Case study of the implementation of pull production in a company of plastic packaging segment.

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Abstract

A manufacturing process generally involves numerous controls and different kinds of programming and one of them is the pull production system. The pull production system is identified by its visual way to see the need of production, the synchrony between the stages of production and simplicity, as the programming is only sent when the consumer wants it. Using this system, there is a significant reduction of inventories as these are controlled and dimensioned. The pull production system is characterized by its visual way to see the need of production, synchrony between the stages of production and simplicity, because the programming is sent only when the consumer wants. Using this system, there is a significant reduction of inventories as well as these are controlled and sized. Using the pull production system, it becomes available the possibility for the consumer to pick an item when needed, as they are available in the supermarket of the process. The objective of this research is to evaluate the application of the pull production in an industry of plastic packages. It was elaborated through the bibliographical review of the pull production and case studies, developed in an industry of plastic packages in São Paulo's state, Brazil, anchored on the discussed concepts. As a result, it was obtained a simpler and cheaper control of production, on the very factory's floor, supplying the client's demand at the moment they want it, without the need of carrying large inventories, maintaining a leveled flow of material by the factory.

Keywords: pull production, plastic packaging, reduction of inventories.

1 Introduction

The term lean production was created in the early 90's to name the "Thinking Process" by Taiichi Ohno (Toyota engineer) and the set of methods that describe the production system of Toyota Motor Company. This term became popular in the book "The Machine that Changed the World" (Womack et al, 1992), which clearly illustrates the significant difference in performance achieved by the implementation of the concepts of Lean Production in the Japanese automobile industry, in relation to Western industry.

According Rentes et al, (2000), Lean Production brings together a series of principles to eliminate the waste during production, seeking to meet or even exceed customer expectations. These techniques seek to minimize the losses within the company, generating products with lower cost and enabling the organization to produce at a lower price and without loss of quality.

To better understand lean production, there is a need to define it. In this way Womack et al, (1992), shape this new philosophy production as it follows. 1. It is an integrated production system, focusing on the production flow, small-batch production according to the just-in-time philosophy and a reduced level of inventory 2. It involves actions to prevent defects instead of fixing them 3. Works with the pull production rather than pushed production based on demand forecasts; 4. It is flexible, being organized through working teams formed by multi-task manpower 5. Practice active involvement in addressing the causes of problems with a view to maximize the added value of the final product 6. It Works with an intensive partnership from the first supplier to end customer.

According to Hines and Taylor (2000) the five principles of lean production are: 1. Specify what adds value and what does not, according to the perspective of the customer. On the opposite way of what is done

traditionally, this evaluation should not be done according to the perspective of the company or its departments; 2. Identify all the steps required to produce the product throughout the entire production line, in a way to avoid every kind of waste 3. Promote actions to create a flow of continuous value, without interruptions or delays; 4. Produce only the amount requested by the consumer; 5. Strive to keep a continuous improvement, seeking the removal of losses and waste.

It takes a few steps, principles and tools to create a lean flow for the organization to become a lean company. However, based on the definition of Womack et al, (1992) and the principles of Hines and Taylor, (2000), we noted that both philosophy and principles lead us to: give the client (which may be the next step in the process production) what he wants, when he wants and in the quantity he wants, which means, to generate customer value. According to Liker (2005), if we can accept a request from a client and produce a single product just for that application - using a cell production piece flow - this will be leaner than the system can be imagined. But as there are interruptions in the normal flow of processing raw materials into finished products delivered to customers, it is necessary to use the pull production with a leveled programming.

One of the control tools used by Lean Production, which meets the objectives and principles described above, is the pull production system.

In the "pull system", each next step of the process is a customer from the previous process, which produces to the next step only what was required, which means to supply each process with the exact needed items, in the right quantity and at the right moment. (Cunha et al, 2003).

The objectives of the "pull system", listed by Moura (1989), are: to minimize inventory in the process, minimize the fluctuation of the inventory during process, reduce the "lead time" production, prevent the transmission of larger fluctuations in demand or volume between processes, to raise the level of control through decentralization (delegation of responsibilities); to react faster to a changing demand, and reduce defects.

According to Rother and Shook, (1999), what is intended to be done in the lean production system is to built a process to meet only what the next step needs and when it needs it. It seeks to link the whole process - from the last customer to the raw materials - in a steady flow, without returns, which manages the shortest lead-time, the highest quality and lowest cost.

One of the tools that makes possible to produce only what the next step needs, and when it needs it, is the use of the pull systems based on “supermarkets”, leveling the production range in order to control it.

Pull systems for production scheduling are conceptualized as systems where customers are supplied from a basic stock items only at the time and in the quantities needed (just-in-time), leading from there a due replacement (Monden, 1984; Ohno, 1997, Schonberger, 1992; Moura, 1989). This system generally operated with the tool Kanban cards, frames and preconceived supermarket items, is historically recommended for repetitive production systems in batches (Tubino 1997, Harmon, 1991, Corrêa and Gianesi, 2011).

1.1 Objective

The aim of this study is to evaluate the implementation of pull production in a plastic packaging industry through a script of 12 questions proposed by Smalley (2008). In order to do it, there will be a bibliographical review on the pulled and pushed systems, as well to present the Kanban concepts and the steps to create a leveled pull system. Then you it will be presented the case study held in plastic packaging industry, where it is intended to achieve the objective proposed in this paper.

2 Bibliographical Review

2.1 Pull Production versus Production pushed

An effective and efficient production control system must be able to produce the right quantity at the right time and at competitive cost. All stages of production must be well synchronized, so that materials produced at certain stages of the process come in the correct quantities and at the correct time to the next stages, which will use them.

The production processes with several stages can be classified into two kinds: The pull production and the push production systems.

In the pushing system, the production schedule is based on time schedule. This is done by a core of developers who take the orders, and then schedule each step of the process where these orders should go through. The stages are given the information about the arrival of the requests to be processed, their size, and when they must be concluded. It is common to have several requests waiting in the same process step. In this case, the supervisor decides which one is a priority. The problem is that this priority is not always the same priority to the programming department. This fact and the material delays, broken machines and other unexpected events cause the production schedules to become obsolete as soon as they are created. (Nicholas, 1998).

Even though several authors describe pushing systems under different aspects, (Huang et al, 1998), consider that the pushing systems are generally recognized for operating a release of material in the system. That is, the push production system operates releasing the needed material for the first operation according to the demand's forecast. Then the semi-finished product is released to the next step without any request made by this stage, meaning that the materials are pushed throughout the production process.

Fundamental problems with the push production into batches can be seen: each process in the value stream operates as an isolated island, producing and pushing the product in accordance with the schedules received, rather than meeting the real needs of the following processes. Once this material is not necessary yet, it should be handled, counted, stored, etc... - Pure waste. The faults lie buried in inventories in the process until the next step finally uses these parts and identify the problem. As a result, while the time of adding value to produce a product is too small, the total time that the product takes, through the plant, is too long (Rother and Shook, 1999).

The pull system eliminates the need to program all the operations where a request will go through. Decisions according what to do and the quantity to be done are taken by operators, using a simple sign system that connects the operations through the process. The Kanban system is a method of doing this sign system (Tardin and Lima, 2000).

The pulling system production is, generally, initiated by the last stage of the process. This system requires the existence of small inventories of finished pieces at the end of every step. Thus, only the last stage receives the client's request. To accomplish it, it seeks in a small inventory of parts from the previous steps, the pieces it needs to perform the request. This step, in turn, searches the database of the previous step the parts needed to restore its own inventory, and so on.

Pull production means not to produce until the customer (internal or external) request the production of a particular item (Tubino and Andrade, 2003). The objective of putting a pull system between two processes is to have a way to give the exact order of production to the previous process, without attempting to forecast demand and schedule later the previous process.

However, there are some conditions in order to implement a pull production system: a bigger power for the factory's floor workers, who will decide what, when and how much to produce, to produce what the customer orders, to reduce the amount of material in process, preventive maintenance of equipment, quality assurance, as the inventories should be minimal, minimal setup time in order to obtain flexibility, all steps should be able to produce in the same pace of the final step, relatively stable demand.

2.2 Kanban System

In lean manufacturing, kanban is a specific tool to control information and regulate the movement of materials from the production processes (Smalley, 2008).

Kanban is a Japanese term that means card; this card acts as a trigger of the production (or moving) by the production centers present in the process, coordinating the production of all items, according to the demand for final products (Corrêa and Corrêa, 2008).

Moreover, according to Voss and Clutterbuck (1989 cited by Rentes, 2000) kanban is a pull system control movement of material, which comprehends a mechanism which triggers the movement of a material of an operation to the next. Corroborating with these notions, Liker, (2005), states that Kanban means sign, card, and announcement card.

The kanban is used in pull systems based on supermarkets (product designed stock). On the factory floor, the supermarkets should normally be located near the delivery process to help that process to have a visual concept of customer needs. The responsible one for moving the process material "the client" goes to the supplier's supermarket and withdraws what is needed. This withdrawal triggers the kanban movement since the supermarket up to the supplier's process, where they are used as the only instruction for that production process. (Rother and Shook, 1999).

When the continuous flow is not possible because the processes are far away or because the cycle times to perform the operations vary widely (in the packaging industry), the next best choice is the kanban/pulled system. Rother and Shook (1999) says, "make it flow where it can, pull where it should". If there is a desire to create lean systems, where it is not possible to create the piece flow, the best alternative is the pull system with some inventory and the use of kanban.

According to Slack (2002), there are three types of Kanban cards: 1. transport Kanban: it is used to warn that the material can be removed from a previous step and transferred to a specific destination. This one contains information such as: number and description of the component, place of origin and destination, among others. Smalley (2004), calls it a withdrawal kanban 2. production Kanban: it is a sign for the productive process, meaning that it can start to produce an item to be placed in the inventory; 3. supplier Kanban, there are used to notify the vendor that it is needed to send material or components for a stage production.

2.3 Creating a leveled pull system with the use of kanban

To deploy a leveled pull system using kanban and supermarkets, there is a need to start with a family of products at the closest point to the customer. According to Smalley (2008), it is necessary to answer 12 questions at the time to implement the pull system.

The questions and explanations below are described, according to Smalley (2008):

- What products are to be kept in an inventory of finished products and which ones are to be produced only according to the client's order?

Most manufacturers have a wide range of demands for different end products in their value stream. To target a product there is a need to use the ABC analysis of production. In this analysis we can see the amount of products ordered by customers every day, the "A" products with larger volumes. A second group represents the orders made very often, but not daily, the "B" products with an average volume. And finally, the third group, which consists in products that are not ordered so often, but in very different quantities, making the class "C" of lower volumes.

After the analysis is done, one of the options for the decision of finished products versus on demand production, would be o keep A and B products at the supermarket of finished products and make the C products on demand from semi finished components - mixed pull system.

- What quantity of each product is to be kept at the supermarket of finished products?

After employing the mixed pull system and keeping the finished products for the A and B items, it is necessary to calculate how much each of these items should be maintained and this can be determined by a simple formula that is described in Table 1.

	Average daily demand x lead time replacement (days)	Cycle inventory
+	Changes in demand as % Inventory Cycle	Buffer inventory
+	Safety factor as % of (Inventory cycle + buffer inventory)	Safety inventory
=		Inventory of finished goods (supermarket)

Table 1 - Calculation of finished products. Source: Smalley, (2008, p. 20)

- How to organize and control the supermarket of the finished goods supermarket?

You will need to create places for each item, places carefully designed to ensure that the oldest parts are checked before. They should be posting signs above the storage sites, clearly indicating the maximum quantities for each finished item. It allows the finished products to be organized in a logical and visual way, allowing distinction between normal and abnormal circumstances.

Another important issue is to divide the items A and B into three categories: cycle inventory, buffer inventory and safety inventory, so it is possible to check which stocks are within the normal variation.

- Where to set the value stream?

At this point a process should be selected to work as a general value stream puller and the whole process must be functioning at the same pace - takt time of the pacemaker process.

According to Rother and Shook (1999), the takt time synchronizes the pace of production to keep pace with sales. Is the frequency in which a part or a product must be produced, based on the pace of sales, to meet customer demand. The takt time is calculated by dividing the time available for work (in seconds) per turn, by the volume of customer demand (in units) per shift.

Still, by the same author, the takt time is used to synchronize the pace of production with the pace of sales in the "puller process".

In the pulling replacement system, the final assembly will be the pulling system in almost every case.

- How to level the production in the pulling process?

To level the production the batch sizes in the pulling process must be reduced according to three constraints: 1. Differences in work content between the products: The work content of the pieces that pass through each operation must be evaluated; and if possible in each cell the products should vary only a little and possibly no product should have work content above the takt time; 2. Setup requirements between models: Strategies to reduce the setup time (time for tool changes and the time to put the materials in the right places) should be implemented to allow limitations on the sizes of the batches 3. Pitch interval production: Pitch production determines the maximum length at which the pacemaker process can be leveled by the mix. Pitch is a lean concept and is calculated by multiplying the amount of takt time in a package (number of products per container transferred by the finished products from the cell assembly).

By clearly knowing the daily time available in production, daily demand of the customer per model and the minimum batch size, it is possible to level the production by its mix. For this, it is necessary to divide the available time for production by the pitch to calculate the number of pitch intervals available to meet demand.

- How to transmit the demand information for the pulling process in a way to create the pull?

In the lean production, the specific tool to report the production orders to regulate the movement of materials is the kanban. As a process consumes the product, signals are sent to the previous via kanban so that the quantities consumed are restored.

These kanban cards must be ordered and there is a need to set the pace that they will be delivered. For this purpose a heijunka box can be used. According Lexico Lean (2003), the heijunka box is a frame of load leveling where each horizontal line is assigned to a product type and each vertical column represents identical time intervals to a kanban pace withdrawal. Each kanban spaces represent a pitch production of a type of product.

This simple method uses the time intervals at the top (identification of the columns) to order visually the production orders - production kanban - in order to make clear the next items to be produced and the exact moment to do this.

- How to manage the information and material flows from the previous process to the pulling one?

Supermarkets can be created to control the flow of material in the previous process that have different standards of operation or set-up times from the pulling process or even, significant distances from the two processes. At this moment the withdrawal kanban is used, which will help the material movers to identify where to deliver or to collect material.

- How to size the supermarkets and trigger the pulling?

A standard quantity for the inventory must be set for each part to be kept in the assembly cells based on the nature and frequency of the transport route, to create a separate withdrawal kanban for each container stored in the cells and determine the right amount of products held centrally in the supermarket.

- How to control the flow of batch processes from the supermarket?

To program the batch processes a set of tools known as kanban signal is used. To implement the kanban signs four steps are needed: 1. Determine the time available for the setup 2. Establish the number of daily setups 3. Determine the size of the production batch 4. Specify a trigger point for replacement.

- How to expand the leveled pull throughout the plant?

The expansion options might be the value stream approach, when all the resources of the plant can be divided and dedicated to individual value streams, and the departmental approach, when processes use shared resources.

- How to maintain the leveled pull system?

To keep the leveled pulling system is not an easy or a short term task. In any leveled pull, three managing activities are critical: 1. continuous monitoring of customer demand; 2. continuous assessment of performance index and process stability 3. Daily supervision of the production control and of the operational processes to ensure that standardized work is followed.

Someone should perform each of these functions and assign responsibilities for the daily activities the organization.

- How to enhance your leveled pull system?

To improve, the organization must maintain the stability of the process by reducing the safety inventory and the setup, as in every process there is a remaining loss that will be manifested as a loss of availability, speed or quality.

Moreover, a major source of improvement of the system can be found in non-productive time, especially during the waiting of the material in supermarkets. The inventory cycle can be decreased only by reducing the lead time of the door to door manufacturing.

3 Methodology

This paper is an exploratory study, therefore, there is little knowledge about the problem studied (Cervo and Bervian, 2005). It analyzes the producing process of a packaging industry from the perspective of the

pull production. Thus, this study aims to get acquainted with the phenomenon (production of plastic packaging) gaining a new perception from it (from the perspective of pull production) and discovering new ideas. (Cervo and Bervian, 2005).

The research development that provided a ground for this paper came through the bibliographical review. The concepts of the pull production system were analyzed in the bibliography concerning the subject and the concepts were applied in a case study performed in an industry of plastic packaging, located in the state of São Paulo.

As for the period of investigation, there was a cross-sectional once the data was collected at a given time. The processing of such data was qualitative, as the qualitative methodology is traditionally identified with the Case Study (Marconi and Lakatos, 2007).

4 Case Study

The implementation of the pull system was applied to a plastic packaging industry located in the state of São Paulo, Brazil. The industry produces plastic packages made of polyethylene of high and low density polypropylene, and PET. Its main customers are the pharmaceutical sector industries and major customers are located within the state of São Paulo.

The packaging industry tried to keep inventories to avoid the lack of products to its customers; however, even then, there was a lack of a type of packaging, produced under the scheme for overtime. The production system adopted by the company was to push, where each process "pushed" downstream programming. Each process produced what they believed was most beneficial and not what the end customer (pharmaceutical industry) needed and when needed.

When these discussed problems were analyzed, it was detected the need for a change and it was proposed the adoption of the leveled pull production with kanban, following the 12 steps proposed by Smalley (2008).

First, to implement the pull system, it was determined which were the finished products that should be kept in the inventory and which ones would be produced according to requests. Therefore, it was analyzed the volume of sales in the period from September 2010 and September 2011, which comprehends thirteen different periods. The analysis of the segmentation was applied and it is called “the ABC analysis in production" where products were rated according to their production volume, from the biggest to the lowest.

When it was done, it was noted that 12 of 204 items accounted for 60.73% of the demand and were ordered almost every day by the customer. These 12 items were classified as A. The second group consists of 17 items, accounting for 19.29% of the demand and requests by customers almost every fortnight. This group is called group B. The third group consists of 175 of 204 items that account for 19.98% of the demand and were requested monthly by the customers. This group is called Group C.

After the classification of products according to the ABC analysis of the production, the company chose to use the mixed pull system, where items are placed in categories A and B should be on supermarket products and items in category C should be made according to their requests. It means that the company would spend less time managing the 80% of the volume for which they were responsible for items A and B, and so they could concentrate on the production of items C to meet the orders. By adopting this type of system, the company needed a dedicated group of machines (cell) only for the production of items C, and all efforts to reduce machine setup were made to meet the large number of items that would be produced in that cell.

Once defined which items were in the supermarket and what items would be made by order, the next question was how much each of these items should be kept at the supermarket. For this, it was determined the overall daily average demand, the replenishment lead time (in days), the inventory cycle,

the safety inventory and the stock buffer to get to the finished goods inventory at the supermarket, as shown in Table 2.

With the new methods of inventory control and determination of inventory levels for each item, the company planned a new arrangement for the physical inventory, from what was perceived that it would take less physical space for the storage of products. So the company decided to separate certain areas segregated for each of the 29 items that would be stored, allowing a visual control that would be added to the inventory control that the company had in its ERP (Enterprise Resource Management). The data calculated in table 2 were registered in the ERP system to obtain a better control of the products movement and a fast answer in the production of the items that might vary in the inventory levels.

Code	UM.	Average daily demand	Lead time replacement (days)	Cycle Inventory	Buffer Inventory	Safety Inventory	Inventory of finished goods (supermarket)
121130009	UN	47.160,73	7,00	330.125,14	33.012,51	33.012,51	**396.150,17**
121130031	UN	43.344,48	7,00	303.411,37	30.341,14	30.341,14	**364.093,65**
121030206	UN	30.511,73	7,00	213.582,13	21.358,21	21.358,21	**256.298,56**
121020027	UN	25.400,27	7,00	177.801,92	17.780,19	17.780,19	**213.362,30**
121130029	UN	18.006,48	7,00	126.045,33	12.604,53	12.604,53	**151.254,39**
121130055	UN	16.610,01	7,00	116.270,06	11.627,01	11.627,01	**139.524,07**
121130030	UN	15.308,90	7,00	107.162,28	10.716,23	10.716,23	**128.594,74**
121130024	UN	14.347,76	7,00	100.434,33	10.043,43	10.043,43	**120.521,19**
121130077	UN	11.119,47	7,00	77.836,31	7.783,63	7.783,63	**93.403,57**
121130074	UN	9.857,65	7,00	69.003,56	6.900,36	6.900,36	**82.804,27**
121030162	UN	9.602,65	7,00	67.218,53	6.721,85	6.721,85	**80.662,23**
121130008	UN	9.382,31	7,00	65.676,14	6.567,61	6.567,61	**78.811,36**
121130085	UN	7.761,25	7,00	54.328,78	5.432,88	5.432,88	**65.194,54**
121130053	UN	7.729,53	7,00	54.106,70	5.410,67	5.410,67	**64.928,04**
121030196	UN	6.898,67	7,00	48.290,72	4.829,07	4.829,07	**57.948,86**
121130022	UN	5.622,50	7,00	39.357,49	3.935,75	3.935,75	**47.228,98**
121130054	UN	5.503,89	7,00	38.527,24	3.852,72	3.852,72	**46.232,68**
121130082	UN	5.284,54	7,00	36.991,81	3.699,18	3.699,18	**44.390,17**
121020019	UN	5.026,10	7,00	35.182,73	3.518,27	3.518,27	**42.219,28**
121030141	UN	4.705,86	7,00	32.941,03	3.294,10	3.294,10	**39.529,23**
121130025	UN	4.247,81	7,00	29.734,66	2.973,47	2.973,47	**35.681,59**
121030221	UN	4.116,36	7,00	28.814,50	2.881,45	2.881,45	**34.577,39**
121130064	UN	3.778,55	7,00	26.449,88	2.644,99	2.644,99	**31.739,85**
121030174	UN	3.778,55	7,00	26.449,86	2.644,99	2.644,99	**31.739,83**
121030202	UN	3.546,36	7,00	24.824,54	2.482,45	2.482,45	**29.789,45**
121030204	UN	3.217,53	7,00	22.522,68	2.252,27	2.252,27	**27.027,22**
121030129	UN	2.820,24	7,00	19.741,71	1.974,17	1.974,17	**23.690,05**
121020018	UN	2.800,80	7,00	19.605,59	1.960,56	1.960,56	**23.526,70**
121030039	UN	2.787,26	7,00	19.510,79	1.951,08	1.951,08	**23.412,95**

Table 2 - Calculations for the implementation of the pull system. Source: Authors

The factory is divided into three distinct sectors of production: industry blowing bottles, injection caps and screen printing (painting) bottles. When analyzing the flow of production value, it was found that the process of blowing bottles is 26.6% slower than the screen printing process (the next stage of production), being needed only 5 hours of daily production in injection to meet the demand of the products in the industry. Thus, it was planned that the team linked to the blowing process would come in 3 hours earlier and would be moved to the sector of injection as soon as the normal work shift starts. Additionally, it was decided that the sectors of printing and injection processes would be the pulling process of factory.

With these decisions, the company started to level its production, balancing the customer's tact time and the lead time of the factory production. It is sure that for this result other things were planned: reductions in batch sizes of products, investment in reducing setup times of machines through the acquisition of new tools that enable the rapid exchange of parts, and even the acquisition of machinery. Additionally, it was calculated the production pitch for products classified in families A, B and C and it was determined intervals seeking a new production planning.

For this whole process to become real, it was necessary to determine how to transmit the information to the production cells. For this, at the lean production, there is a specific tool for the communication of production orders and to regulate the movement of materials called kanban. To plan how to operate the kanban, the company needed to analyze the environmental demand of its products and determine if it is stable or subject to large variations. As the company makes 90% of sales to only two customers and the demand for products from these clients are stable, it was determined that the withdrawal kanban is the tool that best fits the company's reality. Since the company's warehouse department is responsible for the movement of materials through the plant, the storekeeper became responsible for movement of the Kanban factory, both in the pulling process and in its earlier process.

The next step was the dimensioning size of the supermarket. Therefore, it was established that the route of movement of the materials should present a fixed amount and variable time, because the quantities of

materials produced and the way to store them in the inventories are fixed. Then, it was designed the size of each finished product inventories, items from the curve A and B, where the cycle inventory was considered that will be added to the buffer inventory and to the safety inventory. Since the beginning of the plans for the change into the pull production system, the expected volume to reduce the inventory level is around 45%. This is a fairly a large number, because the company decided to create in its plans, a supermarket of intermediate products for the items in group C, which would help to reduce the lead time production of products that would be ready and waiting for the final step production in the sector of screen printing.

To control the production of items for the inventory of finished goods and intermediate goods supermarket the thought was to use the kanban signs. Using this type of kanban, the removal of product in the supermarket triggers replacement of the same product in the previous step. The operation of this kanban type requires the determination of the available time to set, to set the number of daily setups, the determination of the size of the batch production and specifying a trigger point for replacement.

It is worth to remember that all products made in the plastic packaging industry were used in the plans and in the calculations to set the pulling system. However, it is recommended that the implementation is done by product or product family. Thus, it becomes easier to carry out the measurement of results and possible correction of process deviations. Some indicators can be used to measure the improvements brought by the implementation of a pull system. These indicators can be described and classified into the following groups and were extracted and adapted from Smalley (2008).

- **Indicators of productivity:** Direct Labor (parts / person / hour) and number of movers of materials.
- **Quality indicators:** index of scrap and rework of the parts produced.
- **Indicators of Call:** downtime per shift.
- **Inventory turns:** how many times the inventory turns per month, estimating the level of inventory in monetary values by dividing cost of sales of stock in the month.
- **Delivery on time:** This indicator is important for both internal customers (meaning the screen printing industry) and for external clients.
- **Costs:** reduction of production costs of the plant, for example: overtime, loss of product, among others.

For the plant to maintain the leveled pull system three basic activities are required. The first one is the continuous monitoring of customer demand by calculating the average demand in a given period. The second is the continuous evaluation of performance indicators and process stability, which should be made through a statement of the result of value streams that show the numbers at the beginning of the implementation of pull system, the goal, the current state and improvement obtained in the process. The third is the daily supervision of the control of production and the operational processes that the standardized work is being followed; this activity must be made by controls highly visual and easy to interpret.

5 Conclusion

The implementation of pull production system in a plastic packaging industry is feasible, therefore, simulations were made with data extracted from databases of the company and the project was made based on everyday situations from day to day business.

Based on the bibliographical review, a detailed analysis was carried out as on how the pull production system can be deployed in a plastic packaging industry. Due to the high degree of detail, this work can contribute in many ways for the same sector industry.

The first aspect to be highlighted concerns the reduction of inventory levels of the plant, obtained through the analysis and classification of the daily demand of products by ABC method.

The inventory reduction has led to consideration of a second aspect related to the improvement in the organization of the factory, which allowed the design of a new production layout.

A third aspect referred to the observed improvement of the production process obtained as a result of the two previous results and, consequently, led to a fourth aspect which is the improvement in the flow of information.

The sum of these improvements resulted in a reduction in production costs that can be treated as a fifth appearance.

However, there was also a gain that could not be measured, on the change of the philosophy of the company that will enable the adoption of a culture of continuous improvement and this culture could lead to incalculable benefits to the company and also to society as a whole.

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