Analysis and improvement of internal logistic flows at an industrial company

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Abstract

Undertaken at Preh Portugal, Ltd., the main objective of this study project resided in defining the system of supply to a new assembly line, the Ford B479. Supply to the assembly lines is a crucial activity in internal logistics since the entire production system relies on the supply of materials required for the line. It is, therefore, extremely important to study solutions which will facilitate these activities, thus enhancing productivity and guaranteeing the on-time availability of products, in suitable quantities and at the best cost.
The initial phase consisted of studying the type of supply system used by the company for the remaining lines, as well as gaining a detailed understanding of the entire assembly line production process. One was then able to create a database to include all of this information. Once all the required information had been gathered, one proceeded to define the supermarket for the Ford B479 line, and calculated the number of positions required. With the purpose of building a more effective and efficient supermarket, one analyzed the possibility of building the supermarket next to line instead of resorting to the existing solution where the shelves for all lines are in the same location. When the site for the supermarket was defined, one proceeded with its construction and determined the supply system of both the supermarket as well as the line sides. Due to the proposed changes, one was able to reduce the distance covered by raw materials by 55% as well as to decrease handling.

Keywords

Internal Logistics; Supply System; Assembly Line; Line Side; Supermarket.

1. Introduction

Preh Portugal, Lda., Founded in 1969 in Trofa, produces electronic boards and components injected in plastic, performs the painting of injected components and the assembly of the final product. Its major customers are the world's largest automobile manufacturers such as BMW, the VW / Audi / Seat / Skoda group, GM / Opel / Vauxhall, Daimler and the Sony / Ford group. The company is divided into nine departments, and it was in the logistics department that the project that bases this report was developed.

The main purpose of this project was to define the supply system for an assembly line. Supply to assembly lines is a crucial activity in the company's internal logistics, since all production is dependent on the supply of the materials needed for the line. For this reason, it is extremely important to study solutions that facilitate these activities, thus increasing their productivity and ensuring the availability of products at the right time, in the right quantity and at the best cost.

This research is organized as follows: In section 1 the problem is introduced. Section 2 presents the methodology used, followed by the presentation of the initial situation in section 3. The existing supply system for the rest of the assembly lines is described in Section 4. Section 5 presents a survey of data, and in section 6 is where this paper presents the conclusions that were obtained on the supermarket. The analysis

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carried out on the location of the supermarket is described in section 7. Then the evolution of the construction of the supermarket is presented, as well as the changes that have been made in section 8, and the section 9 presents the final result. In section 10 the proposed supply system is described. Finally, section 11 presents the conclusion.

2. Methodology

During the execution of this project a method was made up of several stages which facilitated its execution and the achievement of the desired results.

In the first stage a period of integration was carried out in the company, providing an overview of the operation of the various departments, especially the logistics department. During this period, it was possible to follow the various activities carried out and to understand the process of supplying the assembly lines. In the second stage, the entire production process of the line on which this project was studied was analyzed in detail, in order to know the various versions of existing final products, as well as the different materials that constituted each version and the workstations where they were needed. The third step consisted of a bibliographical research of themes related to the project that could be useful as theoretical support for its realization. In the fourth step a database was created containing the information about the capacities of the various BLs (line edges) with respect to the respective materials. With all the data collected, it was possible to define the number of positions needed in a supermarket and its capacity to store them, identify the total area required for it and make a layout proposal, which, once approved, was put into practice. In the last stage, the proposed changes and the proposed supply system were implemented, the results obtained were evaluated and future work proposals were indicated.

3. Total Flow Management Tools Used in The Project

Mizusumashi

Mizusumashi, also called a logistics convoy, is responsible for the internal flow of materials. It should have well-defined routes, which are repeated in an established time frame. In the supply of materials only those that are strictly necessary, in the exact quantities and at the right time, must be supplied. Usually, the logistics train is associated with the use of visual management and Kanban cards to control the supply needs, being therefore closely linked to the concept of Just-in-time (Ichikawa, 2009).

Supermarkets

Supermarkets correspond to dedicated locations with fixed spatial organization that store small quantities of each type of material, which allows the good flow of internal logistics by facilitating the picking of components (Coimbra, 2013).

These units are created according to certain rules such as (Gonçalves, 2006):

- Each reference has a location (fixed);
- Good access for picking;
- Enable visual management;
- Ensure FIFO, *First In First Out.*

Line Edges

Line edges are where Mizusumashi deposits the materials and components to be used in the production lines. They are also the interface between the line and internal logistics. Internal logistics are responsible for supplying the exact material, with the desired quality, at the right time and for the right location. They are the access points to the components that must be optimized in order to minimize distances and times (Coimbra, 2013). The line edge should be sized so that its capacity is adjusted to the time it takes to Mizusumashi to return filled the empty cartons that he took in his last pass (Rodrigues, 2011).

A well-designed line border must meet the following four criteria (Coimbra, 2009):

1. The location of the components should minimize the picking movements of the operators;
2. The location of the components should minimize the movements of those who supply the lines;
3. The time required to change components from one final product to another should be reduced;
4. The decision to replenish or replace components shall be visible and instantaneous.

4. Presentation of the Initial Situation

The Ford B479 assembly line produces 19 final product references that correspond to the various existing versions of the Ford Fiesta's climate control system.

At the beginning of the project, the assembly line was in an early stage, whereby it was not operational yet, so there was no defined supermarket and there was no defined supply system. For those reasons, we analyzed the supply system and the existing supermarkets for the remaining assembly lines.

5. Existing Supply System for Remaining Assembly Lines

Supermarket Supply

As the main objective of this project was to define a system of supply, we began by studying the system used to supply the supermarkets of the remaining assembly lines, as well as supplying the BL of the various assembly lines.

Those responsible for the supply of the supermarket are the warehouse employees. They have to do a visual management in the supermarket through the magnets present in the various positions of the shelves. This visual management begins with a survey of all the references to be supplied. These references are entered in the scanner during the round. At the end of the round the employee goes to the warehouse to pick up all the references. If references exist they are returned by the scanner with the information of their location of the oldest material in the warehouse, following the FIFO, if not, the warehouse employee exchanges the magnet with a blue one, which indicates to the operator of the logistics train that there is no material of that reference in the warehouse. After having all the missing references in its possession, the operator supplies the supermarket and makes a new cycle. In this way, the route taken by the warehouse employee is not always the same, since it depends on the materials to be supplied.

Line Borders Supplies

The materials needed to supply the lines are withdrawn by the logistics train operators from three supermarkets:

- Supermarket of high turnover or large rotation components, such as reels and painting trays, usually referred as Supermarket 1;
- Electronic supermarket, usually referred to as SMS Supermarket
- Supermarket of the remaining components, usually referred to as Supermarket 2.

The supply of the assembly lines is made from the BL. This supply is made by the operators of the logistics trains and is very similar to the supermarket. The current flow of information consists of three methods: Visual Kanban, the train worker while supplying the assembly lines makes a visual management of the BL, recording in a notepad the references that need supply; Kanban boxes, the worker takes the empty boxes that the operator of the production line puts in the return of the BL and there are, also, some components that are supplied by the junjo system. In the next round the BLs are supplied and a new survey is made of the references that must be supplied. Mizusumashi takes a definite course starting from supermarket 2, through several lines and SMD supermarket, which is located in the assembly area. Then, the Mizusumashi makes a stop at the dock to deposit the waste and reenter the assembly area. Finally, goes around the warehouse to go through supermarket 1, which is located at the bottom of the warehouse shelves, and arrives again at the origin. With this route the train travels an average of 400 m and takes about 45 min.

6. Data Collection

In a first phase it was essential to find all the materials that belonged to the various versions of the final product. Next, it was necessary to identify, for each reference: to which work station and to which BL belonged; the capacity of the BL; the type of packaging (it may vary between: carton, bag, paint tray, Styrofoam tray, etc.) and the incorporation factor (number of parts in the final product), Table 1.

Table 1. Sample of Collected Data.

Workstation		Incorporation factor	Ref.	UM (Unit of Measurement)	Current Qtt. (UM)	Qtt. (UM) required	Capacity of BL	BL where it's used	Associated end product
Rotary knob assembly	1	1	11195-384	Bag	200	100	4	R1A	B479 B515 H62X
		1	12792-069	Bag	100	100	4	R1A	B479 B515 H62X
		1	12792-068	Bag	100	100	4	R1A	B479 B515 H62X
		1	12792-180	Bag	424	100	4	R1A	C519
		1	12792-136	Bag	250	100	4	R1A	C519
		1	12792-283	Bag	400	120	3	R1A	B479 B515 C519 H62X
		2	05053-377	Plastic ESD box 600x400	450	500	2	R1A	B479 B515 C519 H62X
	3	2	10013-552	Reel	700	700	2	R4B	B479 B515 C519 H62X
	4	1	12376-005	Bag	50	750	4	R4B	B479 B515 C519 H62X
		1	05132-193	Blister	24	24	60	R4B	B479 B515 C519 H62X
		1	12375-786	Bag	1000	150	3	R4B	B479 B515 C519 H62X
		1	12694-718	Bag	10000	1500	4	R4B	B479 B515 C519 H62X
		1	13061-528	Pianting Tray	144	144	6	R4B	B479 B515 H62X
	5	2	13566-088	Bag	500	225	2	R5A	B479 B515 C519 H62X
		1	13566-092	Bag	700	300	2	R5A	B479 B515 H62X
		1	13566-089	Bag	2000	1500	2	R5A	B479 B515 C519 H62X

To facilitate the interpretation of the Table 1, the explanation of the various columns is presented:

- The first column indicates the workstation where the material is used.
- The incorporation factor, as mentioned above, represents the number of pieces, of their reference, necessary for the final product.
- The reference (Ref.) is the internal code used to identify the material.
- The unit of measure is the type of packaging in which the material is when it arrives at the BL and can be: bags; small ESD box BL; 600x400 plastic ESD box; 400x300 plastic ESD box; ESD card 600x400 box; ESD card 400x300 box; styrofoam tray; paint tray; blister and reel.
- The quantity per unit of current measurement represents the quantity that comes from the supplier, per packaging.
- The quantity per unit of measurement required represents the quantity that is to be received from the supplier in order to be in conformity with the respective capacity of the material in the line.
- The next column indicates the capacity of the BL in units of measure for the desired quantity.
- The penultimate column tells us which BL contains the respective material.
- Lastly, the last column shows the final products where the component is used.

7. Supermarket

In order to define the number of positions required, it was essential to collect information on the capacities of the supermarket boxes for the various materials, like Table 2 briefly presents.

Table 2 – Sample of Supermarket Data Collected

		Component box	
Reference	**Inc. Factor**	**Dimension (Supermarket)**	**Qtt. per box (Supermarket)**
Workstation 1-Inserting components on the pallet			
11195-384	1	600x400x220	400
12792-069	1	600x400x220	400
12792-068	1	600x400x220	400
12792-180	1	600x400x220	424
12792-136	1	400x400x220	200
12792-283	1	600x400x220	400
05053-377	2	600x400x220	450

Once the data were collected and the necessary analysis was carried out, it was possible to conclude that 111 supermarket positions 1 and 2 would be necessary, as can be seen in table 3. Since the SMD supermarket is managed by the SMD assembly area, this part will only focus on supermarket 1 and 2.

Table 3. Number of positions needed in the supermarket 1 and 2- 1st Analysis

	Super 1	Super 2	Total Positions
B479	15	96	111

However, not satisfied with this solution, two changes were made:

1. Analyzing the results obtained it was noticed that there was a set of 11 references, also known as subgroups, representing 55 of the total positions, that is, about 50%. Analyzing the process, it was found that each reference of final product can only use a reference of subgroup. For that reason, it was defined that in the supermarket would only be stored the reference that was being used at that moment, that is, the position of the subgroup was the same for the 11 references and the subgroup reference would change according to the version that was being produced. As the subgroup needed 5 positions in the supermarket, it was concluded that the best storage option for this material would be on a pallet next to the supermarket shelves. With this change the total number of positions was reduced to 57, as can be seen in table 4.

Table 4. Number of positions needed in the supermarket 1 and 2- 2nd Analysis.

	Super 1	Pallet	Super 2	Total Positions
B479	15	1	41	57

2. De seguida, decidiu-se que se deveria adicionar mais duas paletes para as referências 13061-514 e 12792-067 uma vez que a primeira necessitava de 11 posições em supermercado e a segunda necessitava de 3 posições em supermercado, obtendo uma redução para 45 posições, como se pode observar na tabela 5.

Table 5. Number of positions needed in the supermarket 1 and 2- 3rd Analysis.

	Super 1	Pallet	Super 2	Total Positions
B479	15	3	27	45

With all the modifications made, it was decided that two shelf modules (with 15 positions each) and 3 pallets would be required for supermarket 2, as shown in figure 1. For supermarket 1, would be required 15 positions.

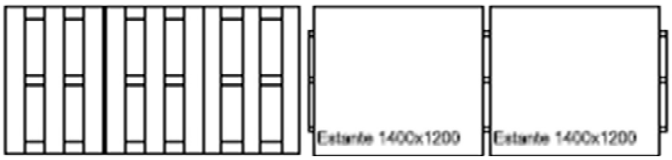

Figure 1. Schematic representation of the supermarket 2

8. Supermarket Location

When analyzing the location of the Ford B479 line, it was found that it was only approximately 28m from supermarket 2. It was also verified that along the Ford B479 line there was a space where there were three

cutting machines, however it was possible to move those machines to another location, leaving that area free. Analyzing these two factors, it was decided that the best option for the supermarket of the Ford B479 line would be in the area of the cutting machines.

9. Supermarket Construction

With the progress of the construction of the supermarket, it was noticed that there were no 15 free positions in the supermarket 1, for the 14 paint trays and the reel required for the Ford B479 line. Supermarket 1 is located on the first level of the warehouse's shelves, so it is not possible to buy more positions, so there were only 6 free positions. For that reason, it was necessary to find solutions to put 9 of the 15 references in the supermarket 2. For that, we analyzed the points to improve and made several changes.

1st Change*:* From the beginning, with the choice of the area for construction of the supermarket, it was noticed that there was room to place another pallet. In order to choose which material would occupy the fourth pallet, a study of bottlenecks was conducted, and it was concluded that it would be the painting tray with the reference 13061-508 to occupy the free place.

2nd Change: It was then realized that it was possible to place two painting tray references per pallet, since each tray occupies an area of 600mm X 600mm and the pallet has an area of 1200mm X 800mm. Therefore, based on the bottlenecks and also the planned production needs until the end of the year, reference 13061-509 was chosen to share the pallet with the reference 13061-508*.*

3rd Change: As the bobbin was also in supermarket 1, because it was large, it was decided to place 2 positions on the side of the shelf to place them, which reduced the number of positions needed in the supermarket 1.

4th Change: At this point, with the above changes made, 12 positions were still needed in supermarket 1, which was still not possible. To solve this problem, a four-story support trolley was purchased where four painting tray references could be placed, which reduced the number of positions required in the supermarket 1 to 8.

Figure 2. Changes 1, 2, 3 and 4.

5th Change: With the construction of the supermarket and the beginning of the line, it was noticed that it was urgent to change BL 3.A.3, since its capacity was very low and the return was too much to the available area. Initially, reference 13061-514 was stored in 600mmX400mmX220mm boxes with 16 painting trays, that is, 32 units per carton, since each tray had 2 units. As the BL was not configured for the boxes, but for the trays themselves, it only had capacity for 36 trays, that is, 72 units. In conjunction with the painting section, it was defined that the reference would be stored in boxes of 400mmX300mmX220mm, without the painting trays, with paper dividers between each layer of pieces, thus the capacity of the box would be 64 units. With this change, the BL, which has been configured for the boxes, it has now a capacity of 7 boxes, that is, 448 units. So, this change allowed to increase the capacity of the BL from 72 units to 448, which represents a gain of 522%

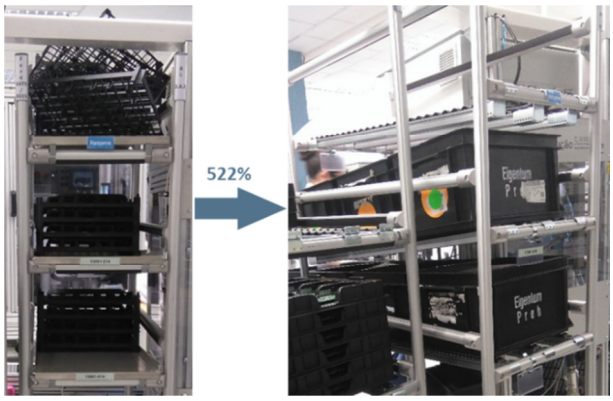

Figure 2. Change 5

6th Change: Over time, it was realized that when it was necessary to make reference exchanges, there were many problems in the subgroup's supply system. This happened because there was only one position for all references, which implied that when the version of the final product was changed, there was a need for a full exchange at the exact moment of the change. For that reason, two more shelves were acquired, only with the two levels from above, in order to place them on top of the four existing pallets. These new shelves generated 16 new positions. With those positions it was possible to place tow boxes of each reference of the subgroup in the supermarket, in order to guarantee that when there was an exchange of reference there were always at least 72 units in it..

7th Change: As there are only 11 subgroup references, it was possible to use the 5 free positions for other references. Thus, it was possible to remove the reference 13061-514 from the pallet, since after the changes in storage and BL, this material was no longer the bottleneck of the line. In this way, the reference of the pallet was withdrawn and it took to occupy 3 positions in the shelf which represents 12 boxes, that is, 768 units in supermarket. The remaining two positions were used to duplicate the positions of two materials that could represent some sort of danger to the supply system.

8gth Change: With a free pallet it was possible to remove two more painting trays from the Supermarket 1, leaving only the 6 painting trays for the 6 existing free positions. The trays were chosen based on the bottlenecks and the expected quantities of each reference by the end of the year.

Figure 3. Changes 6, 7 e 8.

After making all the changes, the result can be seen in Figure 5.

Figure 5. Final result of the Ford B479 line supermarket

10. Supply System

Supermarket Supply

Although the supermarket of the Ford B479 line is not located in the intended area for the shelves of supermarket 2, which contain the raw materials of the remaining lines are located, the supply system will be equivalent to the existing one for these shelves.

The supply is also made by the warehouse employees who through the colored magnets make the visual management in the supermarket. This visual management begins with a survey of all the references to be supplied. These references are entered into the scanner during the course of the round. At the end of the round the employee goes to the warehouse to pick up all the references. The only difference is the distance traveled by warehouse employees, which increases by about 60m per round.

Line Borders Supplies

The supply of the BL is made by the operators of the logistical trains (Mizusumashi). As the supermarket is next to the line, the information flow used in the line is Kanban Boxes, that is, the train operator collects the empty boxes / trays that the production line operator places on the return of the BL. In the case of the boxes, train operator refills them and put them back on the line. In the case of the trays (paint, styrofoam or blisters), the train operator places them in the convoy, transport them to the waste deposit and goes to the supermarket to replenish the quantities required.

With this change it was possible to reduce the Visual Kanban, where the train worker while supplying the assembly lines makes a visual management of the BL, registering in a notepad the references that need supply; only for the painting trays found in the supermarket 1, and for the blisters of the SMD plates that are in the SMD supermarket.

11. Conclusion

Supply to assembly lines is a crucial activity in the company's internal logistics, since all production is dependent on the supply of the materials needed for the line. For this reason, it is extremely important to study solutions that facilitate these activities, increasing their productivity and ensuring the availability of products at the right time, in the right quantity and at the best cost.

With the decision to build the supermarket next to the line several advantages were obtained, among them:

- The raw materials travel shorter distances, i.e., instead of traveling around 400m due to the return of the logistic train, travel approximately 180m. This represents a reduction of approximately 55% of the total distance covered by the raw material.

- Reduction of handling, since in the existing scenario of the company, the raw material passes through Warehouse - Supermarket - Mizusumashi - BL. With the new solution the raw material passes directly from the supermarket to the BL, hence the decrease in handling.

Finally, the realization of this project represented an attractive challenge for me, since it was a test of my abilities. It was also a very enriching experience because I had the opportunity to work in a company that is renowned in its business area and that bets heavily on innovation and growth at a national and international level.

As future work, it is suggested to continue the analysis of the developed supply system, in search of problems or opportunities for improvement.

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