Testing an Internal Supply System in a PIM`s company

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Abstract

This article analyzes the implementation of an internal material supply system in an electronics company installed at the Manaus Industrial Pole (PIM). This system is a lean internal logistics model with the leveled replacement of materials and defined frequency, facilitating the communication of the people involved and ensuring the efficient use of the productive area. The method used was a practical application adapted from the one proposed by Harris et al. (2004) to control the internal movement of materials. As a result, this paper surveyed the key advantages of adopting the new supply system and identified potential opportunities for improvement.

Keywords: Lean Manufacturing; Lean Logistics; Supply Route; Material Handling.

1. Introduction

1.1 Contextualization

Following the success of the Toyota Production System, other companies around the world have adopted the lean system to increase their performance by eliminating unnecessary processes and balancing activities to ensure continuous flow through production lines. Womack and Jones (1994), in an article seek to extend the concept of Lean Manufacturing to the entire organization, noting that all non-value-added processes can be worked to reduce waste.

Under this approach that all areas of the organization can be optimized, a new concept of logistics emerges. The combination of in-house logistics activities with the Lean Manufacturing philosophy focuses on the transition from mass sourcing logic to a lean system, ensuring what is needed, when it's needed and in the exact amount, and eliminating activities that don't add up. value to the process. In this system, there are well-sized routes to avoid the lack of raw material and the need for materials is expressed employing cards that signal the need for materials, better known as Kanban.

The Manaus Industrial Pole is one of the most modern in Latin America, bringing together about 700 industries comprising electro-electronic, two-wheel, computer, optical, chemical and other sectors.

Installed companies benefit from the exemption of various taxes, which attracts industries from the various segments mentioned. PIM's electro-electronic segment represents the largest manufacturing center for electro-electronic products in South America (SUFRAMA, 2016). According to the Manaus Industrial Pole Performance Indicators Report of September 9, 2015, the electronics sector is responsible for 40.5% of the jobs generated and 29.77% of PIM revenues.

The company object of this study hereinafter will be called as Z due the information security policy, is a multinational company active in the electronics sector, considered of medium size installed in Manaus since the '80s and that produces electrical protection devices for residential and industrial use. The research was done in the warehouse, which aims to meet the demands of internal customers, production and planning, storage and delivery of materials before the process of transformation into the finished product.

In an article published by Exame magazine (2011), Brazil had the 4th most expensive shed rental value in the world: R $ 23.50 / m², behind Tokyo, Zurich, and Hong Kong. When it comes to Latin America, São Paulo is the most expensive city. The current conditions of the macroeconomic scenario, however, present excellent opportunities for reviewing the manufacturing area needed to meet production demands.

In order to reduce the fixed cost of rent of the warehouse and, consequently, the amortization under the value of the products, Company Z started in April 2016 three front lines for reduction of manufacturing area: 1st) The layout of the production lines; 2) The increase in the warehouse occupation rate and expedition, and 3) The process of implementing an internal supply system, the latter being the main theme of this article.

Previously, each production line had two supply schedules per day, morning and afternoon. The production leader was responsible for ordering the materials according to the production orders to be executed and at the signal of the line supplier who is responsible for separating the materials for use on the production lines. The inventory team, made up of 10 warehouses, delivered, when the separation of the materials requested was completed, to one of the 4 line suppliers also responsible for keeping the production supermarket clean and organized.

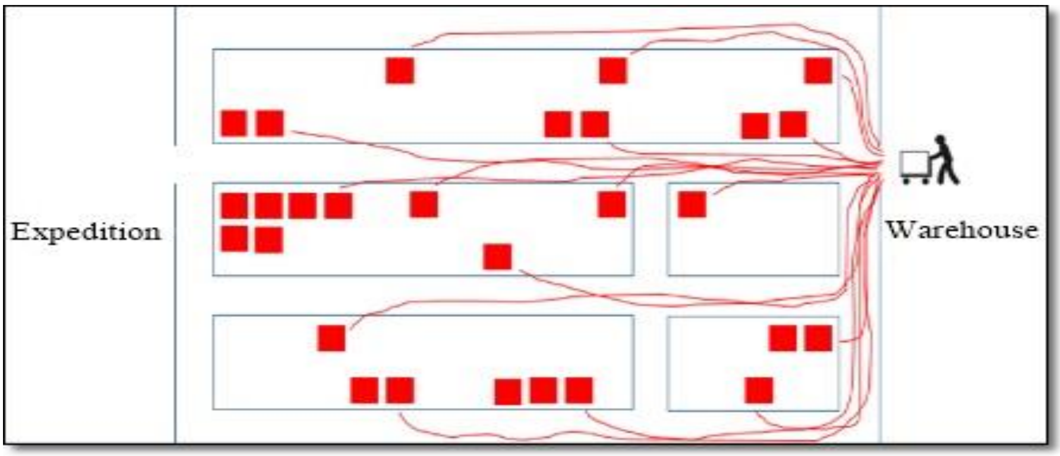

Figure 1- Layout before supply system deployment.
Source: Author (2016)

The transportation of materials, from the warehouse to point of use in production, arranged on pallets, were manually moved by hand pallet trucks, also known as transpalette. Figure 1 simulates the various supply points and the movement to reach these points. It can be observed system numerous disadvantages, such as:

a) High level of stock in the process due to unreliability in the supply process;

b) Supermarket areas of overproduction due to the high level of inventory;

c) Excessive movement of people, both to make delivery and to request material to stock;

d) The production leader and only he is responsible for requesting the necessary materials under the signal from the line supplier.

It was then from the above disadvantages that Company Z's senior management decided to invest and implement a new internal supply system. The planning and implementation phases took place between April and September 2016, having as main actions: a survey of the characteristics of all items in the Plan for each piece (PPCP) worksheet, need analysis of each job, transportation car purchase Kanban card development, the definition of supply routes, among others.

From the implementation of this system, there was a study to investigate the difficulties encountered, how they were overcome, the main results obtained and what can still be improved. Thus, the main questions are: what gains has the implementation of an internal supply system brought to company Z? what are the difficulties encountered and what improvements can be made to make the supply system even more efficient?

The main objective is to analyze the implementation of the internal supply system carried out in Company Z's Warehouse sector, to propose improvements to the organization's managers.

To this end, it was defined three specific objectives: 1) Describe how the process of implementation of the said system took place; 2) Compare the states before and after implantation; 3) Identify the main results obtained, difficulties encountered and propose suggestions for improvements to make the supply system more efficient.

The research project is relevant for the following reasons:

a) For the company: analyze gains that the project brought to company Z, making the process more efficient, as well as suggesting improvements that can be studied for possible implementation;

b) For customers (internal): loyalty in delivery and in less time;

c) For academia: Marodin et al. (2012 p. 457) identified few research focused on internal logistics improvements after lean manufacturing methodology implementation, so this article could contribute for classroom discussions and its limitations generate further investigations;

d) For society: an approach to a supply model that can be used in companies of various segments that want to optimize their internal logistics processes.

2. Theoretical Referential

This topic will present a sequencing for a better understanding of the article. Here it will approach Lean Logistics, followed by the Kanban pull signal method and finally, the supply route according to the studied literature. The method proposed by Harris et al. (2004) for internal material handling.

2.1 Lean Logistics

A truly lean process is achieved when it is fully perceived and analyzed, from receiving raw materials to shipping finished products. Because of this, it becomes much more important to control and manage the entire logistics supply system for production lines (SHINGO, 1996). Logistics is one of the main aspects of the lean system operation (WOMACK, 2004).

Baudin (2004) conceptualizes lean logistics as the dimension of lean production about the delivery of materials, done repeatedly and in small batches, as opposed to a traditional supply system, made in high volume and infrequently.

Carrera (2008) states that some of the main gains that companies seek with lean vision in their logistics processes are: a) faster and more flexible deliveries from stock to point of use; b) The reduction of operational logistics costs; c) Increased labor productivity; d) Reduction in inventories and consequently increase in inventory turnover; e) The release of the internal manufacturing area.

2.2 Kanban System

The idea of Kanban arose in Japan from the observation of the operation of American supermarkets. Taiichi Ohno observed various activities of the supermarket, paying attention to the merchandise replacement system. Four characteristics were perceived: a) goods are withdrawn by the consumer himself: as in a self-service system; b) goods are distributed on shelves: the items with higher output are placed in larger quantities; c) Replacement is made according to demand: as items are consumed, they are replenished; d) The required information is presented on a card: the product identification and its price, and even if space is empty, it is dedicated to the item described on the card.

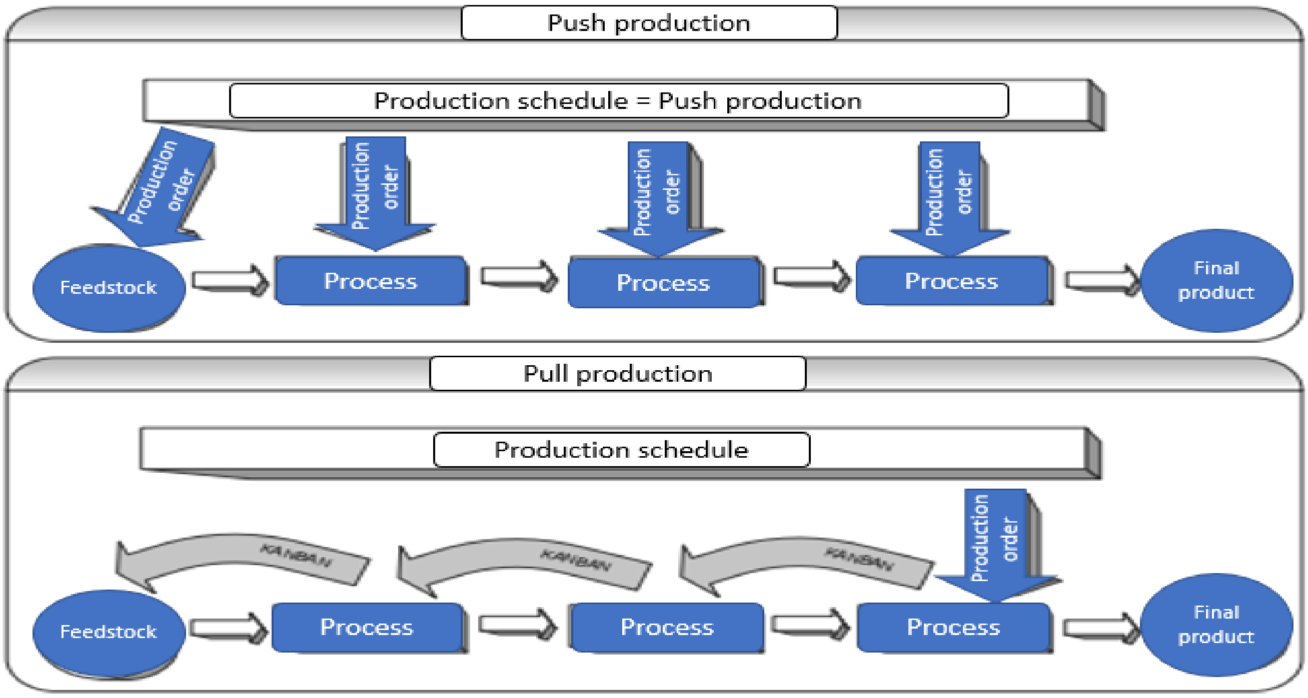

Figure 2 - Push production x Pull production.
Source: Adapted from TUBINO (1997, p. 105).

In the Kanban system, there must always be a balance between the previous process and the later process, i.e. the previous process cannot produce more parts than the subsequent process needs to consume.
Figure 2 illustrates the difference between a pushed system, in which the master production plan prepares a production plan, issuing purchase orders and production orders, considering the remaining stocks as if stocks pushed production. In the pull system, however, production stocks only enter the company or are produced by an earlier process according to what subsequent processes can absorb as if production pulled the stock.
In general, it can be said that in the pushed system, the stock dominates production, while in the pulled system the opposite occurs, production dominates the stock. The vendor can only produce if he has a customer request kanban card.
For Peinado and Graeml (2007), the Kanban system seeks to move and supply production items only as they are consumed. Beyond simplicity, Kanban offers many other advantages over more traditional ways of controlling production. Although not necessarily contributing to the reduction of inventory levels, it generates a production environment within which improvements can be made in this regard.

2.3 Supply System

Where there is a transformation of raw material, at least one of the three necessary production resources - labor, machine or raw material, has to move for such transformation to occur, in most processes, the material is the moving element.
In choosing the most appropriate method, the company should focus on the most convenient solution that, within the constraints of each process, meets the required handling requirements and transport type capacity to reduce project costs. Figure 3 illustrates the difference between a conventional supply system and a lean supply system.

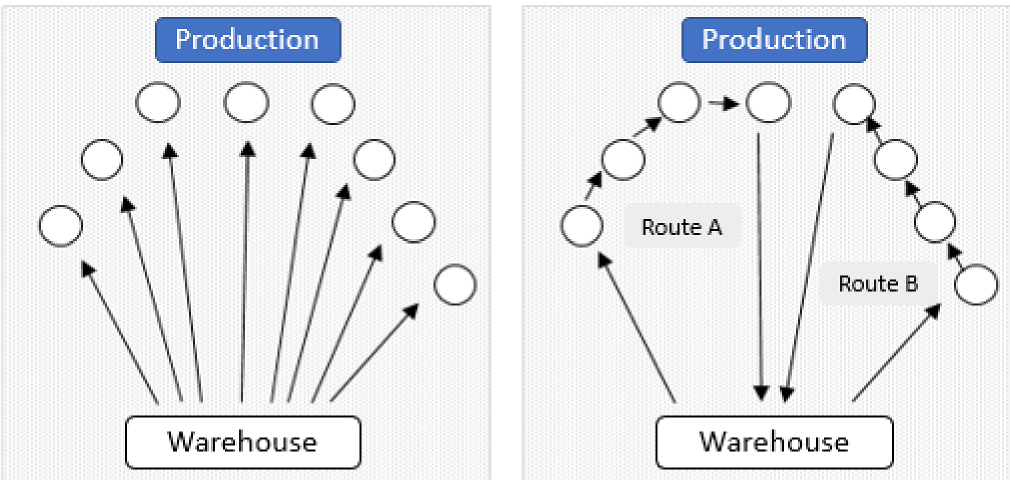

Figure 3 - Conventional supply system versus lean supply system.
Source: Author (2016).

In the first model shown in Figure 3, an analogy is made to a taxi race: the passenger embarks (material) and is taken to his final destination (production line). In the second system, an analogy is made to a bus: well-defined routes, with stopping points already determined, in which each point goes up (finished product) and passengers go down (raw material).

Harris et al. (2004) present the objectives for a lean supply system, which in addition to flowing materials more accurately and less costly, also highlight:

- A process for accurately describing how each part would be managed from the receiving dock to its point of use on the plant;
- A purchased parts market near the receiving dock to store and control the necessary parts;
- An accurate delivery system to get parts to their point of use;
- An accurate signaling system that each production area would use to pull only the necessary parts from the purchased parts market.

The deployment phases depend on the constraints and needs of each company. In his master's dissertation, Soares (2014) proposes seven phases of lean supply system implementation:

a) Definition of the form of supply to be adopted: the system may have replenishment with fixed or variable interval, and fixed or variable quantity, depending on the need of the production lines;

b) Characterization of the supply material: it is necessary to know all the information related to each part or material that will be moved;

c) Definition of supply containers: which may be the supplier's packaging or the product packaging, which defines the type of container are the ergonomic aspects of access to the parts, the physical size and its occupation in the supermarket;

d) Supermarket Supply Project: A location should be sought where materials are handled at a minimal cost and must take into account the maximum quantity that each item can occupy;

e) Supply route: take into consideration the standardization of corridors, definition of the means of material movement;

f) Define the communication in the supply: usually utilizing a kanban card that is sent to the warehouse to replenish the material;

g) Supply schedule: synchronized supply (based on actual consumption) or kit supply (failure risk reduction).

2.4 Deployment Method

Harris et al. (2004), propose a more generalized method in the guide of the implementation of internal logistics, citing four steps:

Step 1) develop a Plan for Each Part (PPCP): database with part information, such as place of use, quantity, packaging, among others;

Step 2) create a single purchased parts supermarket: create rules and manage all parts entering the plant in one place;

Step 3) initiate accurate delivery routes: create and standardize the way materials arrive in the process;

Step 4) support and improvement: Verify that the developed standards are being followed.

To transport materials, Harris et al. (2004) specify that the most efficient method is the use of electric trolleys that can pull multiple loads in one route, reducing the logistics operator's transportation and handling the waste.

3. Deployment

First was made the survey of the current situation by mapping all the items and maximum quantities in process. This concerns the elaboration of a Plan for Each Piece (PPCP), needs analysis of each job. Engineering and production team support was needed to study the capacity/hour of each line and to understand the flow of the manufacturing process. In the second stage, the planning and execution of activities necessary for the implementation were made: preparation of the PPCP-based Kanban card, as well as the preparation, under the responsibility of the maintenance team, of the wagons for the transportation of materials, among others. Also, a technical visit was made in another PIM electronics company that already has a stabilized supply system, to understand and verify opportunities that could be applied in Company Z.

In the execution stage, the new system was tried out, already using the electric transport car, using the defined quantity Kanban cards to meet one production hour. Here, we analyzed the performance reports of the routes performed, the data collected were: time of each route, number of items per route, compliance with predetermined times, material separation time.

In the fourth stage, opportunities for improvement, planned and implemented, were identified. The main opportunities identified were about the organization of items by product family, change of route itinerary, creation of new supply points. With the system in full operation, the future state was analyzed based on the same variables of the first step.

4. Methodology

The research is applied and was an adaptation of the methodology proposed by Harris et al. (2004), explained in Section 2.3 because it most closely resembles company culture. Information and data were collected through day-to-day work findings, where internal logistics flow was observed, and problems and improvements were identified. To better understand the functioning of both the warehouse and production, the operators were monitored during their activities. Besides, material requests and delivery reports were analyzed.

For comparison between the two states, data from three variables were studied: V1) Space occupied by the production supermarkets: the quantitative data, in square meters, of all the spaces occupied in the production with storage of raw material, empty boxes and finished product released for collection by the Warehouse were collected; V2) Coverage time: this refers to the total time that the quantity of each raw material available in supermarkets meets the need for production; V3) Headcount: number of people working in the company in the line supply and warehouse functions.

The schedule of this work was established as observed in Chart 1. For data analysis, a comparison was made between the states before and after the implementation of the supply system based on the three variables mentioned.

The difficulties encountered were addressed based on consensus with other team members and opportunities for improvement were made based on indirect satisfaction interviews with key employees who benefit from such a system.

Stage	Date completed
Methodology and Collection	01/27/2016
Analysis of the current situation	04/04/2016
Implantation	05/02/2016
Improvements	09/21/2016
Results	11/21/2016

Chart 1 - Schedule of the implementation of the supply route.

Source: Author (2016).

5. Discussion

Next, the results obtained through the implementation of the internal supply system will be reported. In this section, we will compare the data of the three variables: Space occupied by production supermarkets, Coverage Time and Headcount, in the states before and after implementation. Besides, the main difficulties encountered based on the opinion of the team members were raised, as well as the potential opportunities for improvement and how they can be addressed.

5.1 Main Results

An analysis was made by observing the supply process, from which was elaborated on the flowchart shown in Figure 4.

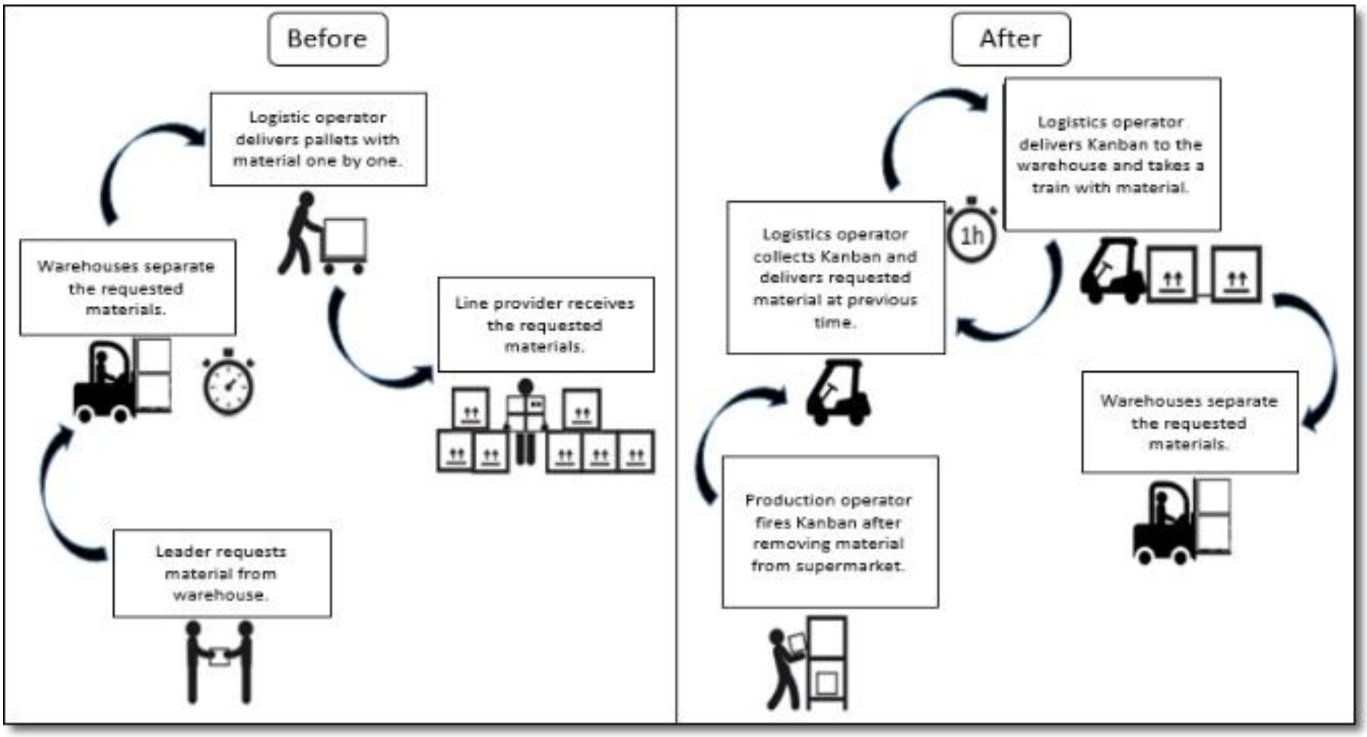

Figure 4 - Flowchart of the material supply process (before and after).

Source: Author (2016).

Materials were ordered twice a day, i.e. the materials supplied to the assembly lines supplied a minimum of 5 working hours, considering a 10-hour shift. Due to the low frequency of supply, the lines had high levels of in-process inventory, as shown in Chart 2. Also, the sorting process was slower due to the high number of items ordered and the larger quantities of each material. to meet production needs by the next supply time.

According to the flowchart of the later state, shown in Figure 4, the supply frequency becomes hourly, divided into two itineraries (Figure 5), that is, every thirty minutes the logistics operator performs an itinerary. Some points can be highlighted:

a) The autonomy of production operators: request materials at each withdrawal from the supermarket and not wait for the production leader;

b) Fast delivery: faster delivery;

c) Less fatigue: the logistics operator makes deliveries in an electric car and not in manual transport;

d) Less movement of the logistics operator: possibility of taking more than one train on one trip.

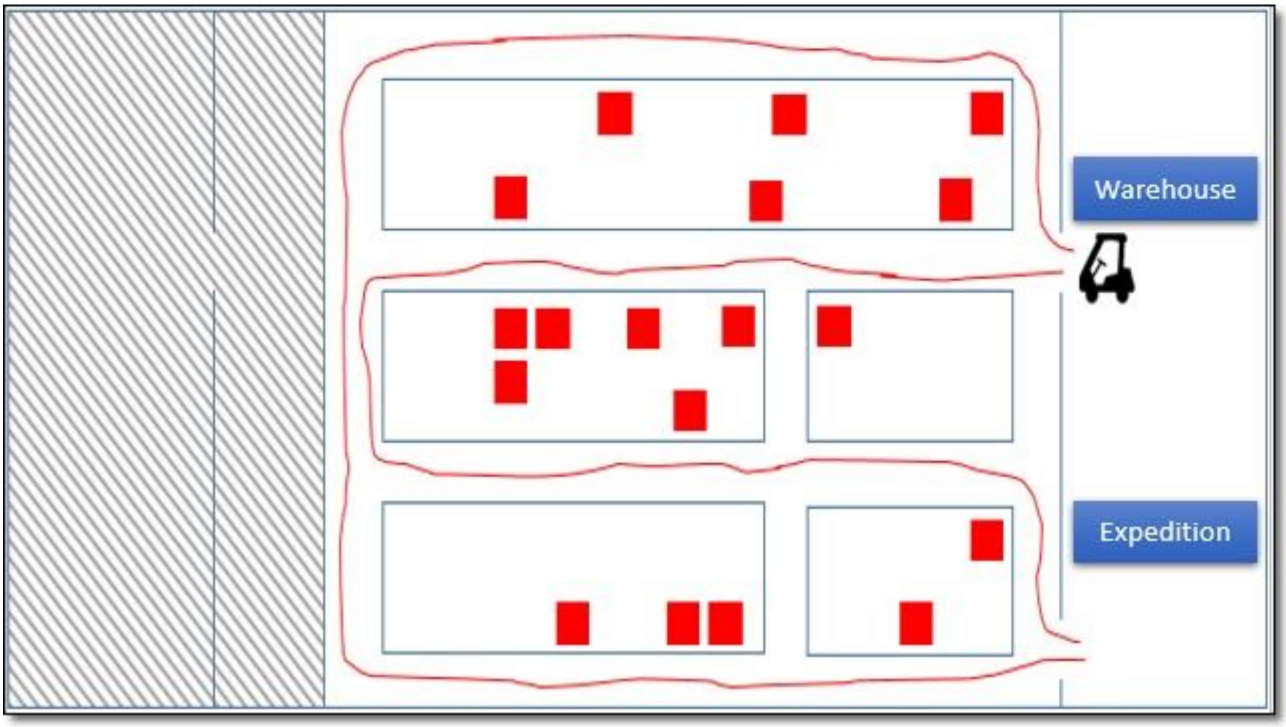

Figure 5 - Layout with a new supply system implemented.
Source: Author (2016).

OCCUPATION	REDUCTION
Feedstock	46,00%
Empty box pallet	
Finished product pallet	

HEADCOUNT	BEFORE	AFTER	ACTIONS
Line provider	4	0	Reallocation in another function
Storekeeper	10	9	Resignation

Charts 2 and 3 - Occupancy Reduction and Headcount Reduction.
Source: Author (2017).

Through the implementation of the internal supply route and layout of the production lines, there was a significant improvement in the efficient use of the production area. Charts 2 show the percentage reduction in occupations with raw material, finished product, and empty boxes, which together add up to 46%. Chart 3 shows the Headcount reduction for the line supply and storeroom functions, which were relocated to another function (Test Line) and shut down from Company Z, respectively. From the reduction of

productive area occupied by each production line, it was possible to start the process of the layout of the lines, to group all the small empty spaces resulting from the reduction of inventory in the process.
Both works performed were responsible for the reduction of a significant part of the productive area (area highlighted in Figure 5), which affects the cost of shed rent, as well as expenses with refrigeration, electricity and factory maintenance. Also, the layout project included the analysis of the efficient use of inventories, and the low occupancy rate of inventories of raw material and the finished product was found. For this reason, Company Z chose to group the two stocks in the same warehouse area, increasing the area to be vacated as can be seen from Figure 5.
Analyzing the coverage time, 91% of the items had coverage over 2 hours of production. In the new state, 20% of items have coverage of up to 2 hours of production. The major difficulty in having the coverage time closest to the frequency of the route is because the supplier's packaging has more than one hour's production. However, they were treated with priority, bulkier items to achieve the objectives of the work. The company has no structure to reduce packaging to smaller quantities, and because they are small items such as screws and springs, it was decided to keep these items in the quantity set by the supplier, although it has coverage of up to 2 days of production.
Another positive aspect of the implementation of the supply route was the possibility of not only supplying the production lines with raw material but also the collection of empty boxes and later, finished product. The collection of empty boxes and finished products, also done manually, was performed when necessary. When the raw material is left, space is cleared at the logistics operator and new material is collected, either the empty box or finished product, as analogous to the bus commented in Section 2.3.

5.2 Main difficulties

After brainstorming meetings, three main points were listed by the members of the work developed:
a) Employee resistance to adapt to the new supply system. These are now responsible for ordering materials as they are consumed. Besides, supplies are hourly, unlike the previous state twice a day. To overcome this problem, a meeting was held on all production lines to explain the operation of the system and its importance;
b) The layout of the production area that prevented the movement and maneuvering of the transport car. It was necessary to make changes in the corridors of the manufacturing areas to expand them;
c) Safety of the operators now dividing the aisles with the material transport car. For this purpose, demarcations were made for traffic and car traffic, so that they do not circulate in the same space. To raise awareness, circulation recommendations were passed at weekly safety and health meetings organized by the Occupational Safety team.
For the elaboration of the article, the main difficulty was the lack of previous state data to compare with the most recent data. As the average displacement traveled by logistics operators to make a comparison between the movement before and after work, as a way to measure fatigue.

Also, the time required to separate the previously ordered items in larger quantities to calculate the average turnaround time of the two sourcing models at Company Z.

5.3 Potential improvement opportunities

Through interviews with key employees on each production line, it was found that the major dissatisfaction of the main internal customer of the supply route is the delayed delivery of the requested material.
From this, an Ishikawa Diagram (Figure 6) was prepared to analyze the possible root causes of the problem.

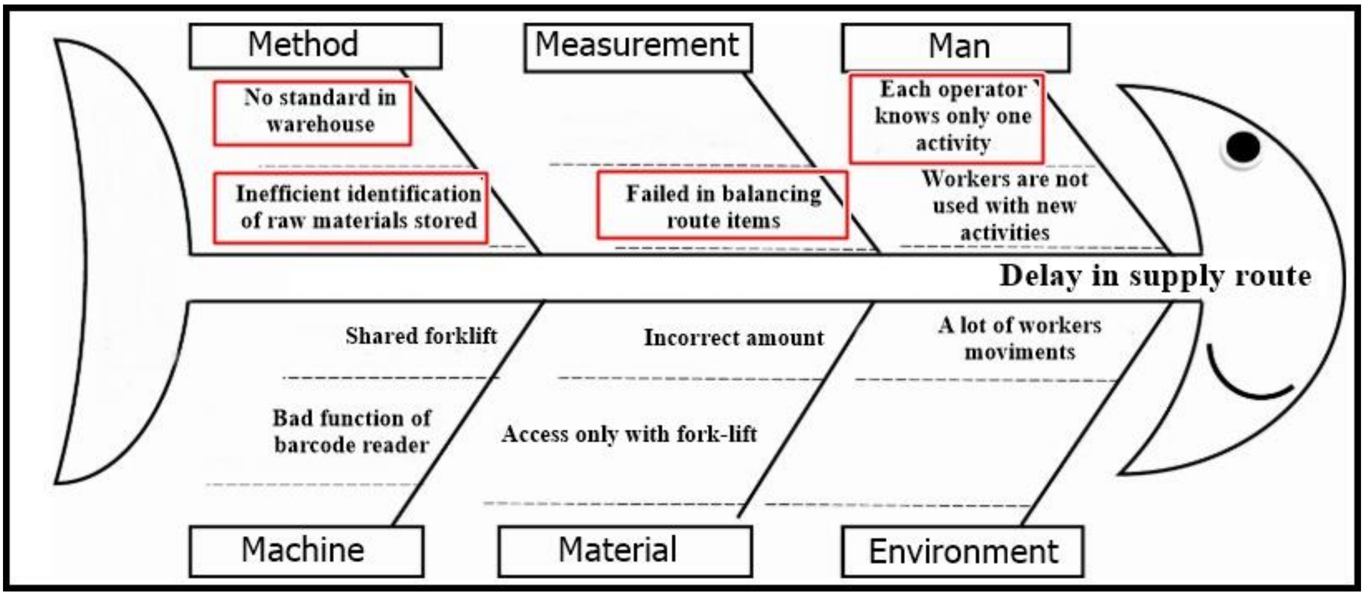

Figure 6 - Root Cause Analysis of Supply Route Delay
Source: Author (2017).

Around ten causes were found to be solved. Then for each of the root causes identified as red box in the Ishikawa Diagram (Figure 6), it was made proposal for improvements.

5.3.1 Balancing supply routes

It was found from the timing of the supply route that the exits established every thirty minutes were not being met.
Analyzing the deliveries made by routes A and B, there was a disparity in the requested quantity of materials, which directly impacts the delivery time and also the delivery time. The greater the number of materials to be separated, the more time will be required in subsequent activities.
To balance routes A and B and respect the set times, the alternative found was to change the route itinerary, to reduce the load of route A and occupy more time of route B.
The result can be observed in Figure 7, which illustrates the times before and after balancing.

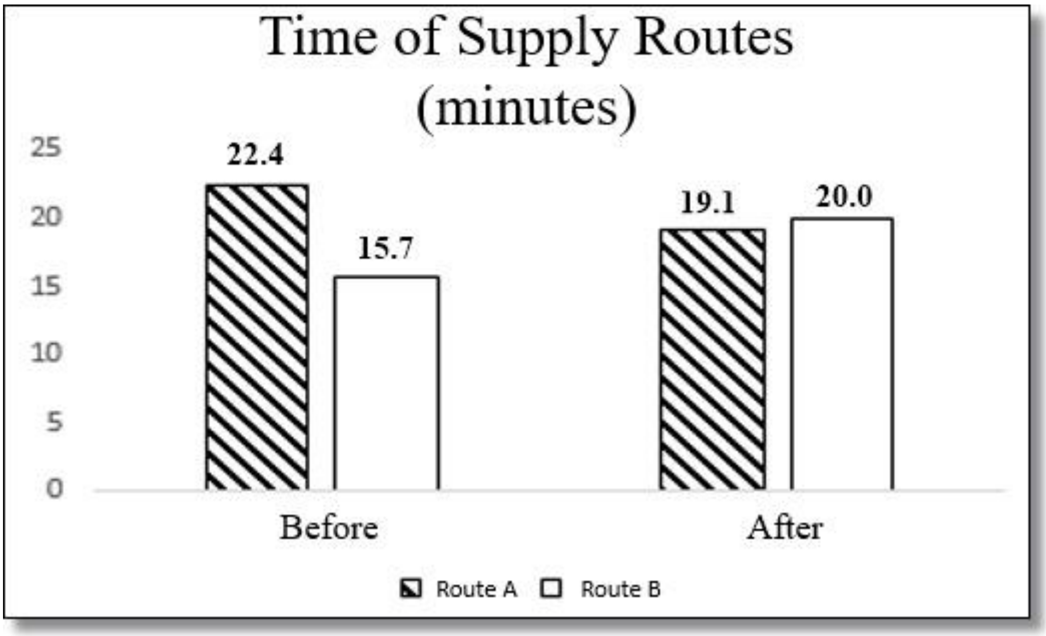

Figure 7 - Route times
Author (2017)

5.3.2 Addressing the inneficiency in identifying materials

As a form of organization, each item arranged in the production supermarket had a defined location marked with item code label and description. However, the filling process takes longer due to the time taken to find the right place to store the material

For this, a new identification model has been designed to meet the demands of employees performing material supply activities and also for production line employees to return unused materials to the correct location. The model consists of identifying in each Kanban board the correct location of the material on the production shelves.

Each shelf is identified in matrix form, lines representing the levels in numeric characters and columns represented by letters. Similarly, cards are identified with alphanumeric characters, corresponding to the column and row on the shelf. For example, Kanban card labeled "A2" means the item must be placed in column A and level 2 of the supermarket.

For R$ 9.80, it is sold in stationery, a package with 2882 label units that can be used in printers commonly used in organizations. Considering 2 packages plus the cost of printing at R$ 0.11, this model costs less than R$ 30.00 and ensures faster supply due to the agility to find the correct place to store such an item.

5.3.3 Training on all supply route activities

Employees involved in the activities must be fully aware of all other supply route activities for their development and meet unexpected demands. This way, everyone needed to be trained to take on other activities in case of the absence of a collaborator, vacation, among others.

This initiative was deployed to the shipping and receiving teams.

5.3.4 Warehouse organization by product

Observing the process of separation of materials, it is possible to observe:
a) Excessive movement;
b) Waiting to use the forklift shared with the material allocation and shipping activity;
c) Materials of the same family arranged in different streets causing unnecessary movement.

To optimize material separation and to ensure that materials are sorted within the defined time, good inventory management is required from receipt of materials from the supplier. However, to have better use of resources, one may choose to organize by product family, that is, to have the items of the same production line nearby to avoid unnecessary movement between the streets of the Warehouse.

Also, to reduce forklift usage, ABC analysis can be done for inventory management. This tool consists of classifying items according to the frequency of use. Higher output items are rated A and should be more accessible, usually, do not require transport tools to collect. Moderate items are often rated B and finally rated C for sporadic items that can be stored at heights.

The ABC rating is based on the Pareto chart, which says that in many situations a small part of a group represents most of a certain characteristic. Thus, items A are usually 20% representing 80% of the annual demand in value, class B items are 30% representing 15% of the demand, and finally items C are 50% representing 5% of the annual demand in value.

6. Final considerations

The present work aimed to analyze the implementation of an internal supply system, to identify the main results achieved based on two variables, the difficulties encountered by the work team and to propose improvements to make the system even more efficient.

The deployment process was divided into four key steps to achieve the results shown. At the same time, line layout initiatives and increased inventory occupancy rates were essential to maximize gains.

From the implementation of a pull supply system, Lean Logistics aims to eliminate waste by replacing only the items that are consumed by customers, in the right amount, at the right time, and closest to the point of use. For the proper functioning of a supply system, the routes must have higher frequencies and lots defined in minimum quantity for the full operation of the production lines. In this way, it is possible to obtain better use of the productive area and efficiency of the whole process, besides ensuring a better movement of people and materials.

As a result of the supply route implementation and line re-layout work, there was a significant reduction in the company's manufacturing area, which means lower rental costs and other fixed costs such as electricity, factory maintenance, among others. Besides, it is possible to highlight the reduction of response time for material delivery to production, less activity fatigue, reduced handling waste.

Through the implementation of this new supply system in Company Z, it was possible to note three main points regarding the philosophy of lean logistics: 1) Increased delivery frequency: hourly supply on two well-defined routes with departures every thirty minutes; 2) Batch size reduction: through the use of Kanban cards to signal the need for the material; 3) Efficient use of the productive area.

Thinking in this way, other opportunities were found in order to achieve a lean internal logistics process, such as: a) stock organization by product family, to group the items used in the same point of use; b) organization of the inventory by frequency of use, where items with higher exit history are addressed in more accessible positions; c) reduction of suppliers' lots, in order to make the lot as close to the route coverage time (one hour); d) adjust the size of containers in production supermarkets.

The limitations of the research are defined by the unique character of Company Z, although factors that may restrict the application of the method in other companies are not identified, only needing adaptations for each one. The difficulties encountered in measuring data can also be considered as work limitations, reason by which the opinions of the employees involved in the supply route activities and the perception of those who use such a system were also taken into account.

As a suggestion for future work, it is recommended an analysis of the impacts of lean logistics on performance indicators such as flexibility, lead time, among others, commonly used in organizations. Another suggestion is the analysis of areas that support production in which the same philosophy can be applied to achieve a lean system or elaborate a generalized Lean Production method for other sectors of organizations.

7. Acknowledgments

We would like to thank the Company Z managers for their support and also Doctors Nilson Rodrigues Barreiros and Joaquim Maciel da Costa Craveiro for their contributions during the Industrial Engineering Course Examining Board when the article was defended in 2017.

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