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Improvement in the Supply System of Wheat Flour Silos

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Abstract: This study was carried out based on the tools used in the process of wheat flour silos and adapted to a food industrial scenario with the purpose of defining the capacity of the supply process of a food factory, and if there are conditions for a possible expansion and the creation of a new line of loaf breads, since the demand of a particular brand is growing, in addition to opportunities for gain and expansion in the current market. Initially, we carried out surveys of times and methods, movements of people and machines, we acquired information and specifications about the efficiency of the machines, based on that we calculated the efficiency of our system, from there, the step was to calculate the demand for flour that the factory needed so that there was no failure in any production line, and we correlated the capacity of the system with the need to consume the factory's main raw material. With the deepening of the study, we realized there is work idleness in the Wheat Flour Silos supply sector, and we implemented some Lean Manufacturing tools, such as DMAIC, analysis tools. In the implementation phase of improvements in the DMAIC cycle (Improve), we implemented in the sector improvements in handling, lean times and some pillars of Total Productive Maintenance (TPM), beginning to start up some autonomous maintenance activities, such as inspection routes, failure analysis, preventive and predictive maintenance, in parallel with operational training and Work Safety dialogues weekly (SHE Pillar). To reach the success in the project, we used as reference the analysis some works of reputed names from the academic and industrial scene, as well studies, reports and technical information from manufacturers and engineers who designed the current system.

Key words: Silo, food, TPM

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1. Introduction

1.1 Silage

Silos are elevated containers, underground or mixed, which are used to store grains, flour, fluids, seeds, cereals, among others. The first records of storage materials in Silos was between 1500 to 1000 BC in North Africa, this was concluded after finding a Silo in the shape of a partially buried tower, in which they estimate to be 1200 BC in Cartago, city of Tunisia.

FIGURE 01: History of Silos

Source: Milkpoint, 2019

From the time of the Roman Empire, silage was used to storage the cereals for animal feeding in the winter, the storage of which was underground and covered by land. This practice was used until the 16th century. In 1860, the first use of silage for corn storage was recorded in Hungary. This practice ended up being widespread in Germany, France and later throughout Europe, arriving in Brazil only in the 19th century. The news of the beginning of this practice had been announced by Luiz de Queiroz in July 1875 in a national agricultural magazine.

At that time, they did not use the direct supply transport from these silos, which used to be supplied by sacks and had one or more forms of emptying. They also did not have control of the temperature of the material, no notion of use of the internal space and no control of storage. From the 1970s onwards, Metal Silos with thermometry and storage aeration were used in Brazil. Automation uses for supply and consumption were also implemented. With this result, the interest of engineers and agronomists is studying the optimization of this space, as well how to map the storage flow based on the amount of material inserted and removed. "(Bernardes, 2010)

Nowadays, there are two most common forms of storage in Silo: elevated and underground. The elevated silos are generally cubic or cylindrical, while the underground silos are cylindrical or trapezoidal trenches. (Carneiro, 1948).

1.2 Types of Silos

Nowadays, the Silage storage industry is increasingly modernizing to keep up with the needs according to each client, making Silos develop according to the type of storage, capacity, stored material, among other characteristics. Some of these silos take into account both food materials and other non-organic materials, such as polymers and rubber. Some foods that can be stored in this are flours, grains, sugar and starch. Polymers can be polypropylene (PP), polyvinyl chloride (PVC), polyethylene terephthalate (PET) among others. The rubbers can be Silica or Carbon Black.

Some most common types of Silos in the market are Weld Tec, which is one of the most used in the market, made of stainless steel or aluminum sheets welded inside and out, they are able to store large quantities, being resistant to winds and weathering. Another type of Silo is the Panel Tec, whose main characteristic is that it is totally pre-molded in stainless steel sheets and assembled only in the field, which facilitates assembly in places of difficult access. These silos are designed for loads above 500 m^3.

The Silos Bold Tec, unlike the previous ones, is not welded but screwed, and can be assembled in the workplace and does not require specialized labor, being able to be assembled by anyone making the cost of transportation and assembly less than the others before. There are also Fabric Silos, which have a galvanized tubular structure, and their body in a Fabric Bag, which can vary in density according to the size of the Silo. Its main advantages are that the Silo becomes self-filtering and perspiring, in addition to being economical and easy to transport.

We can not fail to talk about the Masonry Silo, which are mostly circular, being used nowadays in farms and port structures for grain storage, such as soybeans and other commodities. Among its advantages are the low cost of construction, but it has archaic technology in today's times. These silos can also be distinguished in two other classes: Short Skirt and Long Skirt. Short skirt are the Silos that have their lower funnel exposed, while the Long Skirt is not possible to view the lower funnel, being covered and supported by its base that goes down to the floor. (Zeppelin Brazil, 2019)

1.2.1 Pneumatic Conveying Definition

The Pneumatic Conveying System is a means of transporting raw materials, totally enclosed and moved by air or a inert gas, the first one applies to hygroscopic materials such as dry grains or flour, and the second is used to move sugar or other explosive materials. Pneumatic conveying has the definition of conveying granules in an isolated system, propelled and moved by a fluid current, can be it air or another specific gas for the job. The volume of this transport can vary between 1% and 25% of the solid volume in relation to the gas. To carry out the transport, use pressure differences, it can be positive or negative, and follow the fluidization concept. The fluidization concept is moved to isolated solids through a fluid, such as air, making sure that there is no increase in temperature in the system, facilitating the transfer of mass and fluid, generating pneumatic conveying.

The advantages of pneumatic conveying are the low cost of operation and maintenance, low loss rate, flexibility of assembly, capture, distribution, automation and control. In addition, pneumatic conveying can serve as a dryer or reactor in specific processes. The types of pneumatic conveying can vary in their volume of solid according to the need of the process. The pneumatic transport of diluted flow has a volume of solid below 5% in relation to the gas present in the system, and a speed close to that of the gaseous fluid due to the low pressure drop of the system causing little pressure variation, consequently causing little temperature variation in the system. (Lopes, 2011)

As the solid concentration increases, or the gas speed decreases, the transport obtains a dense flow profile, that is, with a solid concentration above 5%. There are two different ways for this transition, the first mentioned is the sudden increase in solids in the system, causing a phenomenon called "choking", collapsing the system, and causing a pulsatile profile, which has no constant speed and pressure. This flow is called “Slugging Flow”. The form of slow gradual increase of solids in the system, in a way that does not cause the system collapse and its head loss is gradual, can cause a phenomenon called fast fluidization, which has a diluted movement and moving according to the gas flow, and on the sides of the tube there is a dense movement contrary to the fluid, causing a movement of partial recirculation of the solids. The physical structure of pneumatic transport, like other systems, has entrances and exits. Generally, in this type of system, your first entry is gas, as it will transport the solid, which is the second entry, to the destination, where they separate. (Zeppelin Brazil, 2019)

In this study, the gas is fed through six air blowers. Of these, two are exclusively designated for the supply of silos, taking the air from the blower to the designated silo for supply. The other four blowers are designed to transport flour from the silo to the smaller reservoirs of each production line, propelling the air that leaves the blower, passing under the flour dosing valve of the Silos and reaching the line's reservoirs, called Cyclonets .

In this study, according to the analysis carried out in the field, the pneumatic conveying system has a dense flow profile, of the Slugging Flow type, having a pulsating profile, however fast.

1.3 Lean Manufacturing Definition

From the origin of consumer assets in human history to the first industrial revolution, all production processes were carried out by hand. The artisans had great practical skills, but little standardization of their product, always producing according to their specialty or craft, such as tailors, shoemakers, cattle breeders, vegetable producers, among others. The craft was always passed from the artisan to the apprentice in a practical way, without any standardization and totally dispersed in small workshops, and not in warehouses or factories with several workers.

After the first industrial revolution, the emergence of factories was a major milestone in history. The factory had as its definition a large workshop with several workers together carrying out the same craft, leaving aside small craft workshops. As a result, there was also a hierarchy and structuring of the factory as a company, with management, coordination and production managers. According to this hierarchy, the artisans stopped conducting how each product should be produced, this craft was left to accountants and coordinators for having a greater work experience, they defined how each product should be produced. Much is said about the history of the origin of Lean Manufacturing and lean production, however, before that, we cannot fail to talk about Frederick Taylor, who around 1910 gave rise to Scientific Management, which is nothing more than the first concepts about scientific administration that were the basis of studies and improvements carried out by names like Henry Ford, and William Deming, the latter gave rise to the concepts of quality and productivity, sampling theory and is considered the father of continuous improvement. (Sinfic, 2007)

Frederick Taylor started work with the initiative of making factory managers look more critically at their production and see what to improve in terms of efficiency, with the book “Principles of Scientific Management” as the most successful work. The method called Taylorism originated when Henry Ford, founder of Ford automobile company and also a pioneer of mass production, invited Frederick Taylor to come to his factory to conduct a consultancy and teach him the method of making his process more productive through a more critical look at the factory's problems. (FM2S, 2018)

Before Henry Ford, vehicles and other industrial products of the time were made one at a time, where operators started the product and only started working on the next one when it was finished. Ford, alongside Taylor as his consultant, developed the assembly line, which consists of each operator having their job and function. With this change, each operator became more skilled and specialized in their role, making their service more standardized and varying according to the pace of the machines. Exploring production times and methods more and more, the first signs of process improvement began to appear.

1.4 TPM (Total Productive Maintenance)

The TPM is a program to increase the productivity of an equipment by reducing the losses, breaks and downtime. The practical application of this model is the development of goals with intervention of the operation in maintenance and small interventions through autonomous groups of activities. To help achieve these goals, the TPM is divided into stages called “The 5 Basic Pillars of the TPM”

Are they:

1. Autonomous Maintenance: Development of a fully autonomous and trained maintenance group composed of the operation.

2. Planned Maintenance: Structuring the maintenance team in a planned and programmed manner.

3. Initial control of the equipment: It consists of total control of the equipment since its implementation in the sector and start of operation.

4. Specific Improvement: Reformulate and introduce new individual improvements in order to increase the productivity and competitiveness of the equipment and sector.

5. Education and Training: Raise the level of technical knowledge of operators and maintainers, as well as their general and maintenance knowledge.

The 5 Basic Pillars of the TPM were initially developed for use in equipment, however over the years, they started to be implemented in the day to day support sectors, such as administrative and sales environments. (Tondato, 2004)

2. Materials and Methods

Big-Bag – Used to transport wheat flour between the supplier and the storage location. Average capacity of 1,250 kg.

Hoist **-** Used to move the Big Bag from the floor to the Supply Funnel.

Supply hopper **-** Used to control the dosage of flour entering the system.

Silos **-** Used to store flour.

Silo 1 - Weld Tec Type - Material: Stainless steel plate welded internally and externally. Maximum Capacity: 60 Ton.

Silo 2 - Weld Tec Type - Material: Stainless steel plate welded internally and externally. Maximum Capacity: 60 Ton.

Silo 3 - Weld Tec Type - Material: Stainless steel plate welded internally and externally. Maximum Capacity: 60 Ton.

Silo 4 - Weld Tec Type - Material: Stainless steel plate welded internally and externally. Maximum Capacity: 60 Ton.

Silo 5 - Weld Tec type - Material: SAE aluminum plate welded internally and externally. Maximum Capacity 70 Ton.

Silo 6 - Weld Tec type - Material: SAE aluminum plate welded internally and externally. Maximum Capacity 70 Ton.

Silo 7 - Material: Fabric. Maximum Capacity 45 Ton.

Air Blowers - Used to feed the fluid part of the transport, increasing the air pressure of the internal system and making the flour move to the Silo.

Robuschi – RB-LP70C – 800m³/h x 400mbar – 1765rpm x 30cv

Robuschi – RB-LP70/V – 900m³/h x 550mbar – 1780rpm x 60cv

Robuschi – RB-LP70/V – 900m³/h x 550mbar – 3560rpm x 40cv

Robuschi – RB-LP70/F – 800m³/h x 400mbar – 3560rpm x 50cv

Robuschi – RBS 95 – 1050m³/h x 500mbar – 3560rpm x 100cv

Transport Pipes - Used to transport the flour to the Silo and, later, from it to the Cyclone.

Cyclone - It is used as a buffer, which stores a small amount of flour to measure the feed of the production lines.

Rotary Valves - Used to measure the flour in the Silo for the transport system to the lines.

Sleeve Filters - Used to control the pressure of Silos and Cyclones by means of air passage, but not solids.

Filter Cleaning System - Made by “hammering” types of compressed air into the filter fabric to clean the filter pores.

Bypass Valve (Gravimetric) - It is useful to direct the flow according to the need of the production lines.

Rotating sieve - Its function is to separate any foreign bodies in the flour before it is poured into the pneumatic system.

Centrifugal Pump - They are the air propellants of the Air Blowers.

Vibrating Bottom - Its function is to decompress the agglomerated flour at the bottom of the Silo to be dosed without pressure variation.

Magnetic Separator - Its purpose is to separate any metallic foreign matter from the flour.

Relief Valve (Pressure x Depression) - Used to clean the sleeve filters, avoiding the compression of the System.

As for the method, we use the DMAIC tool (Define, Measure, Analyze, Improve, Control), which is a variation of the PDCA cycle (Plan, Do, Check, Act), one of the most used tools in improvement projects and outlets decision-making, both in industry and in various market sectors. When we apply the project's action plan, that is, the “Do” of DMAIC, one of the actions that was taken is the implementation of the TPM, Total Productive Maintenance, which is one of the most widespread tools when we talk about increasing productivity and availability for preventive and predictive maintenance, in addition to being one of the most famous tools of Lean Manufacturing, in which we discussed in the previous chapter.

3. Results and Discussion

In 2018, was identified the need to expand the factory to install, in principle, a new line of loaf bread since the product had been very well accepted in the segment market and the product offer was not supllying the demand. At the same time, the project team responsible for expanding the factory questioned the production engineering team whether the current silos supply system met current demand smoothly, and if there was a need for any investment in this sector for the system to cope with the future demand for wheat flour for the new line to be installed. With that, we in the production engineering and continuous improvement team, supervised by an experienced project manager, started the first DMAIC cycle, where the objective was to analyze what was requested and evaluate possible improvements that could be made in the workplace. We defined the theme of the project and started the field work, performing the time measurements and analysis of methods that were carried out at the workstation, from the operation to the cleaning and maintenance level of it. The first activity was measuring the supply time of 1,250 kg wheat flour bags in the hopper that sends the material to the silos for storage.

TABLE 01: Supply Times Data

Emptying time of 1 bag	Average	Standard Deviation
00:05:14	00:06:46	00:01:25
00:07:30	00:06:46	00:01:25
00:06:09	00:06:46	00:01:25
00:06:21	00:06:46	00:01:25
00:06:00	00:06:46	00:01:25
00:07:21	00:06:46	00:01:25
00:09:45	00:06:46	00:01:25
00:05:49	00:06:46	00:01:25
00:05:53	00:08:18	00:03:56
00:07:21	00:08:18	00:03:56
00:06:50	00:08:18	00:03:56
00:07:23	00:08:18	00:03:56
00:06:25	00:08:18	00:03:56
00:06:17	00:08:18	00:03:56
00:17:50	00:08:18	00:03:56
00:08:24	00:08:18	00:03:56
Average and Standard Deviation	00:07:32	00:02:58

Source: Author, 2019

Based on several samples of times collected from emptying bags in a normal production situation, according to Table 01, we calculate an average of times and their standard deviation. Based on this average, we theoretically calculate how many bags of toast and bread flour the operator can fill in an 8-hour shift, making this number the maximum theoretical production of the job - PMT.

TABLE 02: Supply time of toast flour bag

For one operator	
Medium time to supply 01 toast wheat flour bag	00:07:32
Shift	08:00:00
Theoretical number of bags supplied during the shift	64

Source: Author, 2019

About this calculation, we compare the operator's supply capacity for toast and bread flour with the factory's required demand. We obtained these numbers through the amount of dough batches that the lines consumed per day in order to know if the quantity supplied would supply the demand for flour that the lines consumed from the Silos.

TABLE 03: Toast Flour Quantity

	Number of Doughs per Day			
	Toast line 1	Toast line 2	Toast line 3	Loaf Bread
Day 1	89	157	138	130
Day 2	78	146	102	104
Day 3	69	93	118	93
Day 4	86	52	143	99
Day 5	85	25	153	125
Day 6	79	146	165	109
Day 7	96	142	161	122
MÉDIA	83,143	108,714	140,000	111,714
Average + 10%	91,457	119,586	154,000	122,886
Average+10% * quantity of flour for 01 dough [kg]	22864	28701	53900	28018

Source: Author, 2019

In the second stage of the work, we made these same calculations with flour suitable for cakes, where it has a different time, since its viscosity in relation to toast and bread flour is different, and consequently, its time to be transported on the screw as well. It is understood that the cake flour serves the Honey Bread and Roll Cake lines, which have a lower consumption, due to their lower production capacity in kilograms per hour.

TABLE 04: Supply time of cakes flour bag

Para 01 operador	
Tempo de abastecimento médio 01 bag 10373	00:12:29
Turno	08:00:00
N° de bags abastecidas no turno	38

Source: Author, 2019

In the same way as the toast flour, we collected the quantities of doughs per day in the lines of Roll Cake and Honey Bread to compare with the Fabric Silo supply data that houses the cake flour, with this we obtained:

TABLE 05: Cake Flour Quantity

Number of doughs mixed per day		
	Roll Cake	Honey Bread
Day 1	23	34
Day 2	55	46
Day 3	60	51
Day 4	82	24
Day 5	65	26
Day 6	96	47
Day 7	82	53
Average	66,143	40,143
Average + 10%	72,757	44,157
Average+10% * quantity of flour for 01 dough	5311	8964

Source: Author, 2019

About this calculation, we were able to determine the amount of flour consumed per line, totaling the plant's flour consumption and also how many bags of each flour the operator would need to place per day so that there was no stoppage of production lines due to lack of raw material. After a meeting with the managers of the production lines, adding to the data collection we performed above, we arrived at the table below, which represents the consumption of flour before the implementation of the new warehouse. We divide the flours into “Type 1” and “Type 2”, the first of which represents the toast and bread flours and the second is the proper flour for cakes, the need for this separation is due to the distinct supply time that they present.

TABLE 06: Average consumption of flour per production line

AVERAGE CONSUMPTION		**Partial**	**Bag/day**	**Bag/hour [Bag]**	**Bag/hour [Full]**
Loaf Bread Line [kg] – Type 01 flour	27000	27000	22,5	0,94	1
Toast Line 1 [kg] - Type 01 flour	24000		0	0,00	4
Toast Line 2 [kg] - Type 01 flour	26000		0	0,00	
Toast Line 3 [kg] - Type 01 flour	50000	100000	84	3,50	
Roll Cake Line [kg] - Type 02 flour	9000	9000	7,5	0,31	1
Honey Bread Line [kg] - Type 02 flour	12000	12000	10	0,42	
Panettone Line [kg] - Type 01 flour	12000	12000	10	0,42	1
Panettone Line [kg] - Type 03 flour	12000	12000	10	0,42	1

Source: Author, 2019

After that, we started to map the Macro and Micro production methods, that is, when we refer to macro operations it means the actions from the arrival of the truck at the factory to the unloading of bags in the silos supply room, and when we refer to the micro operations, we treat as the operations of supplying Bags only, but with greater detail between the actions and movements of the operator, in order to reduce their time of movements based on lean production.

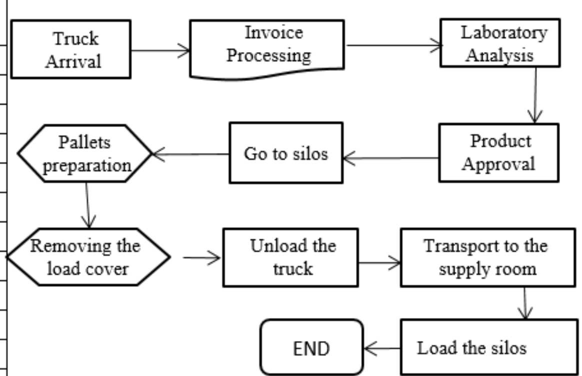
TABLE 07: Macro Process Flow

PRODUCT:	FLOUR							INTERNAL CODE:	Raw Material
MINIMAL LOT	22		UN (bag)					OBSERVATION:	Storage and Supply
STEP	**DISTANCE (m)**	**TIME (min)**	**OPERATION**	**TRANSPORT**	**INSPECTION**	**WAIT**	**STOCK**	**DESCRIPTION**	**EMPLOYEES**
1	-	-		●				Truck arrival	-
2	-	10			●			Invoice processing by receipt	3
3	-	30			●			Laboratory analysis of the sample	2
4		5			●			Product approval	1
5	50	15		●				Moving the truck to the silos area	1
6	-	15	●					Pallet preparation	2
7	-	10				●		Removing the load cover from the truck	2
8	-	30					●	Removing the bags from the trailer	3
9	10	30		●				Transport the bags to the silos room	1
10	-	150					●	Fill the silos with flour	1

Fonte: Author, 2019

As we can see in the table above, the Macro Process Flow represents the big movements that the truck makes through the plant until it arrives at the unloading area. For a better understanding of the movements described above, we developed the Spaghetti Diagram and the SIPOC, which are described in the literature review.

TABLE 08: Macro Sipoc

S	I	P	O	C
Supplier	**Input**	**Process**	**Output**	**Customers**
Flour Supplier (farm)	Raw Material		Flour in the Silo	Production Lines
	Truck			
	Fork-lift			
	Bags			
	Employees			
	Silos			
	Equipments			

Source: Author, 2019

The senior management of the food company, observed the implementation of TPM in other production lines of the factory previously, in mid-2016, and noted that the lines that most generated losses such as sweeping, reprocessing and breaks today are examples for other plants of the company, which leak constant visits in these, and are reference of productivity and cost reduction for the company. With this as a solid guideline, senior management did not oppose the implementation of this methodology as there would be no investment at first and a potential future gain. That done, the first actions started to start the implementation, we collected all the tools used in other implementations that were made, dissemination among others and we started the work.

The Food company has an agreement with a specialized consultancy in TPM and certified by JIPM (Japan Institute of Plant Maintenance), which provided the sector management and operators with the necessary training to kick-start and maintain the methodology. The person in the lead of the area, with the training, also became a TPM facilitator, who has some of his responsibilities to assist the operators in the methodology, train other future employees and multiply the knowledge. The training had a 24-hour workload and had as main topics the definition of the methodology, the explanation on the 8 pillars, the implementation methodology, the classification of losses and a practical part of using work tools such as 5S, where we take operators to production and carry out a practical exercise at the work point, CAPDo, 5W2H among other analysis tools. Although the presenter explained to the employees all the steps of the TPM, the first training focused on the basic stability step of the line, that is, opening maintenance labels, applying 5S in the work area, implementing the tool “Owner of the Piece” and start of autonomous maintenance work, such as listing inspection and lubrication points.

Given the training, we started the work in the supply area, where a 5S audit was first carried out, where the main physical problems of the sector were raised and an action plan to be carried out, where the immediate actions were not included in this, being carried out when the problem was identified. For the actions planned for maintenance, the opening of maintenance labels was carried out and followed up later in the weekly meetings to negotiate labels with maintenance, yesterday the future maintenance of the sector is planned. Also based on the problems raised, the Owner of the Piece was implemented, that is, an operator responsible for the sector, where he feels part of the work, having the autonomy to give an opinion on future actions and being motivated to maintain his workplace always clean, organized and efficient.

The Owner of the Piece documentation is exposed in the framework of activities in the work sector, laminated to facilitate filling with a hydrographic pen, it is very important for communication between shifts, because it contains the main problems as questions to be answered shift by shift. We also inserted the key questions of the 5S audit in the document, in order to keep the sector clean and organized. The "Daily TPM meeting" is held regularly in the overlaps between the first and second rounds to discuss the main problems of the day as well as their KPIs, such as performance and availability. In addition to the "Weekly TPM meeting" where Silos operators participate together with other production lines to absorb TPM content, discuss the main problems of the lines and also the KPIs in what they touch, such as the unavailability of lines due to lack raw material, for example.

With the insertion of the TPM as one of the planned actions for the sector, we can see a considerable gain in reducing breakages, increasing availability, and consequently increasing the efficiency of supply. We are still proceeding with the same constancy of meetings, 5S audits, and other activities such as the elaboration of failure and breakdown analysis tools, the use of 5W2H, 5 Why, among others. Some sector needs are still being identified, and future action plans are being developed. As we can see in the table below, there was a significant increase in the supply flow daily and per shift:

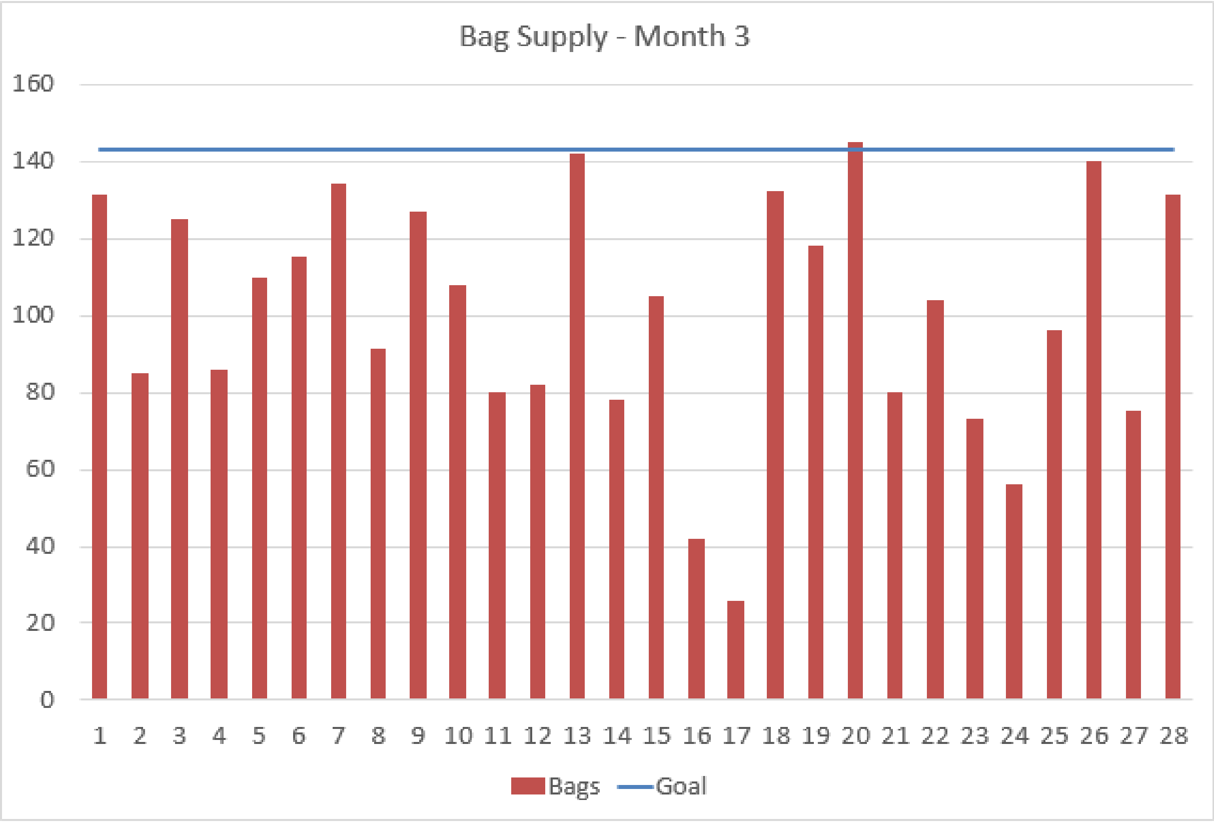
TABLE 09: Month 3 Supply

Third Month Supply							
Day	1st	2nd	3rd	24 hours	MTP	Goal	Eficiency
1	45	40	46	131	191	143	69%
2		45	40	85	191	143	45%
3	40	35	50	125	191	143	65%
4	27	35	24	86	191	143	45%
5	42	35	33	110	191	143	58%
6	46	45	24	115	191	143	60%
7	52	47	35	134	191	143	70%
8	27	24	40	91	191	143	48%
9	42	45	40	127	191	143	66%
10	41	40	27	108	191	143	57%
11	50	30		80	191	143	42%
12	35	7	40	82	191	143	43%
13	50	47	45	142	191	143	74%
14	22	23	33	78	191	143	41%
15	21	48	36	105	191	143	55%
16		20	22	42	191	143	22%
17	10	16		26	191	143	14%
18	50	42	40	132	191	143	69%
19	35	47	36	118	191	143	62%
20	52	48	45	145	191	143	76%
21	12	44	24	80	191	143	42%
22	35	30	39	104	191	143	54%
23	35	32	6	73	191	143	38%
24	8	13	35	56	191	143	29%
25	16	42	38	96	191	143	50%
26	52	48	40	140	191	143	73%
27	40	24	11	75	191	143	39%
28	50	40	41	131	191	143	69%

Source: Author, 2019

When we analyzing the figures in the table above and comparing the values with those in the table for the first month of supply, we can see an increase of 27.8% in the total number of bags supplied per day in the month. We also analyzed the efficiency figures, after the work carried out and concluded that there was also a considerable increase, even reaching the goal established in a few days of work.

CHART 01: Silos Eficiency – Month 3



Source: Author, 2019

Thus, we finished the first work cycle of implementing the TPM in the workplace, always seeking to increase the capacity of fuel supply operators, now, automatic maintenance of silos, with that, we can already notice a great advance in a period of just months and without any financial or material investment.

4. Conclusion

In a factory expansion scenario, a study was requested to find out the capacity of Silos to supply the main raw material of a oven food company, wheat flour. During this study, we noticed a great opportunity to increase productivity and reduce downtime. Solving the main problems and implementing improvements, mainly in the work philosophy, we could see the commitment and happiness of the employees of the sector when they feel useful, qualified and autonomous. The TPM philosophy, as well as others, aims at training and engaging the employee, in addition to providing a better work environment, cleaner, organized, and effective with 5S.

After the third month of work, we noticed an improvement of 27.8% in the efficiency in the supply of wheat flour in the factory and a drastic reduction, which led to almost zero the number of line stops due to lack of raw material in the factory, the improvement works have not yet been fully concluded, but we can see a notable advance, mainly because we followed the problem analysis tools, through the DMAIC methodology and because we took the implementation of the TPM as one of the actions. During all the facts reported above, we can conclude that the tools of the Six Sigma methodology associated with TPM, which come from Lean Manufacturing, really work when applied correctly and provide us with a totally positive result.

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