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Production Process Analysis and Improvement of Corrugated Cardboard Industry

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Abstract

This work was developed into a corrugated cardboard industrial company. In this sector are produced plans resulting from the union between corrugated cardboard produced and the sheets printed in the previous sector. The PDCA cycle was the main methodology used in this work. Firstly, the initial state of the production was analyzed by data collection in both existent lines and it was concluded that a great variability of the parameters was being used in the process for similar works. The main problems in the process were identified and it was concluded that warp and detached plans were the main reasons for concern. It was implemented a set of measures to reduce these incidences. Control charts were implemented to the starch glue and through the analysis of these charts and cause-effect diagrams several changes to the starch glue circuit and to its own recipe were implemented. The steam pressure of the boiler was reduced from 12 bar to 8 bar and a table with temperatures regarding each paper weight was implemented. The results obtained show that the percentage of waste in the sector was reduced from values ranging between 9 and 12% to values around 4%. Regarding starch glue consumption, it dropped from 11 g/m^2 to 8 g/m^2. The energy consumption, namely gas, showed a saving of 9%. Thus, this work represents an important contribute to the sector, allowing energy savings and quality and competitiveness improvements.

Keywords: Cardboard industry; lean manufacturing, corrugated cardboard; waste reduction, quality tools, energy consumption.

1. Introduction

The productive processes of companies must be designed and established in order to make companies more efficient and competitive. For this, it is important to make them not only efficient in terms of the use of resources, but also in reducing waste and thus enabling the increase of economic benefits.

The use of corrugated cardboard for the production of packaging dates back to 1897 [1] and has since been widely used [2]. Lightness, low cost and the possibility of recycling [1] are the main reasons for its increasingly significant use. Corrugated cardboard is composed of two flat outer sheets (liners or facings) of puncture-resistant paper with a central layer of corrugated paper (fluted paper or "medium") that gives the packaging resistance to crushing, and protection of the contents of the packaging [1]. These parts are bonded by starch adhesives derived from corn, wheat or potatoes [1].

This work was performed in a company devoted to the manufacture of cardboard or corrugated cardboard packaging, with offset printing. In this company, the counter gluing sector, fundamental for the design of the packaging and for its final quality, presented several problems, such as product warping, bad gluing, excessive glue consumption and high waste associated with the process. Thus, the objective of the present study was to reduce or eliminate the problems existing in the production process in the counter gluing sector, in order to

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improve the quality of the final product, to reduce costs and waste, as well as to increase productivity. Therefore, the study was conducted in order to answer the following research question: what key parameters exist in the process and how to standardize them in order to eliminate the variability introduced by the operator factor? The rest of the article is organized as follows. Section 2 presents the literature review. Section 3 describes the methodology adopted to achieve the proposed goals. Section 4 describes the process of the counter-gluing section and all work carried out in the company, as well as the proposed changes and corresponding results obtained. Finally, Section 5 outlines the main conclusions.

2. Literature review

The concept of lean manufacturing originated at Toyota in the 1980s and this philosophy was developed with the objective of reducing waste and was defined as an objective on the shop floor, due to the scarcity of materials, human and financial resources. This methodology was adopted by many industries in different countries, due to its cost, quality and flexibility, suggesting the elimination of activities those do not add any value to the customer, reducing the generated waste [3-5].

According to the industrial sector [6], the packaging industry in Portugal has a share of between 3% to 4% of the country's Gross Domestic Product (GDP), which is double the world average, currently on 1.5%. The country produced a total of one million and 600 thousand tons of packaging in 2014, among several other packaging materials (cardboard/paper, glass, polymers and metals). However, the most used is the cardboard/paper, which represents the lion share of 45% of the entire production [6]. These values underline the importance of this industry for the country. Several studies were made in the recent years regarding improvements made in the cardboard industry. The environmental assessment through a cleaner production concept as made for paper and cardboard industry in Jordan, namely, through a waste audit tool and 5 independent options were identified as potential improvements [7,8]. In [9] a closed-loop supply chain for a cardboard recycling network comprising multiple production stages and suppliers was addressed and the authors optimize the recycling network through a mixed integer linear programming model. Other authors, in [10], applied several lean manufacturing tools, mainly Single Minute Exchange of Die (SMED), 5S tool and visual management, in order to improve the performance and quality of the production processes in a cardboard company and in the end, an average reduction of 47% in the setup time was reached. A case study in an Indian manufacturing unit focusing on the execution of SMED on the corrugation machine in a cardboard box manufacturing company is addressed in another recent study [11]. The objective was to decrease all the non-value-added operations and a reduction of 86.6% in changeover time was achieved. In [12], a case study made in Brazil in a cardboard industrial unit, addresses a challenge of cutting rectangular plates into smaller ones with the objective of finding through dynamic programming the best patterns to be cut. The lean manufacturing tool Value Stream Mapping is used in [13] in order to improve the organization of the cardboard packaging production process in case study focusing on the largest producers of cardboard food packaging in Poland. In [14] the authors focus on the organizational impacts due to implementation of the ISO 9001 standards and mandatory certification in Brazilians cardboard companies, a study in which the authors seek to assess the potential benefits of quality and the certification. Regarding the related wastes to this industry an analysis of the production and products of honeycomb cardboard and its use in the current packaging industry is addressed in [15], and the authors argue that this type of cardboard is an environmentally friendly material with characteristics such as low carbon emissions, green packaging, which obeys to sustainable development requirements. A study made in Spain and focusing on the Spanish industry analyzed the cardboard wastes in an overall study of the waste generated by the indirect and direct suppliers of the paper industry [16]. Since this industry consumes high quantities of water a rational application of wastewater management in the cardboard and paper industry following several sustainability standards was made [17]. Another study regarding this issue [18], addresses the wastewater treatment of a cardboard manufacturing plant by infiltration percolation and the obtained results were successfully compared with Moroccan and International standards.

Therefore, many opportunities arise with the potential to improve the performance and reduce several wastes in the cardboard industry.

3. Methodology

To achieve the proposed objectives, a methodology based on the PDCA cycle (Plan, Do, Check, Act) of four stages was followed [19]. In a first phase, daily data collections were carried out in the back-gluing sector, in order to carry out an assessment of its status. Based on these data, statistical control of the process was carried out [20] and through control letters for starch glue and cause-effect diagrams [21-22], several measures were planned to be implemented. In a second phase, changes to the process were implemented, based on the analysis carried out in the previous phase. After implementing these changes, during the third phase, an evaluation of the result of each one was made. Subsequently, in a fourth phase, as a result of this assessment, new measures were established.

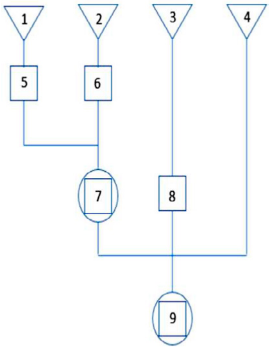
4. Results and Discussion

The company where this work was developed started its activity in 1968, devoting itself exclusively at that time to the typography activity. Currently, its business area is focused on the production of packaging with offset printing, in cardboard or corrugated board.

4.1. Counter-gluing section

This section is responsible for the production of the packaging itself, and works 12 hours a day, for 5 days a week. There are two distinct lines, each consisting of a corrugator and a counter glue, internally designated as line 17 and line 19. Although they almost always work in line, both have the ability to work independently. The lines differ from each other in the maximum accepted formats, 142 cm x 142 cm in the case of line 17, and 160 cm x 160 cm in the case of line 19, the latter having the capacity to produce double card.

The principle of operation of the two lines is similar. The corrugator is responsible for the production of the corrugated channel, called single face, which then enters the counter-glue, where the printed or smooth sheet is glued, thus creating a plan which can contain one or more packages, depending on the article. Fig. 1 and Fig. 2 show the process diagram and the main stages of the production process, respectively.



N.º	Subtitle
1	Paper Reels
2	Starch Glue
3	Printed Format
4	PVA glue
5	Coil Width and Weight vis-à-vis the OP
6	Glue Viscosity and Temperature
7	Channel Making
8	Comparison of the Pallet Label with OP
9	Channel Counter to Printed Format

Fig. 1. Diagram of the gluing process.


1 - Coil zone for liner and fluting


2 - Channel manufacturing area


3 - Area for placing printed sheets


4 - Exit area of the plywood plans

Fig. 2. Main stages of the process.

In the second stage of the process, consisting of counter-gluing the single face, which may have been produced online or can feed the machine in reel, to previously printed or plain paper, depending on the article to be produced, some problems may arise. In this step, a glue applicator unit (Fig. 3), in this particular case, white PVA glue, is deposited between two rollers, through taps, applying glue on the top of the corrugated ridges, with which the printed paper is aligned and adheres (Fig. 4). In the delivery section of a laminator, the board goes through two distinct drying steps: the first, in which each sheet is pressed by two rugs and then continue in scale by another carpet, which gives them the final glue (Fig. 5).

Fig. 3. Glue applicator unit.

Fig. 4. Bonding of printed sheet with single face.

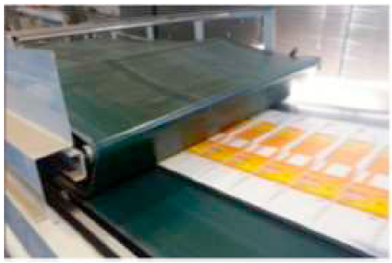


Fig. 5. Area of rugs that give the final bonding.

In this process, poor bonding and product warping are some of the problems that this type of industry faces. This last defect is mainly caused by three reasons: moisture imbalance between the outer and inner sheets, which leads to a warping in the direction perpendicular to the machine's movement; difference in tension between the outer and inner sheets, which leads to a warping in the direction parallel to the machine's movement; and unbalance of tension in the paper due to the distribution of fibers, or induced by some mechanical component that leads to a "twist" warp. In addition to these problems, the boards can also appear too wet, due to an excessive application of glue, or too dry, in which the card has a brittle appearance, which can originate from excessive heat supplied to the card.

4.2. Study of the counter-gluing process

Taking into account the adopted methodology, the PDCA cycle, it was defined in the planning stage that the counter gluing section was a fundamental section for the global process and that due to its weight and the high rate of external complaints and internal non-conformities, would be the subject of an in-depth study to improve the process. It was then decided that a survey of the state of the sector would be carried out and control charts for starch glue would be implemented.

In the second stage of the cycle (Do), an analysis of the state of the sector was carried out in general, so that there was a comparison between the situation before and after the implementation of any change to the process.

During one month, in all the works whose composition of the papers varied, a daily collection was made in the two existing lines, of the temperatures used for the liner and fluting, final temperature obtained from the single face, glue gaps used and the final planimetry of the work. It is important to mention that the glue gap reading is not the same on both machines. The glue gap corresponds to the amount of glue that passes between the donor roll and the doctor roll in the corrugator. However, the values by which operators are guided on the machines are dimensionless.

In line 17, it varies from 10 to 350. An increase in this value corresponds to a greater opening between the glue rollers and, consequently, to a greater application of glue. In line 19, it varies from 0 to 32000, and an increase in this value corresponds to a smaller opening between the glue rollers and, therefore, to a lesser application of glue.

With this data collection, during the third stage of the PDCA cycle, the Check stage, it was concluded that there was a very large variability in the parameters used for each work. The temperature for the same type of paper varied widely in different works. The glue gaps were tended to be high, due to the difficulties felt, mainly in gluing heavy kraft's with semi-chemicals. Keeping in mind this, the objective was to create recipes for the various combinations of existing papers, regarding the glue gap and the temperatures to be used on each paper.

4.2.1. Paper temperatures and glue gap

In the last stage of the PDCA cycle, corresponding to the Act, the first change introduced in this sector was the reduction of the vapor pressure on both corrugators. The initial working vapor pressure was 12 bar, which corresponded to a temperature for the wave group of about 190°C. This reduction was carried out in two stages. In a first phase, it was reduced to 10 bar, and in a second phase to 8 bar.

Before this change, regardless of the preheater's hugging angle, the single face was always produced at a very high temperature, which sometimes exceeded 100°C. This caused the water present in the starch glue to evaporate and led to its crystallization, which resulted in the papers not sticking. To circumvent this situation, larger glue gaps were used, which led to high consumption. The purpose of this alteration was that the corrugated group was at a lower temperature, and that the papers were supplied with the necessary temperature, depending on their weight.

After that, it was implemented in the sector the use of a table with the temperatures that the papers should have at the exit of the preheaters (Fig. 6), depending on their weight (Table 1). With this measure, it was intended to standardize the process and eliminate the operator factor, which introduced variability in the way the single face was produced.

Fig. 6. Paper preheater.

Table 1. Paper temperature, depending on its weight.

Types of papers depending on their weight	Temperatures (°C)
Liner	
Kraft (weight > 170 g)	85-90
Kraft (weight < 170 g)	75-80
Fluting	
Semi-chemicals (weight > 170 g)	85-90
Semi-chemicals (weight < 170 g)	75-80
Medium (weight > 170 g)	85-90
Medium (90 g < weight < 170 g)	75-80
Medium (weight < 90 g)	No contact with preheater

After decreasing the vapor pressure, and with the introduction of the temperature table according to the weight of the papers, tests were started in order to reduce the glue gaps used in the different works.

These tests were carried out during the normal course of production. The operators started the production order, introducing the parameters suitable for the work on the machine. The value usually used for the glue gap was introduced. As the plates left the machine and accumulated on the pallet (Fig. 7), the product's planimetry was observed, and samples were taken to check the quality of the single face bonding. In relation to the corrugated, three cuts were made (Fig. 8), one in the central zone, one on the operator's side and the other on the motor side, and the quality of the glue was evaluated, both in the direction of the machine's movement and in the contrary direction.

Fig. 7. Planimetry of the work on the pallet.

Fig. 8. Glue quality control with starch glue.

If the bonding power was considered to be very good (Fig. 9), in which it was found that the paper fibers were being pulled out, lower amounts of glue were tested. It was proceeded again in the same way, until a limit value has been reached, in which the bonding started to appear weak.

Fig. 9. Glue quality control with starch glue.

It is important to note that, although the quality of gluing is very important, the planimetry of the product is also important, as it influences the speed and quality of the box cutting process, which happens next. As already mentioned, the warping of the work is related to an imbalance of humidity between the two outer papers, and that humidity comes from the paper itself and the amounts of glue applied. The amount of glue indicated for the production was not the minimum quantity that only ensure a good bonding, but the minimum quantity able to ensure good planimetry of the product.

With these tests, it was possible to significantly reduce glue consumption, in the order of 2 to 3 g/m^2. However, this decrease highlighted problems that were camouflaged by the excess of glue used. Whenever there was a slowdown in the line, which could originate in a change of pallet of printed sheets, in a splicing of a reel in the corrugator, or even by a jam in the counter-glue, the corrugated board produced in that time was too dry and brittle and the plans produced were very bent. It was concluded that this phenomenon was related to the fact that the liner preheater is not fast enough to act, that is, the liner is no longer in contact with the preheater. With the machine slowing down, the paper heated up too much, as it was in contact with the preheater longer, which, in extreme situations, often led to crystallization of the glue. On the other hand, the automatic system in the machine to control the paper temperatures, was too slow to react, and was not working properly. This system was replaced by a similar one (Fig. 10), but in which the paper is not in contact with the preheater when the line slows down, and whose reaction times are much faster, thus allowing a reduction in waste associated with this situation.

Fig. 10. Temperature control system as a function of speed.

With the decrease in the amount of starch glue applied, it was found that the bonding power was superior in the direction of the machine's movement. This is directly related to the speed of the glue roll when compared to the speed of the paper. To correct this situation, the speed of rotation of the glue donor roller has been corrected, making it 2% slower than the speed of the paper, thus ensuring that the glue is always applied on top of the wave crest.

In some studies, there was an "S" shaped warp, in which at opposite ends of the plate, the tips were raised. This type of warping is usually caused by an irregular application of glue along the plane, which is related to a poor fit or wear of the glue scraper. This scraper has the function of homogeneously cleaning the doctor roller. This roller must always have a clean and shiny appearance; otherwise, the product's planimetry may be compromised. Taking this information into account, the condition of each scraper was evaluated, individually for each machine and, in the case of machine 17, on each cassette, through the aspect of the doctor roller. In the first stage, the scrapers were adjusted and, in cases where it was no longer sufficient to resolve the situation, they were exchanged.

4.2.2. Starch glue

In the counter-gluing sector, two different types of glue are used: starch glue in the corrugator, for the manufacture of the single face, which is manufactured in the facilities, and PVA glue to join the single face to the printed or plain sheet, which is purchased from specialized suppliers.

Starch glue is manufactured on the company's premises, in an automatic kitchen. The manufacture of starch glue is carried out following a standard recipe created for this purpose, which is introduced in the machine's PLC (Programmable Logic Controller) to achieve the final viscosity. This kitchen has a powdered starch storage silo, and a silo where this powder is mixed with water and the other products (Fig. 11).

Fig. 11. Kitchen where starch glue is made.

As mentioned previously, the quality control of the starch glue is based on two different parameters: temperature and viscosity. Taking into account what was defined in the Plan stage of the PDCA cycle, a record of the viscosity of the glue was implemented after the moment in which it was manufactured, to detect any deviations in the glue production, using a Stein Hall viscometer. In addition, daily logging was also implemented in the sector, three times per shift, on both lines, with regard to the viscosity and temperature of the glue, to analyze its behavior throughout the day. These records were made at the beginning, middle and end of each shift and consist of taking a single sample per machine. In the Do step of the PDCA cycle, mean and amplitude control charts for sample size n = 1 were implemented on each line, to control the viscosity of the glue. It was possible to conclude that viscosity was unstable during the process and that the observable values were outside the control limits. There was also a great variation in the values recorded between different days.

One of the major problems related to starch glue was the fact that its viscosity increased during the night, and also during the weekend, which caused numerous problems at startup, on Monday. To analyze the causes of this phenomenon, the Ishikawa diagram was used, as shown below (Fig. 12).

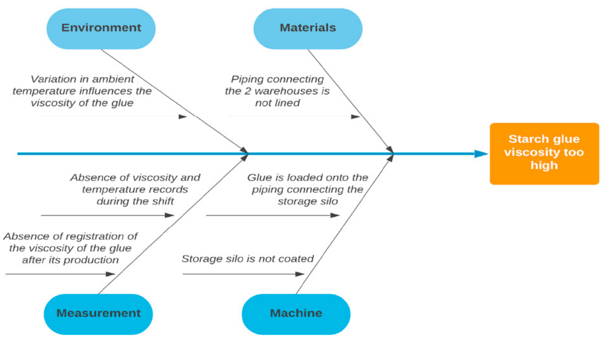


Fig. 12. Ishikawa's diagram for starch glue.

After finishing the manufacture of the glue in the kitchen silo, it is transferred to a storage silo, where it is stirred every 15 minutes for 5 minutes. However, this agitation was not enough for the glue to maintain its temperature and viscosity, and for that reason, the silo was covered with rock wool and two resistors were installed, together with a thermostat, so that the glue could be maintained at 30 ± 1 °C (Fig. 13).

Fig. 13. Starch glue storage silo.

The starch glue remained in the pipeline until it is used in the corrugators, and part of that piping is installed outside the factory, since the lines and the kitchen are installed in different warehouses. The piping installed outside was subjected to wide variations in temperature during the day, and throughout the year, which caused fluctuations in the viscosity of the glue. For that reason, this tubing has been fully coated to eliminate this situation. To eliminate the problem of increasing viscosity during the night and during the weekend, a closed loop of glue was created, starting and ending in the storage silo. In this way, the operators, before starting production, started to have the possibility to return all the glue stuck in the pipeline during the night to the silo, so that it mixes with the glue that was in the ideal conditions, and thus being able to start working with glue that has the characteristics suitable for production.

Before this sector analysis was started, the starch glue was produced based on a preparation called OBM (One Bag Mix), to which it was only necessary to add water and the other additives, namely, anti-foam, which has the function of prevent the formation of bubbles in the glue tray, biocide, to prevent the growth of microorganisms in the pipes, which can degrade starch, and an additive that improves the glue's adhesiveness. One of the disadvantages of this product, in addition to the high cost, was the fact that the gel point of the glue is fixed. Based on the bibliographic review, and a subsequent visit to a supplier that also works with this type of glue, it was decided to study the possibility of switching from OBM to native starch.

A cost analysis was performed (Table 2), to find out the gain of this solution compared to the previous one, and also what changes are necessary to be made in the kitchen for the production of the existing glue.

Table 2. Comparison of costs between OBM starch and native starch.

OBM Starch		Native Starch	
Starch consumption per batch (kg)	300	Starch consumption per batch (kg)	262.5
Tack additive consumption per batch (kg)	12.5	Soda additive consumption 25% (kg)	23.3
Consumption of biocide per batch (kg)	1.1	Borax additive consumption (kg)	3.7
Anti-foam consumption per batch (kg)	1.2	Anti-foam consumption per batch (kg)	1.2
Water consumption (m^3)	0.9	Water consumption (m^3)	0.9
Water cost (m^3)	2.3	Water cost (m^3)	2.3
OBM cost (€/kg)	0.7	Starch cost (€/kg)	0.5
Cost of tack additive (€/kg)	4.0	Cost of soda additive 25% (€/kg)	0.2
Cost of biocide (€/kg)	3.9	Borax additive cost (€/kg)	2.3
Cost of defoamer (€/kg)	3.2	Cost of defoamer (€/kg)	3.2
Cost of a batch of glue (€)	274	Cost of a batch of glue (€)	149

With this change, the savings per batch of glue is around € 125. On average, a batch of glue is produced daily. Assuming that about 20 lots are produced per month, monthly savings are around € 2500 monthly and € 30000 annually.

The glue production kitchen was not properly prepared to produce glue with native starch. Since this formulation requires the placement of water in two distinct phases, it became necessary to reprogram the PLC. The change had a cost of € 15000 that would be amortized over six months, based on the savings previously described. Tests were carried out with native starch, producing the glue manually, and the results were quite satisfactory in terms of bonding quality, which led to a change in the type of starch used in the manufacture of the glue.

4.2.3. Consumption of starch glue, gas and waste in the sector

All the work developed in this sector, aimed to produce with better quality with regard to gluing and a better planimetry of the plans produced, to optimize the consumption of glue and to reduce the waste of paper associated with the process.

After all the changes made in the sector, mentioned in the previous sections, tests were carried out during production, in order to optimize the consumption of starch glue. The graph shown in Fig. 14 shows the evolution of starch glue consumption from October 2016, until July 2017.

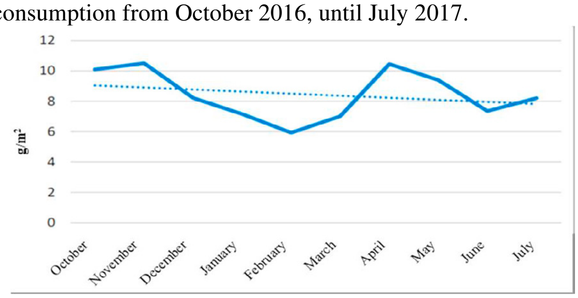


Fig. 14. Evolution of starch glue consumption.

By analyzing the figure, it can be concluded that, with the exception of April, the consumption of glue has dropped significantly. At the beginning of the analysis, this was around 11 g/m^2, while after all the changes and measures implemented, it was reduced to values around 8 g/m^2. The excessive consumption observed in April is related to the difficulties felt in stabilizing the viscosity and temperatures of the glue, when the ambient temperature started to be higher. Every year, in summer and winter, a change is made in the parameters of the glue recipe, so that it keeps its viscosity and temperature values within the acceptable range of values. At the end of May, there was a definitive exchange for native starch. Consumption recorded throughout the month of June was 7.7 g/m^2, confirming the trend of lower consumption in the sector.

Throughout this process, two reductions were made in the steam pressure of the boiler. Initially, this was 12 bar. In November 2016, a reduction was made to 10 bar, and in February 2017 a reduction was made to 8 bar. The graph shown in Fig. 15 shows the evolution of gas consumption per hour in the sector. This was calculated taking into account the total kWh consumed in a month, and the respective workload.

Table 3 shows the savings results, in percentage, compared to the same month of the previous year. Savings in gas consumption are around 9%, on average, when compared to the same period in which the pressure was 4 bar higher.

The waste produced in this sector, namely leftover paper from the reels, the channel produced when the corrugator is set up and non-compliant plans are placed in containers located next to the machines. It was defined that these would start to be weighed, in order to be able to estimate the percentage of waste associated with the total production. Fig. 16 shows the graph illustrating the evolution of waste associated with the counter-gluing process, from week 42 of the year 2016 to week 32 of the year 2017.

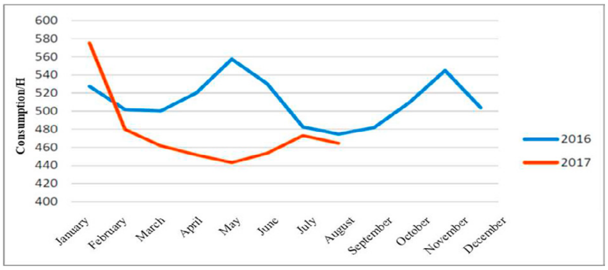


Fig. 15. Gas consumption before and after pressure reduction.

Table 3. Savings in gas consumption in %.

Month	Savings (%)
February	4
March	8
April	13
May	20
June	14
July	2
August	2
Average	**9**

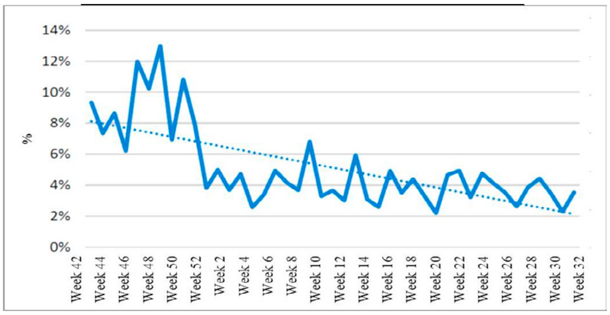


Fig. 16. Waste from counter-gluing section.

By analyzing the figure, it is clear that the waste associated with the process has been decreasing over time. In October 2016, these fluctuated between 9% and 12%. After all the measures and improvements implemented in the sector, this figure is currently around 4%.

5. Conclusions

This work was developed in a key section for the organization. The counter-gluing sector is of fundamental importance for the manufacture of packaging, as this is where the packaging itself is produced. If the process parameters are not respected, namely paper temperatures and amounts of glue to be applied, the final quality of the product, as well as its function, may be compromised.

The study allowed to answer the main research question and not only identified but standardized the key parameters of the process. Thus, the improvements achieved in this sector are directly linked to the change that has occurred in the way two key aspects of this process are dealt with: quantities of glue to be applied and paper temperatures. The study allowed to answer the main research question and not only identified but standardized the key parameters of the process. Thus, the improvements achieved in this sector are directly linked to the change that has occurred in the way two key aspects of this process are dealt with: quantities of glue to be applied and paper temperatures. Initially, the two lines were powered by steam, coming from a boiler that worked at 12 bar of pressure. The temperature of the wave group was too high, and caused the single face produced to have temperatures close to 100 °C. This led, in several situations, to the crystallization of the starch glue, compromising the quality of the plans, and was circumvented by the application of large amounts of glue. With the lowering of the boiler pressure, and with the implementation of the temperature table to be supplied to the papers according to their weight, the way of working in the sector has changed. Operators began to use preheaters, to give the paper the desired temperatures, and began to decrease the amount of glue applied, applying only the amount needed for different combinations of papers.

The measures implemented in the sector have allowed to significantly reduce costs. Starch glue consumption dropped from 11 g/m^2 to 8 g/m^2. The waste associated with the counter gluing process on the two production lines was also reduced from 10% to 4%. Regarding energy consumption, namely gas, there was an average savings of 9% compared to the previous year between the months of February and August.

Although this work has contributed to the improvement of the counter gluing process, there are still several opportunities for improvement in this sector that can contribute to increasing the efficiency and competitiveness of this type of industries and to increasing the quality of the product. Thus, it would be important to develop, in future research, studies that allow the modernization of the production lines and implement methodologies that improve the organization not only of this sector but of the entire plant, such as the 5S and SMED methodology.

The data correspond to the years of 2016 and 2017 because the work was kept under confidentiality due to the existing agreement with the company.

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