Increase of productive efficiency and service level of a business food company using lean methodology

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ABSTRACT

In a time of extreme competitivity, organizations search for methods and tools that promote their success, minimizing the costs. In that sense, the *lean* methodology appears, translating "a systematic process of change applied by a set of principles and good practices, aiming at the continuous improvement" (Womack *et al.*, 1990), which is explored in the present work, developed in Company X.

Currently, Company X – a food business company – is in a very privileged position compared to its competition. However, the company aims to improve its level of service and operational efficiency to, thereby, achieve an even greater competitive advantage over competition.

Based on an extensive literature review, a multi-methodology was developed, with the goal of solving the problems identified previously, in an initial analysis. This one, exploring a set of lean tools, is divided in three steps: 1) identification of improvement opportunities (with support of VSM tool); 2) definition and implementation of improvement proposals (using pull planning, line balancing, standard work and daily kaizen); 3) being this consequence of 2) and, thus, discretionary, involves the implementation of improvements with investments.

The first step of multi-methodology provided a basis for the creation of a solution capable of assisting management and planning considering actual demand, whose dimensions of storage and production supermarkets were calculated. From the second step, an increase in overall equipment efficiency was achieved in two different testes: in the first using line balancing and standard work provoke and increasing of 43%; with daily kaizen, this improvement was 120%. In this way, the implemented proposals allowed an increase in production competitiveness to be achieved, proving the improvement potential of Company X.

Key words: lean, kaizen, operational efficiency, pull planning, supermarket, logistics.

1. Introduction

Being competitive in a market where customers are increasingly demanding quality, innovation and better prices does not is something simple for most organizations. In food industry, focus sector in the present work, two arguments motivated the interest in analyzing operational efficiency and waste reduction (leading to application of lean methodology): the industry representativity and its competitivity.

Company X (name given because confidential motives), a food business company, is the company where the work was developed: this is a company that produces sauces and spices, with a business invoicing of 20 M€, 300 employees and 1 000 SKUs. Despite its competitive advantage, it was felt the necessity to improve its service level (90%), as well as increase productive efficiency (since OEE average is 30%).

The tools used to discover the potential improvements of Company X and to find the respective solutions followed a strategy based in lean methodology. There are plenty definitions to this strategy but many authors highline the idea of continuous improvement, involving every person from an organization, at every time.

2. Literature review

2.1. *Evolution of lean concept*

Industry and its manufacturing processes have been developing under many paradigms. In figure 1, an evolution of these paradigms is showed, as well as their relation with the variety of products and production's volume.

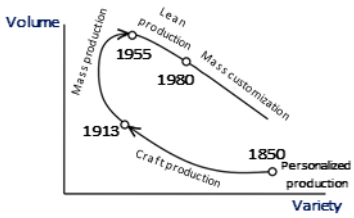

Figure 1 - Relation between volume and variety in manufacturing paradigms.

For Hu (2009), the first paradigm was craft production, where the client can choose which specifications a product should have. Then, appeared the concept of Fordism, focused on an easier production, increasing products' quality and reducing costs. However, after World War II, the Japanese company Toyota Motor Company felt the need of developing other production process, to answer to the economy’s fragility and size of internal market (it was residual). Therefore, it was concluded that because of these factors, the best way of satisfying clients (or attract potential ones) was by offering products with high value, in a competitive price. Focused in this premise, it is developed the Toyota Production System (TPS) or lean production: a process of systematic change that is applied through a set of principles and good practices, focusing in continuous improvement (Womack *et al*., 1990).

The concept “*lean* was propagated in 1990 (through the book *The Machine that Changed the World).* Since then, the methodology has been increasing its applicable scope: in the beginning, the focus was in production lines of automotive fabricants; nowadays, it is possible to see lean in many other businesses, related or not with productive processes. Found & Bicheno (2017), described lean as operational system, management system and philosophy.

Operational system

This definition is directly associated with the traditional vision of lean methodology, where the focus is on shop floor and, consequently, increasing processes efficiency through specific tools.

One of the main topics of lean thinking is the erase of waste (muda, in Japanese), esteeming the activities that add value to the clients. There are seven categories of muda: overproduction, over processing, waiting (people), transporting, unnecessary inventory, excess of movements (people) and defects (Mouzani & Bouami, 2016). Also, lean thinking follows a set of principles crucial for the reduction of 7 muda, starting in value identification (to customers), defining a value stream mapping, creating continuous flow, implementing a pull system and, in the end, looking for perfection (improving 4 principles).

Management system

The 5th principle identified previously was the search for perfection. It is on this principle that lean as a management system is worried: the constant improvement of processes; the change for the better (kaizen).

Methodologies should be applied according to the problem. To Found & Bicheno (2017), there are three levels of different problems to be solved: daily problems, whose focus is on small problems that can be solved immediately; (2) kaizen events, a Western innovation, which last about a week and focus on problems of some magnitude; (3) strategic and large-scale problems, where projects can last longer than three months. Thus, lean management system focuses on supporting lean principles and aligning organization's goals with operational improvement plans through a structured development of strategic policies.

Philosophy

Lean thinking is based on two pillars: just-in-time production and jidoka system. The first is the most visible and publicized feature of the methodology, but the second is of the utmost importance: jidoka represents the practice of never letting a defective part go to the next procedural stage, whereby people are responsible for identifying problems and stopping the line when necessary.

2.2. Tools

In Company X, since there is nothing structured developed to understand the initial situation, it makes sense to draw an initial visual representation of flows of people, materials and information. In a complex system, the use of *value stream mapping* (VSM) is the more appropriated tool, given the fast results.

To enhance productivity, depending on the exact problems detected in VSM, many tools can be used: *single minute exchange of die* (SMED), *visual management*, *5S*, *standard work*. To improve planning systems and internal logistics, a pull planning strategy must be followed.

According to Shingo (1985), SMED is a methodology capable of reducing setups and changes in equipment operations in less than ten minutes. A setup represents all the necessary process for the adjustment of equipment and production system due to the change of components/products, until a certain production rate is reached with quality.

To Eaidgah *et al*. (2016), visual management is the practice of information or display requirements to define directions. It argues that all tools, activities and indicators should be visible to all stakeholders in order to better understand the current state of the system (Koch et al., 2012). This is essential to a successful application of *standard work* (implementation of best working method, that must be documented and those who are involved must have training) and 5S (practices of workplace organization, where all the stakeholders must be involved using standards and discipline).

A pull system begins at the customer and recedes throughout production, where the actors produce the right quantity of components/products at the right time. This flow must continue to the raw material suppliers so that each segment of the business is connected in the chain (Byrne, 2012). Pull planning provides greater resistance to demand fluctuations: the systems that apply it will achieve greater production flexibility, reducing the bullwhip effect - distortion of demand perception along the supply chain.

3. Characterization of Company X and its improvement opportunities

3.1. Company X

Company X, inserted in the food market – more precisely in the production of sauces and condiments –, is a 100% Portuguese organization and was founded in the early 80's. In addition to the production of food condiments, the company is also responsible for the distribution of some products and exports to more than 40 countries, spread across 5 continents.

Company X controls about 1,000 stock keeping units (SKUs) and it is currently the main source of employability in the region where it is headquartered, with 300 employees. Although Company X holds a leading position in the market in which it is located, its administrators intend to implement and sustain a culture of continuous improvement. This objective is justified by the desire to keep increasing the results previously achieved. The focus of the company is, therefore, the increase of efficiency, and consequent productivity of the operations, resulting in the amplification of service level.

3.2. Improvement opportunities

Identifying opportunities for improvement is necessary to the work development. In this way, a VSM was constructed: with this tool it will be possible to achieve a better perception of the activity of the plant, as well as the respective transport and information flows.

For the realization of a VSM in Company X, there is a need of following a product and realize which flows are inherent to it. Hence, to try to understand the flow of critical components for production – raw materials, packaging and labels – and, knowing that the flows are the same, the finished product value chain was mapped following a plastic bottle. This mapping, given the required confidentiality, the complexity of operations and the lack of a control structure for information extraction, is simplified - also enhancing simplicity for a better understanding of the flow. Thus, the operations associated with the mapping developed are now explained: (1) receiving, (2) filling, (3) palletizing, (4) filming, (5) shipping, (6) commercial, and (7) shopping.

Opportunities for improvement were collected throughout the mapping, allowing to conclude that the main problem was the absence of a continuous flow during the process, characterized by 1) inventory breaks where the material was not in the right place and/or in the required quantities; 2) excessive amounts of material stopped between operations. Both situations lead to long waiting times and, consequently, a general inefficiency in production. From this point on it makes sense to use the 5 Whys tool (figure 2), given its simplicity of application, and because it is the answer/conclusion of this: the root cause encounter.

Figure 2 – 5 Why questioning technique.

Explaining every methodology step applied:

- 1 Why: The apparent reason for the flow being constantly stopping is related with products quantities moved. In fact, what tends to happen with regularity is the carriage of packages in very different quantities from the necessary ones (having variability in these differences, superior or inferior to needs). In addition, for the quantities that do not match the demand, space is also a problem: the quantities sent do not consider the space they occupy or the space of the destination;

- 2º Why: The answer found is divided into two different subjects. The first concerns the inexistence of data that translates efficiency and productivity, leaving doubt of consumption time of all the containers transported to the lines. This point is of the utmost importance: not knowing the OEE, for example, causes a lack of knowledge about the quantities that respond correctly to the needs and, consequently, the number of productive stops; the productive stops have very relevant implications in the OEE and, in turn, in the level of service. The second issue notes the lack of organization of spaces: there is no notion and space by reference, promoting less displacements for the next references or references with high turnover;

- 3 Why: The justification for the two problems identified above is governed by the lack of communication inherent to Company X. If, on the one hand, there is no communication in the *gemba* between the production lines and the respective supply, on the other hand there is no a good flow of communication between the *gemba* and the purchasing department;

- 4 Why: Communication does not exist because there is nothing (in a standardized way) to communicate: there are no standards defining what flows of information should exist, as well as indicators;

- 5 Why: The lack of correct planning means that there are no team goals (e.g., planning is done only by priorities, where there is no temporal division, not existing pressure on what must be done today). Another point is the non-verification of materials before orders.

In this way, the inefficiency in planning proves to be the root cause of the difficulties observed in the construction of the VSM. Inefficiency in planning makes it impossible to create a continuous flow throughout the process, which has proven to be one of Company X's main problems, causing high levels of stock, low levels of service and long lead times.

4. Definition and implementation of improvement proposals

4.1. Pull planning

4.1.1. Theoretical grounds

The model adopted in Company X is push – production model for stock – and, in order to create flow, guarantee alignment among all stakeholders and ensure that all consumables are available, the implementation of a pull planning model appears as more proper. The development of this model involves the analysis of three phases:

1) Strategic planning: It aims at categorizing the products in MTOs (Make-to-order) and MTSs (Make-to-stock). This categorization is initiated by Product-Quantity Analysis (PQ or ABC Analysis), where product references are allocated by groups. After this analysis, the production strategy of each reference must be decided, being: 1) MTS - the product is available for immediate delivery, where the company withdraws from stocks to the customer and triggers a production order (PTO - Picked to Order; BTR - Build to Replenish); 2) MTO - the customer has to wait for the product, in this case it can have a long lead time.

2) Capacity planning: It has an extreme importance given its role in anticipating demand variation (including seasonal periods). The capacity should be determined based on takt time (equation 1), and for this some variables must be considered: assembly line capabilities, specific machines, transportation, supermarket sizing, etc.

$$Takt\ time = \frac{Available\ production\ time}{Demand} \quad (1)$$

3) Implementation planning: After the development of the two previous phases, the company can move forward to an implementation plan. This is used to decide when and how much to produce, considering three types of orders: a) final customer orders (MTO); b) Replenishment orders (MTS); c) special orders from the end customer when order quantities are high (MTS). In the management of orders, it is important to consider level of replenishment and security stock. The first concerns the time when a purchase order should be triggered, considering the replenishment lead time (equation 2). The second should consider demand variation (equation 3).

$$Replenishment\ level = security\ stock + lead\ time\ consumption \quad (2)$$

$$Lead\ time\ comsuption = consumption_{last\ 12\ months\ average} \times lead\ time\ \times seasonality\ rate \times growt\ rate \quad (3)$$

To avoid ruptures, the stock level (number of units) that generates the order must be equal to the sum of the units consumed during the replenishment lead time and the safety stock (normally equal to the variability of consumption). Consumption in lead time represents the amount of inventory needed to be in inventory between the time the order is placed with the supplier and the time it is delivered to the company.

4.1.2. Implementation proposal

4.1.2.1. Strategic planning

Firstly, as indicated in the previous section, the production strategy of Company X - ABC Analysis – was categorized. The analysis was performed for all end products (1 000 SKUs), positioning them based on three variables identified as crucial in the company: monetary value, quantities consumed and frequency of consumption. It should be noted that the assumptions in this analysis were based on the Pareto rule, this is: 1) For all variables, category "A" is considered to be 80% of the total value; 2) For all variables, category "B" is considered as 15% of the total value; 3) For all variables, category "C" is considered to be 5% of its total value. In table 1 is presented the result of ABC Analysis.

Table 1 - Distribution of SKUs by quantity / value and frequency of consumption.

		Consumption frequency A	Consumption frequency B	Consumption frequency C
Quantity/Value	A	84	99	101
Quantity/Value	B	137	152	63
Quantity/Value	C	95	191	78

After the allocation of the products to their value, quantities ordered and frequency of consumption, the production strategy of each reference must be decided. Remember, this strategy may be MTS, where the product is available for immediate delivery, or MTO, the customer must wait for the product, there may be a long lead time. It is important to note that when talking about MTS planning, the strategy to adopt is continuous replenishment (CR): the supplier – in this case, Company X – calculates, based on historical data, the inventory levels indicated for each product. Continuous replenishment can be understood as replenishing stocks based on sales and actual consumption of products (Vivaldini, 2007). When the customer places an order, the supplier can respond quickly (producing what to certify the calculated inventory levels). The strategy for the choice to be made for each type of product is shown in figure 3.

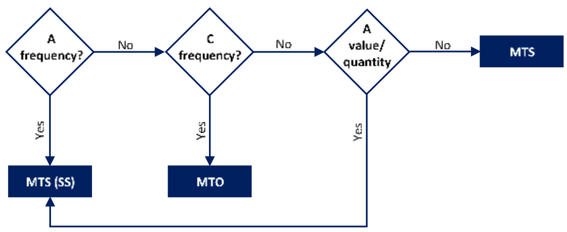

Figure 3 - Production strategy flowchart of all references.

Note: MTS (SS) corresponds to a strategy MTS considering safety stock; MTS corresponds to a strategy MTS not considering safety stock.

The logic created in the flowchart follows the subsequent assumptions:

- References with high levels of consumption (i.e. frequency) should always be in inventory: if they were not, or the company should have to be constantly producing them, or breaks would occur on a regular basis. It makes sense to refer that safety stock is really important;

- The references with low levels of consumption are, as a rule, special orders and very infrequent. In this sense, it does not make sense to be MTS, assuming for this scenario an MTO strategy: the production orders are released when the ordering is done;

- If a product has frequency B and value/quantity A, it means that it is a product with a high value for the company and therefore, there must always be a safety stock (figure 4);

- If a product has frequency B and value/quantity B or C, it represents a less significant part for the company and, therefore, the need for the safety stock is lower. Because the product is less valuable, Company X assumes responsibility for possible inventory breakdowns - the company prefers to lose/delay the order to consider space and production time for the security stock. Parallels with the Pareto rule: if 20% of sales (B and C categories) are associated with 80% of references, non-use of a security stock could mean a drastic reduction in inventory costs (figure 4).

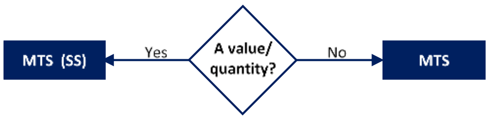

Figure 4 - Production strategy flowchart of references with medium level of consumption.

After the definition of the production strategies to be taken for the finished product, the analysis was effectively carried out. All SKUs were analyzed regardless their typology (i.e. mayonnaise, ketchup and mustard). However, for reasons of product quality, an assumption had to be made: mayonnaises, regardless of the production strategy chosen because of the ABC analysis, should be make-to-order since the product cannot be more than 24 hours in storage silos. Although the product listing cannot be presented, but the total number of products per strategy is shown in table 2, and this list is updated with the assumption explained above.

Table 2 - Total number of SKUs per production strategy.

	MTS		MTO
	With safety *stock*	Without safety stock	
Number of SKUs	267	303	430

4.1.2.2. Capacity planning

Production capacities

Company X has 46 tanks used to send the products to the filling lines (sometimes they can be used only for storage): 13 fixed and 33 movables (1 ton), where the 13 are split in 8 of 10 tons and 5 of 5 tons. Currently, all silos store all products, not existing priority or reserve per product. In this way, sometimes there is a product that is not necessary which is taking up space that could be used to respond to the real needs of consumers. Based on the three types of products existing in Company X, we have:

- Mayonnaise: this type of products will follow a make-to-order production strategy, as mentioned;

- Ketchup and mustard: these products can be stored with a maximum of one week, reason why it makes sense to follow a make-to-stock strategy - the products must be available for immediate delivery, where the company withdraws from stocks for the customer and a production order is triggered.

To MTS strategy, the calculations must be developed. The goal, in this phase, is to calculate the minimum amounts of mustard and ketchup produced per day. Firstly, the maximum production should be calculated (equation 4):

$$Max\ production = \frac{batch\ size \times opening\ time}{batch\ production\ time} \quad (4)$$

This calculation must be done for SKUs more relevant per typology. After this, the calculation of the production that should be reserved must be defined, based on the real demand of clients: production of SKU A per day, where the SKUs that should be evaluated are the ones that represent a higher value to the company. When results are achieved, it is possible to know which percentage of silos should be reserved to, in this case, ketchup and mustard. These are presented in figures 5 and 6.

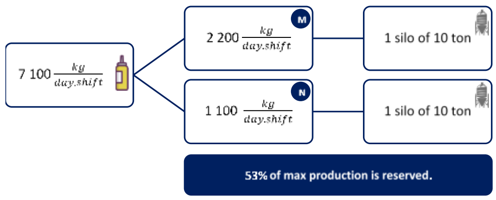

Figure 5 - Daily production of mustard and its distribution per silos.

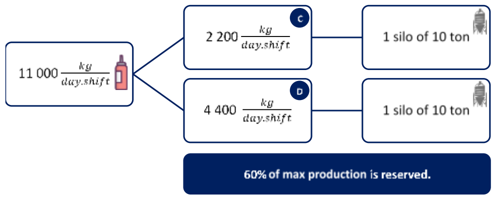

Figure 6 - Daily production of ketchup and its distribution per silos.

The allocation to the silos of 10 tons is justified through ABC analysis: these are the products with a higher consumption frequency, so the biggest silos should be associated to them. Though, these have higher dimensions than the required (if the company had done properly the calculations, smaller machines should be brought).

Batches' size

According to the service level that Company X intends to achieve (99%, a growth of 9%), and as previously stated, the articles were defined and the respective quantities to be in stock. Thus, the focus should be on meeting the real needs of customers, increasing their service level and optimizing the costs of the entire value chain.

The question you want to answer is: "how many setups can I do?". With optimal setups, the optimal batch number and batch sizes are calculated. In the current model of Company X, batches have about a month (on average), which implies a weak response delivery: the company can only respond one month after a new request arrives. After the determination of the number of setups, the reduction of the setups is of extreme importance, with the help of the SMED tool, for example, the goal is to exchange time in setup for productive time, with the possibility of producing more batches in the same period.

The first step refers to the calculation of available time – without scheduled stops – considering the setups. Define itself as "available time" (to produce and perform setups; equation 5):

$$Available\ time = time_{\ without\ schedule\ stops} + time_{\ setups} \quad (5)$$

Then, the calculation of time to perform just setups could be done. Equation 6 represents this, where the demand time corresponds to production time of the batches that were ordered by clients (real demand).

$$Available\ time\ to\ setups = available\ time - demand\ time \quad (6)$$

Therefore, it is possible to achieve the optimal number of setups: having the available time to setups, it is required just to have the time of each setup (equation 7). The number of batches is equal to the number of setups plus one (if there is one setup on a day, there are two moments of production, before and after; equation 8).

$$Number\ of\ setups = \frac{time\ available\ to\ setups}{time\ per\ setup} \quad (7)$$

$$Number\ of\ batches = number\ of\ setups + 1 \quad (8)$$

The next question is: "does it make sense to have a number of batches lower than the number of references that you always want to have in inventory?". What happens is, for instance, in 5 days of production, it is only possible to produce 7 of 8 make-to-stock references of the line under analysis. Using the concept of every part every interval (EPEI, equation 9), whose definition goes through the time the line takes to produce all the references, it is concluded that the level of replenishment should be:

$$EPEI = \frac{total\ amount\ of\ SKUs}{\frac{amount\ of\ SKUs\ produced\ in\ an\ interval}{interval}} \quad (9)$$

Knowing the exact number of days of each production cycle, i.e. how long the line takes to produce all the references (that follow a make-to-stock strategy), it is possible to calculate the production times (equation 10) and, consequently, the batches' size (equation 11).

$$Production\ time = \frac{production\ time\ in\ interval \times EPEI}{interval} \quad (10)$$

$$Batch\ size = \frac{production\ time}{cycle\ time} \quad (11)$$

Stock levels

After defining which strategy to follow for each type of product, be it final product or consumable, and the batch sizes of those who take a make-to-order production strategy, the next step goes through the inventory level calculations. These will have to be calculated for all products and consumables that, of course, follow a make-to-stock strategy.

In companies such as Company X, which work directly for the mass consumer market, and because its portfolio of products is affected by various external factors, a seasonal analysis of the entire range of products is essential. The analysis must be done quarterly to ensure that the seasons – a highly important variable in the market where Company X is inserted – are translated in the calculation. Thus, for the calculation of the seasonality rate, the company should look at the following three months of the previous year (equation 12).

$$Seasonality\ rate = \frac{consum._{\ homologous\ period\ under\ analysis}}{consumption_{\ average\ annual\ period\ ^{(1)}}} \quad (12)$$

(1) Calendar year of homologous period in analysis.

In addition to the seasonality rate, the growth rate must be studied: if, on one hand, there may be periods with peaks or lows of production, on the other hand, consumption may have an increasing or decreasing behavior over the previous year. So, the growth rate could be given by (equation 13):

$$Growth\ rate = \frac{consumption_{\ last\ 12\ months\ of\ year\ n}}{consumption_{\ homologous\ months\ of\ year\ n-1}} \quad (13)$$

For the calculation of the safety stock, the time window used is also quarterly. The safety stock should protect the company against all fluctuations in demand and lead time, creating a buffer for all potential occurrences. Thus, the calculation is represented as follows (equation 14):

$$Safety\ stock = \left[\begin{pmatrix} consumption_{\ max} \\ \times \\ lead\ time_{\ max} \end{pmatrix} - \begin{pmatrix} consumption_{\ average} \\ \times \\ lead\ time_{\ average} \end{pmatrix}\right]^{(1)} \times rate_{\ season.} \times rate_{\ growth} \quad (14)$$

(1) The values must be used having as basis the last 12 months.

The equation of safety stock used considers the worst-case scenario, considering the max consumption and max lead time. This should be reviewed periodically, potentializing decreases of stock. With the safety stock values, it is possible to calculate the replenishment levels (equation 2):

$$Replenishment\ level = security\ stock + lead\ time\ consumption \quad (2)$$

Although space organization is not theme at this point, a maximum inventory level should be set. Equation 15 translates the calculation of the maximum stock.

$$Maximum\ stock = replenishment\ level + safety\ stock * 2 \quad (15)$$

In this situation, the security stock was considered in duplicate to give greater confidence to the algorithm that will be developed based on the present model.

Finally, Company X should be able calculate the stock that is available. In this sense, the variables that must be considered are: (1) what is in inventory; (2) what will come out, that is, what is already ordered and therefore reserved; (3) what is being produced. Thus (equation 16):

$$Available\ stock = actual\ stock\ - orders + production \quad (16)$$

4.1.2.3. Implementation planning

For an understanding between what must be produced and what can be produced, a contract between Production and Planning should be developed. This seeks to answer the questions: (1) what to do if there is no capacity sufficient for planned production?; (2) what to do if the planned production does not occupy the existing capacity?. The contract built is:

What to do if capacity is lower than planned production?

- Produce MTSs by coverage $\left(\frac{stocks}{monthly\ average\ sales}\right)$;
- Produce MTOs by delivery date.

What to do if planned production is lower than capacity?

- Anticipate exportation MTOs;
- Anticipate others MTOs;
- Anticipate MTSs with consumption frequency and that are closer of replenishment level.

The basis used for the sequencing of production orders was empirical. In a first stage, the production must meet the orders already made by customers. When everything is already produced, it has decided to prioritize exports, since these are, as a rule, have large quantities and generate more margin than the others. When all MTOs are produced, an anticipation can be given to MTSs with higher frequency of consumption.

If planned production is less than capacity is repeated, and point 4 is reached several times, the topic of shift reduction and/or FTEs (full-time equivalents) may make sense, as well as if the capacity is less than the planned production in a consecutive way, the hypothesis of increase the number of shifts and/or FTEs should be evaluated. Note that other analyzes should be carried out, related, for example, to efficiencies and productivities.

4.2. Line balancing and standard work

4.2.1. Theoretical grounds

Line balancing is the distribution of activities sequentially per work stations, with the goal of having the greatest possible use of work and equipment, trying to minimize downtime. According to Farnes (2007), "balancing a line means assigning tasks to workstations, to optimize a measure of performance".

The strategy adopted in this work for line balancing was the strategy approved by Kaizen Institute and consists of three main steps: (1) defining the references to be studied through an ABC analysis, (2) cycle times associated with these references, using the process chart tool, and (3) balancing the line using yamazumi.

In a first phase, a product-quantity analysis (ABC analysis) should be carried out. The objetive is to understand which products are worked in each row: references A are good candidates for semi-automatic lines, since they are produced frequently and generally in considerable quantities; references B are good candidates for manual and less automated lines, since the frequency of consumption is average (so there is no such a need as that of references A for automatisms and robotizations); references C are good candidates for single-line manual lines, and this is flexible for many references.

After defining which references to work with, a process chart should be constructed for each, as well as the estimated cycle time (time without change tasks). A process chart represents the most logical production sequence: the start must be based on the main component, i.e. the component to which all the others go, somehow, on; the changeover operations should not be accounted for, and the withdrawn times should be times of operation/added value.

That said, the next step involves using the yamazumi tool. Yamazumi is a lean tool whose use reflects the workload of and between processes. This consists on vertical bars that represent the total work (by operation and time) of each operator. The working time of each operator should be compared to the takt time: at most, one unit should leave the line at takt time. This graph is used to balance processes and create continuous flow.

Standard work is a methodology oriented to the observation and simplification of tasks. This is a tool to measure and improve working methods and is based on the observation of operators in execution of their tasks, allowing a perception of the difficulties and opportunities of the operators. In this way, this tool must be applied directly in the gemba (both observation and analysis of the work, with process improvement tests), being a transversal tool, applicable to any area and organization.

4.2.2. Implementation and results

The first step involves the development of the ABC analysis for the products in production. However, this has already been done for the implementation of the pull planning method. Thus, it was possible to proceed to the next step in the construction of the process chart (figure 7): representation of the production/filling sequence by reference, this sequence having to consider the base product as well as all the secondary components necessary to incorporate. The reference that will be chosen to exemplify the balancing performed will be Z mustard, but about 9 references were selected for the effect in the real context, since these have a consumption frequency A (in that production line).

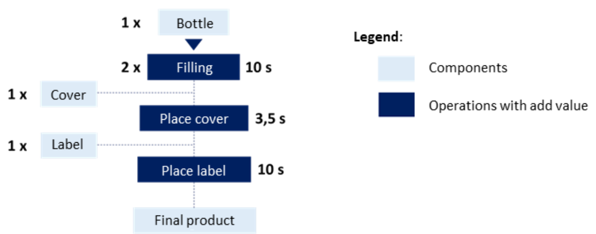

Figure 7 – Process graph of any SKU of the line.

After the identification of value-added activities, the remaining activities be removed (*muda* activities). The data were collected during several productions of the Z mustard reference, for greater accuracy of the data and absorption of the variabilities thereof: in manual tasks, one operator may be fast than another, for example. Thus, it was concluded that line operators performed 12 different tasks, shown in figure 8. Note that the colors presented will only be relevant in the next step.

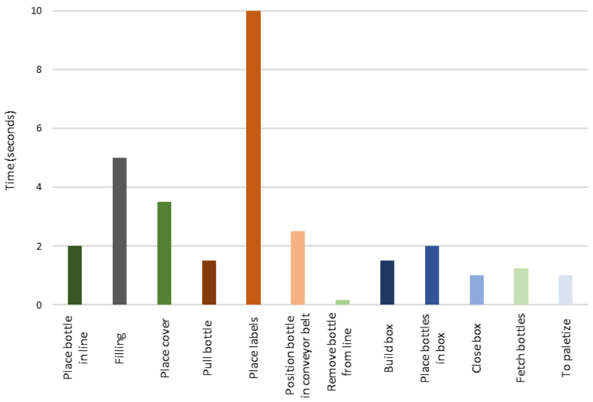

Figure 8 - Tasks executed, per bottle, by operators of line in study.

After the analysis carried out, where the data of tasks and their execution times were collected, there is a need to understand the problems in the balancing. In this way, the yamazumi visual tool was used, making the distribution of the workload clearer and more evident. Figure 9 shows the yamazumi of the line under study, where there are 4 main players: the work performed by the machine and the work performed by the 3 operators that work in the line.

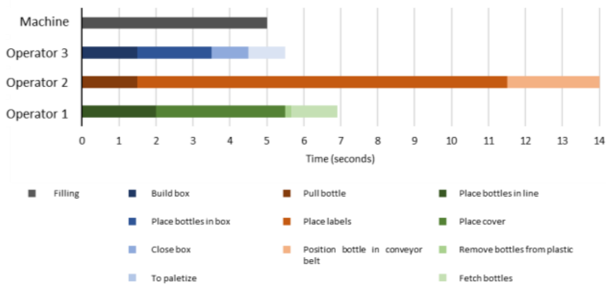

Figure 9 - Yamazumi of line in study.

The time associated with the filling – time represented as the task performed by the machine – is something that cannot be change given the parameterization of the machine. In this way, the balancing will be performed between the three machine operators. The balancing, as previously mentioned, should be based on takt time. The takt time, as well as the process chart, should be done for each reference (whether an average can be made after a few iterations, depending on the variability among all the production references associated with that row). Takt time is given by equation 1:

$$Takt\ time = \frac{Available\ production\ time}{Demand} \qquad (1)$$

Therefore, the calculation for the time available for production had to be performed. It took account of all the references produced on the lines in question. Simply put, the example where there are only 3 references (table 3):

Table 3 - Example of calculation of available time per production/SKU.

SKU	Quantity	% Volume	Effort	Total Effort	% Effort
A	2 000	50%	10s	10 × 2 000 = 20 000s	57%
B	1 000	25%	10s	10 × 1 000 = 10 000s	29%
C	1 000	25%	5s	5 × 1 000 = 5 000s	14%

The effort represents the average time required to produce a unit of references. This time is considered for the calculation of the percentage that the line must make available to produce the average quantity of a certain period. In Company X, it was decided that this period would be monthly, and there is no variability in demand that significantly impacts the values calculated above, for the present effect (except for seasonality).

Thus, after calculating the effort for the 9 references of the line under analysis, it is possible to calculate the takt time of the same. The takt time of the reference of mustard Z is presented in equation 15, based on the actual production data of table 4.

Table 4 - Data regarding mustard Z.

Line dedication	Daily production	Opening time
35%	1 065 units	7,5h

$$Takt\ time = \frac{7{,}5h \times 0{,}35}{1\ 065\ units} = \frac{2{,}625h}{1\ 065\ units} = \frac{9\ 450s}{1\ 065\ units} = 9s/unit$$

In this way, to respond to customer demand, a unit should come out every 9 seconds. However, if the process chart is reviewed again, it is visible that a task exceeds this value: the "put label" task has associated a time of 10s. Consequently, there is a need to: develop another method of labeling (buying equipments) or improving the modus operandi of employees. In this sense, the decision taken was the implementation of overtime, since Company X plans to make specific changes to the machine in the future and, therefore, does not intend to spend resources now.

The next step in the methodology that follows is the use of the yamazumi tool. It was considered, as explained, that a unit should leave the line every 10 seconds (allowed overtime, option chosen by the company). In figure 10 is possible to observe the balancing, where the operator 2 is dedicated exclusively to the task that is the bottleneck of the process, while the remaining tasks were distributed by the other operators.

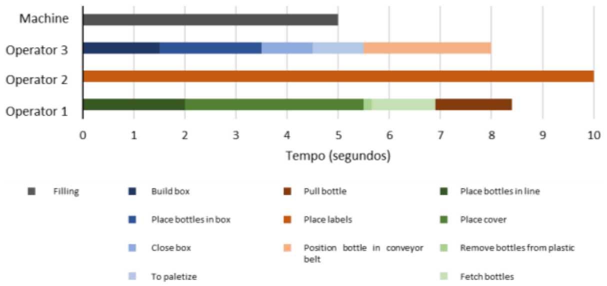

Figure 10 - Line balancing.

Line balancing and standardization tools should be used together, always as possible. As explained earlier, balancing allows the identification of different workloads along the line and, in a visual and simple way, to adjust the tasks to level the cycle time per operator. Consequently, it is possible to reduce the cycle time of the line, resulting in an improvement in the efficiency and productivity thereof. The balancing allows a positive leveling in the line, with a fast gain and without major changes to the process. On the other hand, the normalization of work allows companies to optimize each task, minimizing the change and allowing an increase in efficiency and productivity (higher than those that would be achieved with the application of the line balancing tool only). With the new working standards, the cycle time improved by 43% (from 14 seconds/unit to 8 seconds/unit), takt time was reached and the reference) are now satisfied. The evolution of the times can be seen in figure 11.

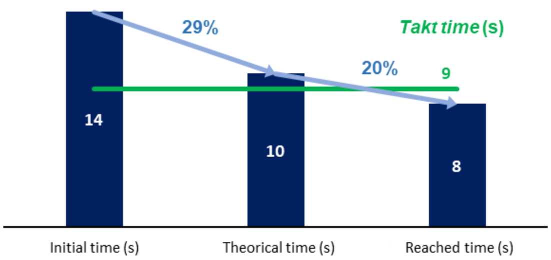

Figure 11 - Results obtained using balancing line tool.

4.3. Daily kaizen

4.3.1. Theoretical grounds

The daily kaizen comes in response to the question "how to develop people and sustain results?". In this way, the main objective is to develop employees and their natural teams, so they gradually become autonomous. As a rule, less productive teams are characterized by their lack of autonomy, whose alignment with objectives is non-existent, and there are often serious difficulties in identifying opportunities for improvement. In this way, this methodology develops teams with the practice of daily routines, with the purpose of monitoring process standards, identifying deviations from standards, solving problems to achieve and improving standards, and reflecting, learning and developing new competencies. This methodology is split in 4 main levels: 1) team's organization, 2) work space organization, 3) standardization of processes and 4) improvement of processes. In Company X, since there is nothing implemented, the focus is level 1.

4.3.2. Theoretical grounds

Company X, as noted previously, had serious structural problems in terms of communication and information sharing in gemba. The lack of indicators, excessive waste and lack of focus on objectives - which are only defined in theory, but no one actually looks at them - end up harming productive efficiency as well as discouraging teams. In addition, each employee is associated with one and only function, not knowing how to execute others, and there is no sharing of good practices and skills development. In this way, the concept of daily kaizen did not exist at all: periodic meetings, whether daily or not, did not exist; daily goals were not defined; sharing of good practices and moments of reflection about working methods were not discussed; opportunity and action plans for them were not carried out.

In this way, a pilot team was chosen. The choice's criteria were: (1) simplicity of data collection for indicators; (2) line simplicity; (3) line automatisms; (4) number of line elements. The line chosen, before the implementation of daily kaizen, had an OEE 2017 = 15%.

The daily kaizen implemented in Company X is level 1 and translates into two main approaches: the construction of a team framework, tool for the exclusive use of it with visual management, and a team meeting, meeting with the aid of the identified framework. The meeting, in an objective way, is based on a dynamic of three main moments: (1) analysis of the previous day, in a structured way using KPIs; (2) analysis of planning for the work day, using visual management; (3) improvement management using the PDCA tool. In this way, in a first phase, the following indicators were defined with the team: line efficiency, time of stops nonscheduled and planned/produced. Since then, several improvements have been observed: (1) the dynamics among employees changed, with a better structure in the information flow; (2) the work was reorganized in a structured way, so that when there is a problem on the line, only one of the employees will ask for help / solve it; (3) communication with maintenance was improved, with a space in the frame for transmission of information; (4) more than 40 improvement actions in 2 months were completed, promoting employee motivation and increasing, in a more or less direct way, the efficiency of the line. In 2 months - and only with the implementation of daily kaizen - the OEE increased about 120%, remaining at 33% (figure 12). It should be noted that the production mix remained the same during the 2 months of the pilot when compared to the baseline.

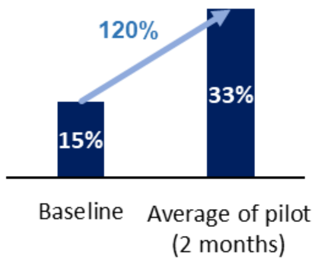

Figure 12 - Results obtained using daily kaizen tool.

5. Conclusions and future work

Company X, named for confidentiality reasons, is a business food organization. For an evaluation and the realization of a survey of the opportunities, a value stream mapping was developed, which allowed to detect three main problems to solve: (1) the inefficiency in the planning, conducted until then by a push system; (2) lack of norms and objectives, there is no standard work, work routines and operator work; (3) lack of communication and indicators, promoting the structural and cultural disorganization of Company X.

Inefficiency of planning process

To solve the first problem, a methodology was developed and defined, which explored pull systems. For a correct application of a pull system and give continuity to the work done, other tools should be used in future work. In this way, a proposal is presented in figure 13.

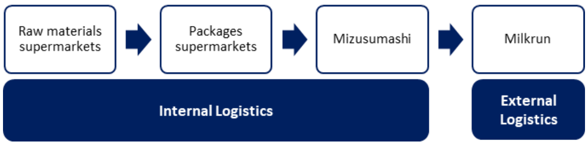

Figure 13 - Methodology for future work in pull planning.

In a next phase, consumable supermarkets should be defined: the basis of the methodology whose result is the size of supermarkets was defined in the present dissertation, but other aspects should be explored. That said, the concept of mizusumashi should be explored, this being a train dedicated to internal logistics, following a route with a well-defined cycle: the various times and places of stop must be previously defined. The definition of these should focus on the needs felt in internal logistics and the balancing of the points to be supplied.

Finally, the concept of milkrun arises the same as mizusumashi but applied to external logistics). This point should only begin to be studied when the internal logistics are already in a consistent and optimized phase. What is proposed for Company X is a detailed study of suppliers, testing the concept of milkrun with them to reduce lead times.

Line balancing and standard work

Regarding the second problem, a line was defined as a pilot. Its balancing was done based on references A of the same, that is, references with high frequency of consumption, value and quantity. Through the new arrangement of tasks and the normalization of all steps, it was possible to reach a cycle time shorter than takt time, allowing production without delays and without the need for overtime.

About future work, this should be reading the outspread of what was done in the present work to all lines. Also, the tool SMED should be explored, to normalize the tasks of setups.

Daily kaizen

Finally, the daily kaizen tool was implemented in a pilot team and its excellent results: a 120% improvement in OEE in only 2 months. However, the team is still finding the best momentum in the meetings, as well as which are the most correct indicators to follow in a daily context. Thus, what is proposed as a future work plan is: hourly or even instantaneous monitoring of objectives; Well-defined daily planning; improve board visual management; definition of the competency matrix and spread of the dynamic to all company.

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