictions and pre-requisites for the application of the 5S in the sealing process.

The following are considered pre-requisites:

– Confirm steps for each of the 5S in order to produce logical and consistent results for standardization and self-discipline in the workplace.
– Establish a space to store materials which are seldom-used, as well as for unnecessary materials, within the company Mara Plastics.

In terms of restrictions, we observed that this tool does not have any restrictions, since this depends on the organization of the person's surroundings.

Subsequently, the tool's scope must be established, which consists in the sealing area, since the majority of the causes occur in this part of the process. Next, the objective of 5S should be outlined, which is to "Improve the infrastructure of the area in question, to increase operational efficiency, promoting organization, standardization and cleanliness, with the co-operation of production team members". The application of 5S in the area in question (Sealing) will produce the following improvements:

- Reduce defects in the plastic bag sealing area
- Greater quality control
- Faster response times

Likewise, a space must be added to start the waste elimination process; Mara Plastics could consider using part of the sealing area next to the last sealing machine.

The next step is to classify the different elements within the work area. This step involves classifying materials, machine parts, tools, and other objects as necessary or unnecessary for the sealing process, and subsequently remove all unnecessary objects from the sealing area.

To promote this principle, information cards will be used to show the current situation of the sealing area; see Figure 4.

Programa de 5's

Etapa: Clasificar **Sección: Sellado**

- Tucos y papeles en el suelo del área de sellado dificultando el paso.
- Cajas y bancos pequeños sin uso al lado de algunas selladoras
- Diferentes trapos industriales, cinta adhesiva y herramientas en el área de sellado

En las anteriores imágenes se identifican objetos que no son útiles en el proceso regular de sellado, por lo que en esta etapa de 5's se requiere verificar qué objetos se utilizan con mayor frecuencia y clasificarlos según las veces de uso y con ello definir su cercanía al proceso, esto nos llevará a conseguir la optimización del uso del espacio.

Elaborado por:	Jefe de Planta	Aprobado por:	Gerente de Producción

Figure 4. Information card for classification stage

In the classification process, many unnecessary or seldom-used objects were found, reducing available space and tidiness in the work area. As such, an inventory of the unnecessary objects was made (Table 2).

Table 2. Inventory of unnecessary objects

Inventory of Unnecessary Objects			
Item	**Description**	**Quantity**	**Observation**
1	Dirty Industrial Rags	15	Lifecycle has completed
2	Unused Tools	7	
3	Pieces of Wood	4	One-time use
4	Different types of industrial tape	8	
5	Obsolete machine parts	-	Area supervisor will determine final use.
6	Defective bags from other sealers	-	Unusable
7	Bag design plans	3	One-time use
8	Used Notebooks	2	Unusable
9	Empty Gallon Buckets	4	
10	Dirty wooden blocks	6	

All unnecessary objects should be labeled with a red 5s card, so that the operator can indicate whether the object should be removed from the area.

In the organization step, the spools should be ordered according to the orders, with high urgency orders located closer to the sealing machines, followed by medium urgency and low urgency orders. Ordering cards (Figure 5) are used so that personnel can easily identify where each spool goes and thus optimize placement time in the sealing machines.

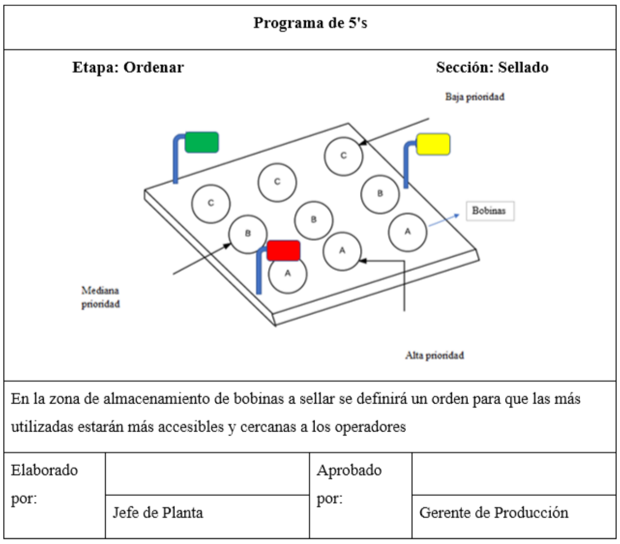

Figure 5. Ordering card

The cleaning stage aims to systemize the clean-up process and promote teamwork, consisting in cleaning routines, methods, times and supervisors. Table 3 details the proposed cleaning timetable for the Sealing area at Mara Plastics. This should be displayed where all operators can see it.

Table 3. Cleaning timetable for the Sealing area

Tarea	Duración	Frecuencia	Materiales	Jefe de área	Sellador n
Limpieza en la selladora	20 min	Diaria	Aceite y trapo industrial	x	
Limpieza y ordenamiento de zona de productos no conformes	10 min	Semanal	Trapo industrial		x
Limpieza y ordenamiento de zona de espera de bobinas	7 min	semanal	Escoba y recogedor		x
Limpieza interior de la selladora	25 min	Semanal	Aceite y trapo industrial		x
Limpieza de piso del área	20 min	Interdiaria	Agua, escoba y recogedor		x

In the final stage of 5S, standardization, the previous steps are implemented for all personnel. To this end, an implementation protocol is established for the sealing area, which details the supporting documents and tables so that the operator and area manager may better understand the 5S.

To implement Kanban, begin with a raw material consumption analysis, with units of 25kg sacks. Raw materials for this analysis were: polypropylene (PP), low-density polyethylene (LDPE) and high-density polyethylene (HDPE).

Subsequently, average daily consumption is calculated; and average monthly consumption is divided into four weeks. The PP, LDPE and HDPE supplier offers a two-week lead time for the company's usual order.

The size of the Kanban is determined by multiplying storage time and daily consumption, as shown in Table 4. As such, Kanban size was established as 635 sacks of raw material, which is the most frequent trimestral result. Therefore, once sack n° 636 is removed, the restock alert should appear. The proposed mechanism is a push-to-break switch, connected by relay to a warning light located in the administration offices, since they are in charge of purchasing.

While sack n° 636 remains in its place, the switch will remain closed and as soon as the operator takes it off, the switch will close and a light will come on, signaling that sack repositioning is necessary.

Table 4. Kanban size calculation

Period	Storage time in weeks	Average consumption in sacks	Size of Kanban
1st Trimester	2	270	540
2nd Trimester	2	317.5	635
3rd Trimester	2	317.5	635
4th Trimester	2	287.5	575

Additionally, a standard removal sequence is required to ensure that sack n° 636 will always be the one pressing the switch.

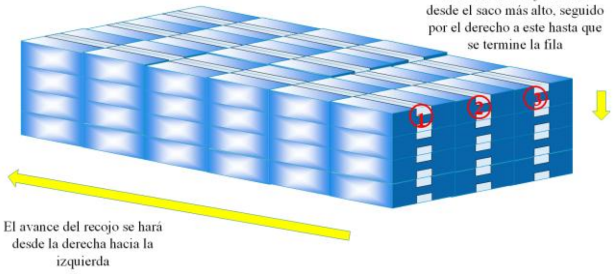

Figure 6: Sack removal sequence

Figure 7 (below) shows how the push-to break switch works and the established Kanban size. Figure 8 presents an electrical circuit diagram for the Kanban alert mechanism.

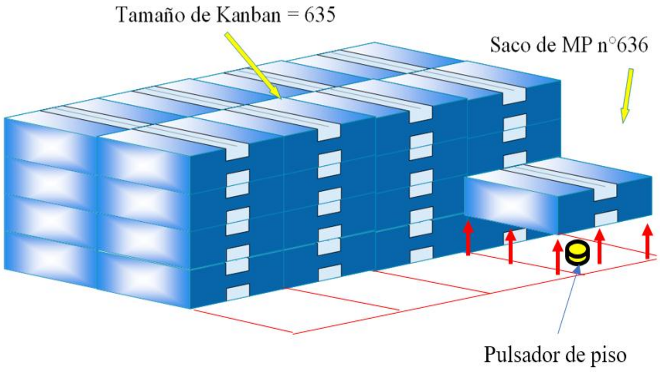

Figure 7. Kanban replenishment system

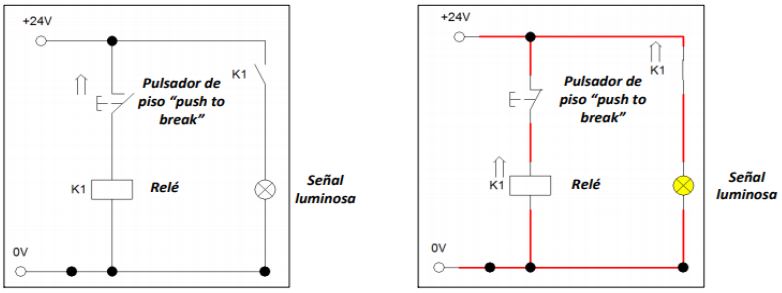

Figure 8. Kanban alert mechanism

Finally, the Kanban replenishment system requires the commitment of both warehouse operators and management. The system must also be checked frequently to avoid failure.

4. VALIDATION

To simulate the current system and the solution proposal, workstation time samples were used as input data. To this effect, the Input Analyzer tool in the Arena Simulator program will be used to analyze the input data according to the probability model presented by each one.

The simulation needs to know which processes are to be programmed, as shown in the system diagram (Figure 9).

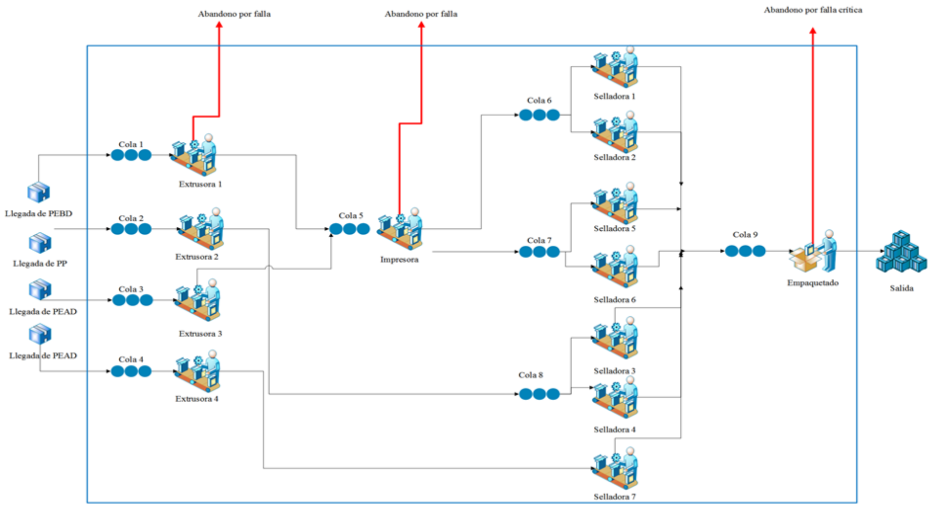

Figure 9. System diagram

Figure 10 displays the current system simulation based on data from the Input Analyzer.

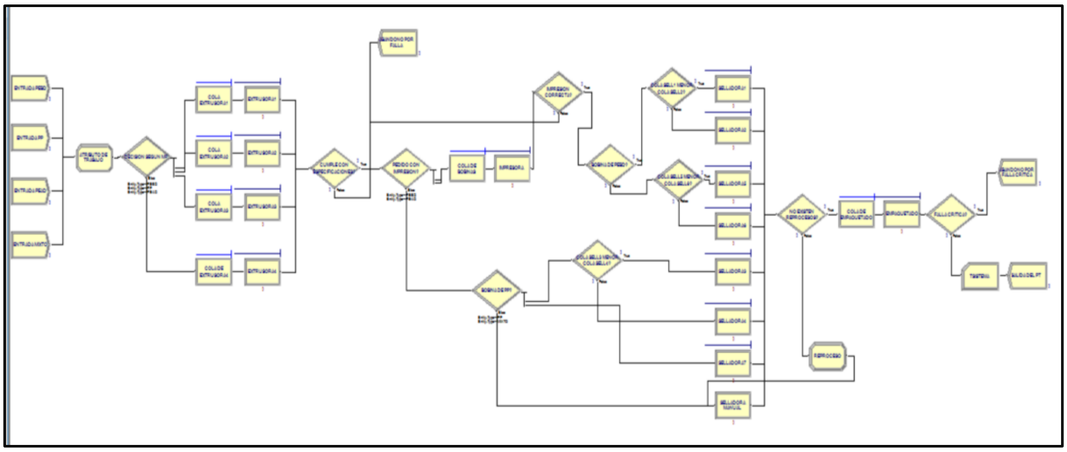

Figure 10. Simulation of the current system

Figure 11, however, presents the proposed system simulation, which includes the proposed Lean tools.

Firstly, with respect to the Kanban replenishment principle, the adequate supply of materials is assured; therefore, the delivery intervals between each batch of raw materials at the beginning of the production process is decreased by 45% compared to the data in Figure 5. On the other hand, the 5s methodology has the objective of organizing the plant to subsequently make improvements in the affected area.

Finally, Jidoka means checks are performed at the source, so each operator will perform his/her own quality control, as established in the work method.

Likewise, with the help of the Quality Assurance Supervisor, the root causes of any defect can be analyzed to take the corresponding corrective action. In Figure 6 lights added to each station will turn red when there is a fault; also, the Inspection area will be linked with the station to proceed with the analysis.

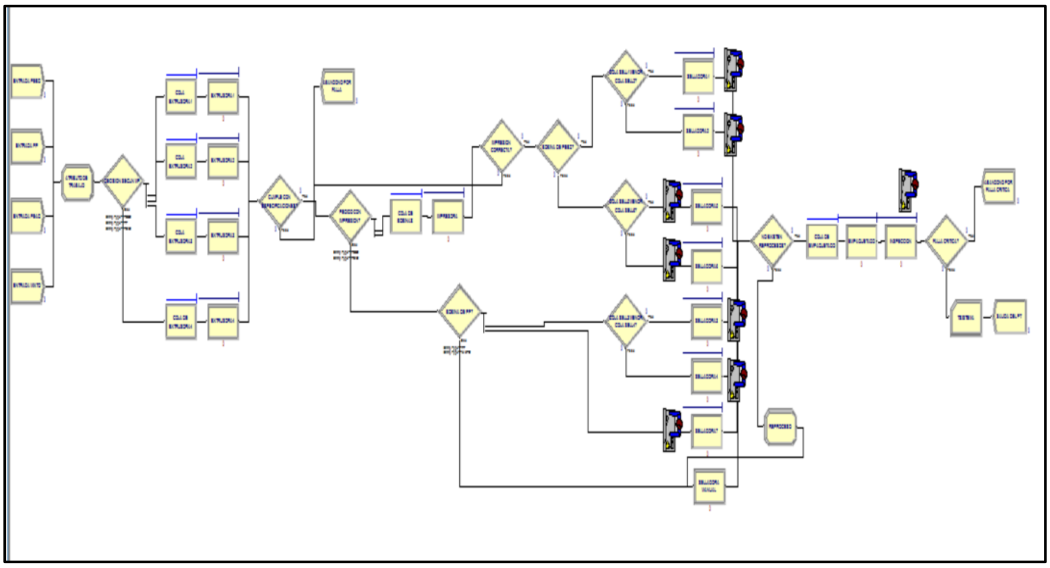

Figure 11. Proposed system simulation

In both cases, the simulation produces a report with the necessary data, as well as the statistical results. Therefore, this simulation confirms that the proposed model does not present errors, that is to say, the data are operationally viable according to the proposed tools.

To analyze the results of the proposed solution simulation, we must first analyze the current company data. The monthly average order is 47 batches, of which 58% meet the date established with the customer, which generates the need for extra/night shifts. This represents the company's current situation, where material shortages are accounted for during the delivery intervals between each batch of raw materials. This means that the extrusion machines are delayed, which is reflected in the entire production process.

Furthermore, an average 12% of batches are defective per month and an average 5% need to be reworked. Figure 13 presents the current model simulation for both work shifts over a period of ten days, producing only eight batches. This means that 21 orders would be produced in a month, far from the 47 batches agreed with clients. In addition, the simulation presents the number of critical failures, i.e. reworked and defective products; one batch during the 10-day simulation. The usage percentage for each extrusion machine or workstation is approximately 52%, due to delays while waiting for raw material to arrive.

In the proposed system, the simulation also ran for ten days, to easily compare the current model with the proposed Lean tools. Figure 13 presents the model simulation, which produced 17 batches. This means that 45 would be produced in a month, or 95% of the monthly orders. The simulation also evidences zero reworked or defective products during the 10-day period.

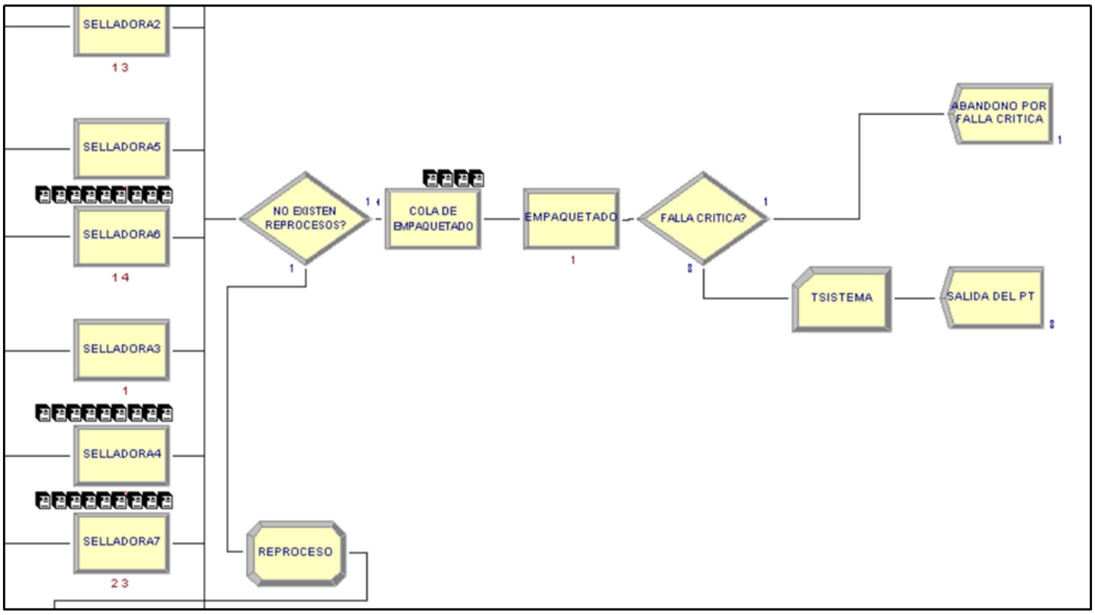

Figure 12. Simulation of the current situation in the sealing area

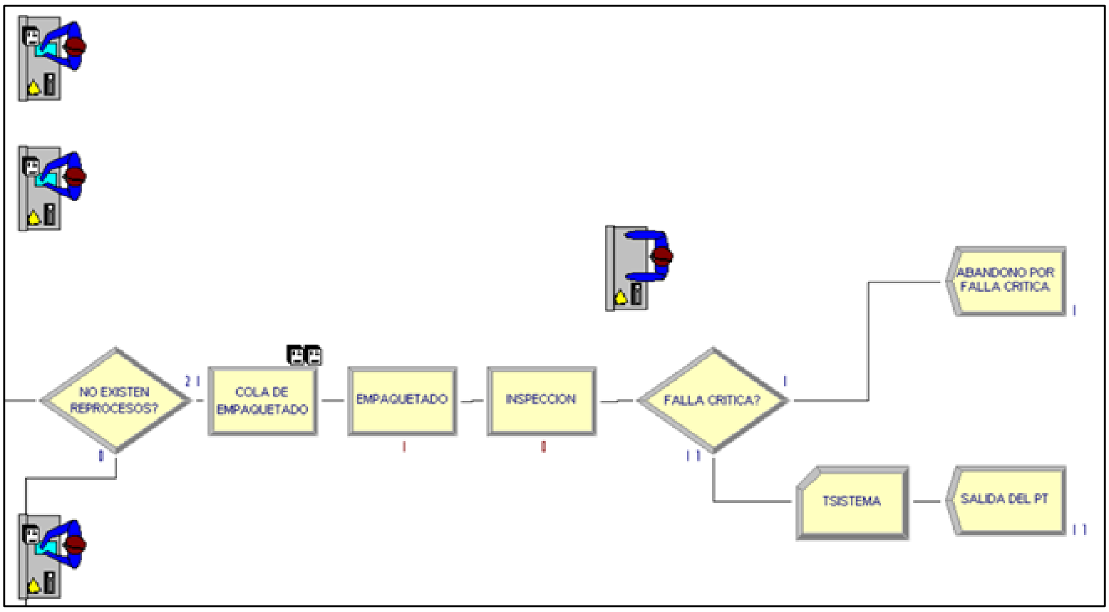

Figure 13. Simulation of the proposed system in the sealing area

With the data produced from the both simulations, a comparison can be drawn between the two models and the following validation of objectives (Table 5).

Table 5. Validation of objectives

Nombre	Tipo	Meta	Colorimetría			Frecuencia	Situación actual	Situación después de mejora
			Verde	Ambar	Rojo			
Índice de cumplimiento de plazos entregas	Creciente	>= 95%	>80%	<80%-70%]	<70%	Mensual	58%	95%
Índice de productos defectuosos	Decreciente	<= 12%	<= 15%	<15% - 20%]	> 20%	Mensual	18%	10%
Índice de productos reprocesados	Decreciente	<= 5%	<= 6%	<6% - 7%]	> 7%	Mensual	7%	3%
Exactitud de reposición de materia prima	Creciente	>= 95%	> 85%	<85% - 70%]	< 70%	Mensual	65%	90%

The proposed model will reduce costs due to delivery dates not being met, also reducing late fees and overtime pay. A financial analysis will demonstrate that the proposed system is more beneficial than the present model with respect to the proposal's implementation costs. This improvement will require investment, entailing a series of costs for the company. However, this investment could lead to significant savings, increasing productivity in the areas studied and improving the manufacture of plastic bags.

In the following section, we will analyze the impact of the proposed model on the company's financial situation:

- Reduced late fees: Current clients apply late fees for non-compliance of deadlines. With the proposed system, the company will be able to meet 100% of deadlines, reducing the probability of late fees. Table 6 presents the approximate monthly saving:

Table 6. Approximate savings due to no late fees

Penalties (S/.month)			
Before	**After**	**Reduction (%)**	**Savings/month**
S/. 15,600	0	100%	S/. 15,600

Table 6 shows the savings that represented by not having non-compliance penalties within the company, approximately S/. 15,600 per month.

- Reduction in overtime: With the purpose of mitigating delays in the production line, instead of overtime work, an additional shift is added (night shift) to the current shift schedule (morning and evening shifts). Table 7 represents the savings to the company by adding an additional shift.

Table 7. Overtime Savings

Cost/overtime (S/.Month)			
Before	**After**	**Reduction (%)**	**Savings/month**
S/. 4,920.81	S/. 0	100%	S/. 4,920.81

Table 7 details the savings with a 100% reduction in costs in overtime that can be obtained from filling the demand. Monthly savings amount to S/. 4,920.81

Table 8. Benefits obtained by the improvement plan

Monthly savings	
Penalty Savings	S/. 15,600
Overtime shift savings	S/. 4,920.81
TOTAL	S/. 20,520.81

The above table shows the benefits obtained with the improvement plan, representing an approximate monthly savings of S/. 20,520.81. Also, these savings should consider the various investments that were previously estimated.

Fort the cost-benefit analysis proposed solution, economic impact is evaluated through Actual Net Value and the Internal Rate on Return under two scenarios:

Optimal Scenario (Recover 100% of the cost overruns (penalties and overtime hours)

• NPV = S/. 43,433.01

• IRR = 36.10%

• PP = Eighth month

• Cost/Benefit = 4.277

In this way, as the net present value (NPV) is higher than zero (S/. 43,433.01 >0), it can be determined that if the implementation is carried out, over the long-term, the investment will be profitable. Similarly, the internal rate on return (IRR) is higher than the opportunity cost of capital (OCC) (36.10% > 9.5%), meaning that the performance rate that is produced by the initial investment will be higher than the minimal acceptable rate of performance to carry out the project and guarantee the performance required by the company.

Finally, the payback period (PP) of this implementation comes within the eighth month, meaning that the initial investment is recovered in a relatively short time.

Intermediate scenario: Recover 80% of the cost overruns, (penalties and overtime hours).

• NPV = S/. 36,528.98

• IRP = 31.45%

• PP = Sixth month

• Cost/Benefit = 3.421

In this way, as the net present value (NPV) is higher than zero (S/. 36,528.98 >0), it can be determined that if the implementation is carried out, over the long-term, the investment will be profitable. Similarly, the (IRR) is higher than the opportunity cost of capital (OCC) (31.45% > 9.5%), meaning that the performance rate that is produced by the initial investment will be higher than the minimal acceptable rate of performance to carry out the project and guarantee the performance required by the company.

Finally, the payback period of this implementation comes within the sixth month, meaning that the initial investment is recovered in a relatively short time.

5. CONCLUSIONS

In the studied company, the principal problem was identified as untimely delivery of finished products to customers, creating losses due to penalties and extra hours. The annual untimely delivery in this regard during 2016 was 41.67%. After more careful analysis on what causes these untimely deliveries, the principal reasons were defective products, reprocessing and inadequate material shortages. Also, the level of reprocessing that the company possessed, especially in the sealing area was greater than 5%. On the other hand, incidences were analyzed regarding internal production orders that were not satisfactorily carried out because of material shortage, obtaining 22% stockout.

One of the solutions to decrease the percentage of defective products was the implementation of Jidoka, based on changing and/or improving work methods. The same method, as well as 5S were proposed to reduce the percentage of "rework." Another solution was the Kanban replenishment principle, using a floor pushbutton, relay and a light signal to achieve exact replenishment of raw materials. As a consequence, simulations were done with the actual and improved situations, where a decrease in waste was seen, complying with delivery times. Defective products were reduced from 18% to 10%, rework products were reduced from 7% to 3% and an increase in raw material replenishment was from 65% to 90%, arriving at an improvement in the delivery time compliance from 58% to 95%.

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