Parameters to reduce waste in the paper curl process in a PIM company

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Abstract

In a highly competitive environment among companies, standardization of processes has been one of the means to reduce errors, defects, and costs. Thus, the objective of this study is to investigate what is the best standard with parameters to be applied to the manufacture of corrugated cardboard in a company in the Industrial Pole of Manaus (PIM), aiming to reduce the number of wastes from this process. The data were collected from the production management system of company X and analyzed through brainstorming with the employees of the studied process. At the end of the research it was concluded that the parameters that most influence the generation of approximately 9 types of scrap are: (a) Temperature of the cover and core; b) Press pressure; c) Corrugate pressure; d) Glue crack; e) Pressure of the coil door brakes. To reduce factory waste, a standardized list was proposed containing the parameters for each composition, observing the peculiarities of this production process.

Keywords*:* Corrugated cardboard; Standardization; Parameterization;

1. Introduction

In 2016, the Brazilian corrugated cardboard packaging industry had a turnover of R$12 billion, employing around 32,000 people (ABRE, 2017). Within this scenario is the company object of this study, which for confidentiality purposes will be called Company X. It has been located in PIM for over 30 years and a large part of its demand is focused on the local market, mainly the electronics industry, supplying around 1500 tons of boxes monthly.

Company X has recorded losses due to the high level of waste generated in the production sector. This sector is divided into 2 areas, that of printers, responsible for printing and cutting boxes, and the corrugation area, responsible for the manufacture of cardboard sheets, where most of the waste generated in the sector is concentrated, which is why will be the focus of this study.

The main machine in the corrugation sector has several problems related to maintenance, but which do not interfere much in its performance and product quality. The employees in this area are trained and knowledgeable about the process. Lately, the company has been using raw material from several different suppliers, demanding even more from the process, this showed that the main deficiency of the corrugation process was the lack of standardization of the parameters used to manufacture the different types of cardboard. The lack of this standard may be generating waste of more than 3% of the total scrap of the factory, especially in curved, peeled and cardboard sheets.

Thus, the objective of this study is to investigate what is the best standard of the parameters to be applied to the manufacture of corrugated cardboard, aiming to reduce the numbers of the aforementioned scrap. Therefore, this article sought to investigate the state of the art concerning standardization and statistical control of similar processes, to propose the ideal parameters for the manufacture of the main types of cardboard used in this industry.

For the company, the importance of this study is the reduction of costs, gains in productivity, a more structured operation, in addition to gains in efficiency and effectiveness in the process. For Dennis (2008), the standard is the foundation of production, meaning that all production parameters must be clearly defined, being a precise image of the ideal desired condition to achieve excellence in processes and products.

For customers, the importance is the gain in product quality and greater reliability in the company.

For the academy, it is gain in the state of the art of a productive process that is still poorly explored by scientific studies.

2. Theoretical Referential

2.1 Corrugated cardboard

2.1.1 Structure

Corrugated cardboard (Figure 1) is a flat structure formed by one or more corrugated elements (core=miolo) attached to two or more flat elements (cover=capa), using an adhesive (glue) applied to the top of the waves by automatic equipment scrolling.

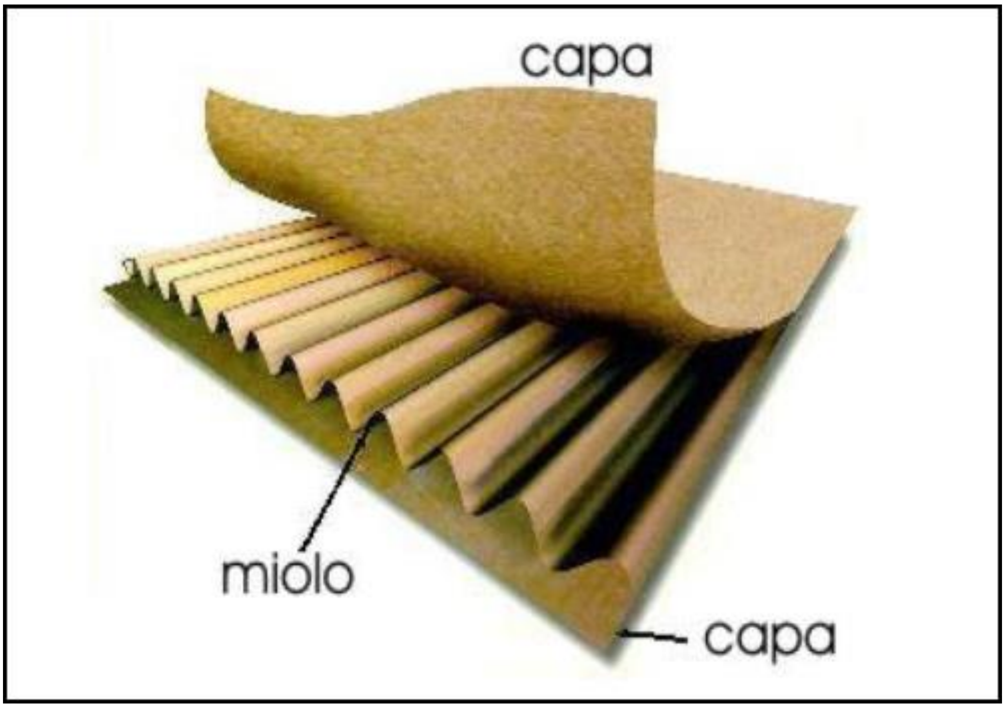

Figure 1 – Corrugated cardboard structure

Source: ABRE (2017)

The core of the corrugated board is formed by waves that are made in the paper during the manufacturing process, it is this configuration that gives the strength and the mechanical characteristics of the corrugated cardboard. The waves differ by their height, in which each composition will give different qualities to the cardboard.

Company X uses only waves of types B and C, and Chart 1 contains the classification of the waves most used by the industry and their main characteristics.

Types of Wave	Height in mm	Waves per meter
A	5,0	110
C	3,8	130
B	2,6	150
E	1,2	300
F	0,7	450
G and N	0,5	550

Chart 1 – Characteristics of the types of wave

Source: Author (2017)

Cardboard sheets can be formed by joining 2 or more waves (core) which are interspersed with covers. This results in combinations widely used in the market, such as the BC model, which is the union of waves B and C, giving greater resistance to cardboard. According to the Brazilian Corrugated Cardboard Association (ABPO), corrugated papers are classified as described in Chart 2.

	Simple face: structure formed by a corrugated element (core) glued to a flat element (cover).
	Simple wall: structure formed by a corrugated element (core) glued, on both sides, to flat elements (covers).
	Double wall: structure formed by three flat elements (covers) glued to two corrugated elements (core) intercalary.
	Triple wall: structure formed by four flat elements (covers) glued in three corrugated elements (core) intercalary.
	Multiple wall: structure formed by five or more flat elements (cover) glued to four or more corrugated elements (core) intercalary.

Chart 2 – Classification of the types of corrugated cardboard.

Source: ABPO (2015)

2.1.2 Properties

The paper used to manufacture the corrugated cardboard is the kraftliner or testliner, depending on the raw material used for its manufacture, and whether it will be used in the cover or core. These papers are still classified according to their weight (g/m²) which is the average weight in grams of a square meter of the paper, this same concept is also applicable to corrugated cardboard.

When the cover is made predominantly of virgin fibers, it is called Kraftliner (higher quality), when the predominance is made of recycled fibers it is called Testliner (lightly lower quality). Core paper is invariably produced from recycled paper and can weigh from 70 to 120 g/m2.

2.1.3 Manufacturing

The machines used to manufacture corrugated cardboard are called corrugator, which is the only machine that makes up the corrugation sector, so this is where the focus of this study will be. The process starts with the fixing of the paper reels on spindles attached to the machine, the reels are passed through the tensioning spindles that will keep the paper with the ideal tension during manufacture.

Figure 2 shows that the paper used for the core first passes through the tensioning rollers, then through the preheating roll (Rolo pré aquecedor), where it will be heated to the ideal temperature depending on the weight of the kraft. Right after it passes between two corrugated cylinders (Cilindros corrugadores) that, by a pressure process, take on a corrugated shape. Glue (Aplicador de Cola) is applied over the top of the formed waves, where the cover will be fixed, which in turn also passed through tensioning rollers and preheaters. The entire process is subjected to the action of heat.

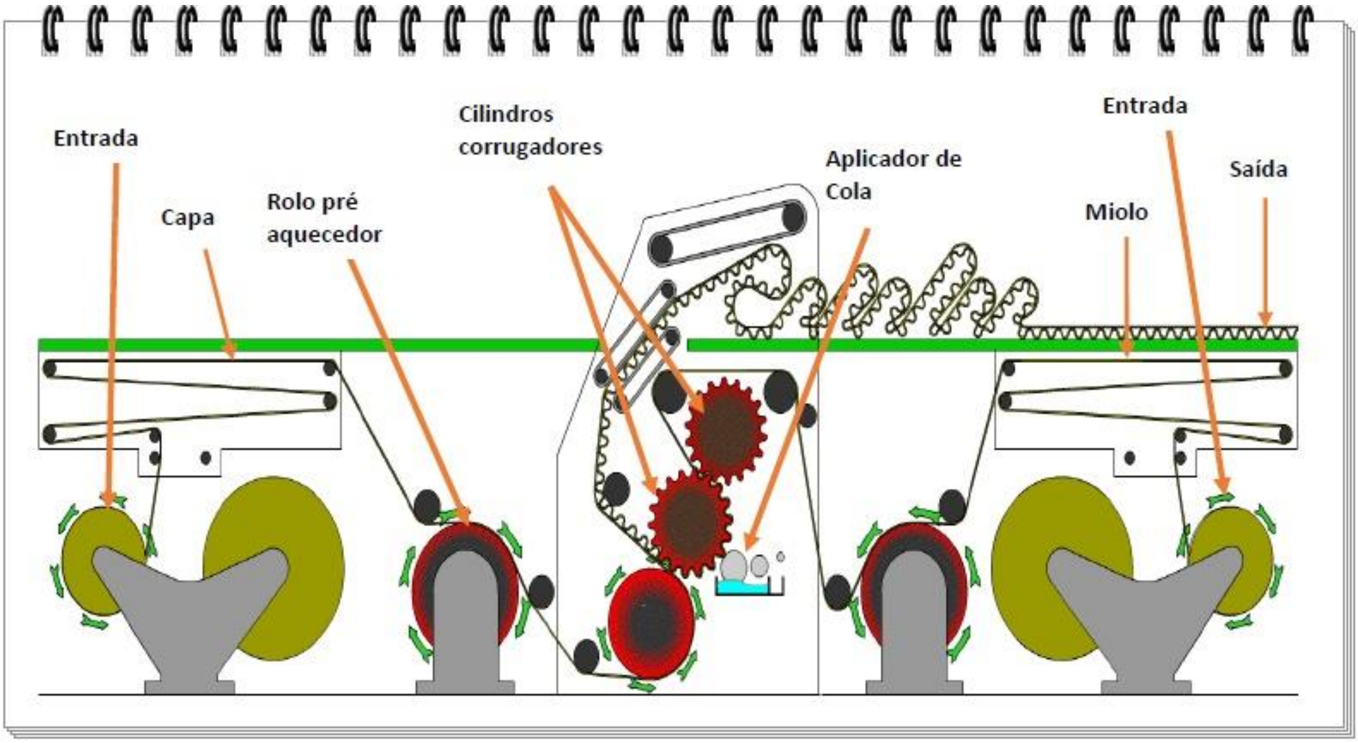

Figure 2 – Paper corrugating process on the cylinder head part

Source: Author (2017)

This process occurs in the part of the corrugator called the cylinder head, from where the simple face (face simples) with the inner cover comes out. In the next part of the machine, glue (aplicador de cola) is applied to the top of the exposed wave of the core, where the outer cover will be glued, the whole process also subjected to the application of heat. This process occurs in the part of the corrugator called "Forradeira"

(Figure 3).

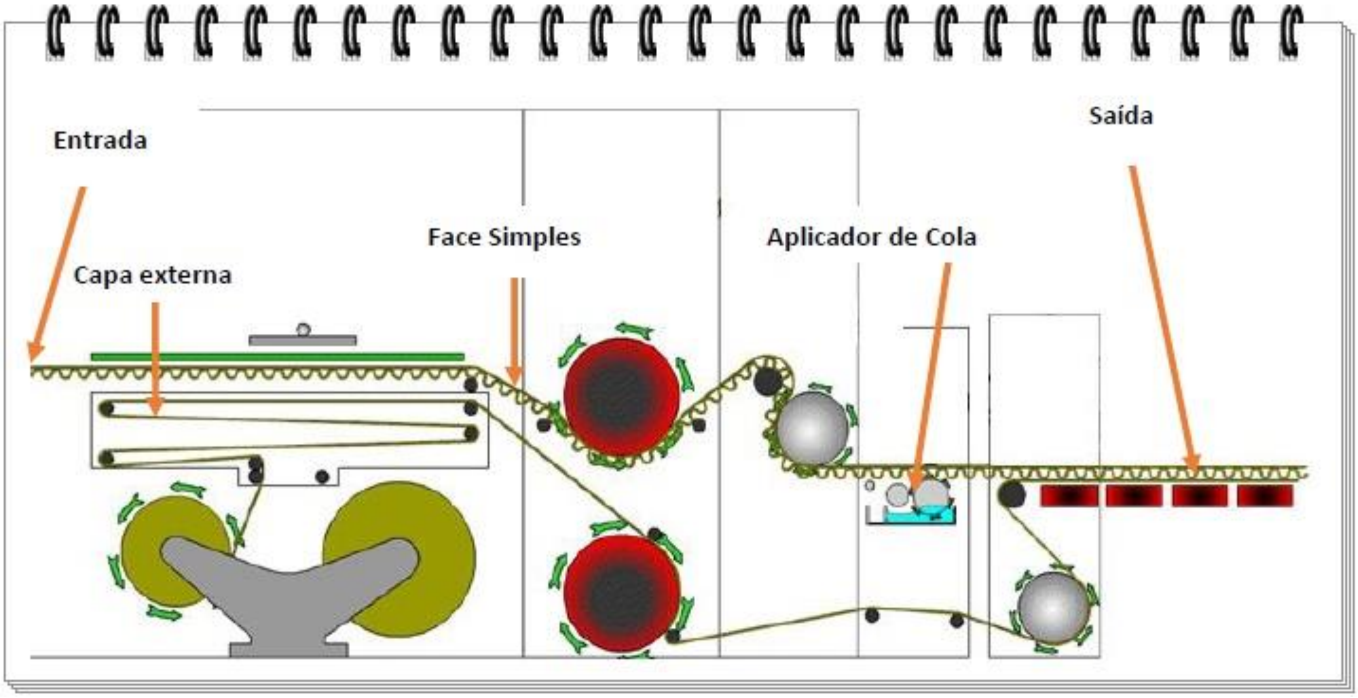

Figure 3 – Process of bonding the outer cover of the cardboard to the corrugator "forradeira" part
Source: Author (2017)

2.2 Standardization of Processes

Since the works of Taylor and Gilbreth, standardization of processes has been used as one of the main tools for process improvement and waste reduction. Since it is used to control, predict and minimize errors and deviations (SANDOFF, 2005), which are certainly one of the biggest villains of scrap within a factory.

When a company standardizes a process, it is guaranteeing that the products produced will be executed equally by any operator, in any shift provided that the mechanical and operational conditions are the same. According to Campus (1994) standard is the planning of the work to be performed by the employee or by the company. A standard indicates a goal to be achieved, shows the product or the ideal scenario to manufacture this product with high quality at the right time.

Employees must be trained and well educated not only about the service they will perform but about the entire context of the company (CREMONESE, 2013). It is important that when presenting the standard to the employee, he has a critical sense of reacting to errors caused by this standard and is motivated to propose improvements to the defined parameters whenever the customer or other sectors of the factory are being negatively affected.

It is not enough just to impose a new standard on employees, it needs to be created with those involved so that each one can give an opinion and be heard. This co-participation generates a feeling of "business owner" in the employee, bringing him greater responsibility and motivation. Thus, avoiding treating them as a mere substitute for a machine and prioritizing participatory management, there will be much less resistance to changes and, therefore, the chances of success of the standardization process will increase considerably (KONDO, 2000).

According to Perin (2005), the standardized process can reach high levels of quality and productivity since

the result is to obtain the reproduction repeatedly of a “best practice” for the activity.
For Cavanha Filho (apud JUNIOR EFIVAL, 2009) there are at least three different types of standardization in an industrial production environment, which are:
a) specification or technique: when it is intended to standardize tangible or intangible goods, such as materials, equipment, services, among others;
b) procedures: when it is intended to standardize how the activities internal to the organization are carried out, such as purchases, production, sales, etc;
c) documentary: when it is intended to standardize the documentation issued by the organization.
According to the methodology presented by Harrington apud Marccelli (2000), the improvement of processes is divided into 5 sub-processes or phases with related activities that are presented below:
Phase I: organization for improvement: define critical business processes; Select process owners; Define the preliminary limits of the processes; Form and train improvement teams; Define the limits of the processes; Establish Performance Indicators; Develop the Project;
Phase II: understanding of the process: elaborating a Process Flowchart; Prepare a simulation model; Conduct an on-site investigation process; Develop cost and cycle time analysis; Implement quick and immediate improvements; Align the procedures to the process;
Phase III: simplifying the process: redesigning the process (focusing on improvement); Design a new process (process reengineering; process innovation; macro process analysis); Macro Analysis; Theory of Restrictions; Automation, Mechanization, Computerization; Organizational Restructuring; Process Simulation. Benchmarking of the process; Improvement, costing and risk analysis; Select the best process; Preliminary implementation plan;
Phase IV: implementation and control: implementing a new process; perform measurements in the process; use feedback system; manage Quality costs.
Phase V: continuous improvement: seeking to carry out critical analysis in each process, identifying and implementing improvements over time.

3. Methodology

For data collection, the period used was from January to September 2017, these data were analyzed from September to October 2017. The entire investigation took place in the manufacturing environment of company X, more specifically in the waving sector, where the corrugating machine is located. The research steps are described in sections 3.1 and 3.2.

3.1 Data Collection

To elucidate the effects that the lack of standardization of the parameters causes, the productivity data of the corrugating machine, located in the corrugation sector, were taken from the reports of the factory's production management system, which monitors all material handling, performance machines, and production orders.
The scrap data was collected from the spreadsheet where the daily scrap weight of the day is allocated by reason and sector. Benchmark meetings were held in September 2017 with other units of the company that

had similar machines and processes. The objective was to learn about the standardization used by these factories, the complexity of their processes, in addition to surveying all material used by them for parameterizing the process.

Through productivity reports extracted from the production management system KiwiPlan used by the company, a survey was made of the formats that are mostly manufactured to be the first to be parameterized, formats that will be presented in the results chapter of this article.

Finally, raw material inspection procedures were collected from the quality team, in this case, kraft paper, and paper core, to assess how much the lack of these inspections could damage the process variability.

3.2 Data analysis

In October 2017, brainstorming meetings were held with process supervisors and machine operators, to discuss the difficulties of the process, analyze the reports generated in the system (stops, machine availability, scrap, productivity), to communicate the operators of the current situation of the machine, making them reflect on the immediate need to parameterize the corrugator machine variables, located in the corrugation process.

Cylinder Head Parameters	Forradeira Parameters
Cover Temperature	Inner Cover Temperature
Core Temperature	Outer Cover Temperature
Press Roller Pressure	Glue Crack
Corrugator Pressure	Paper reel brake pressure of the outer cover
Glue Crack	Simple side brake pressure on the bridge aligner
Paper reel brake pressure of the inner cover	
Paper reel brake pressure of the core paper	

Chart 3 – Standardized variables

Source: Author

From the debates, parameters were raised that are always adjusted to manufacture each cardboard format. This part of the research was very empirical, based on the experience of the employees to obtain the average values of the variables that were being standardized. Thus, a range of variation was defined based on the lowest and highest value of the parameter so that the paper had quality, values that will be shown in the results chapter of this study.

Then the parameters defined by the operators went through the evaluation stage, where the process was monitored to see if the parameters needed different adjustments for the manufacture of each type of cardboard.

The Chart 3 shows the parameters chosen to have their values standardized on the two parts of the corrugating machine.

4. Discussion

The results are divided into four topics, the first addressing a more detailed survey of the main scrap generated in the process, in addition to showing a graph of availability of the printers, evidencing the impact of the lack of standardization of the corrugating machine. The second presents the correlation between the major reasons for scrap and the variables to be parameterized, then the types of cardboard that will have their standardized variables are presented. Finally, the standards established for each type of composition mentioned in the previous topic are displayed.

4.1 scrap generated in the corrugating process

In 2017, company X started to carry out a scrap control with separation in percentage by type of scrap. This control made the action plans for the reduction of scrap more precise and specific, in addition to being able to visualize with greater clarity of data the highest index of the scrap of the plant.

It was found that more than 4.28% of scrap in 2017 was generated in the corrugation sector, with the sector with the highest percentage of plant scrap (corrugation Sector = 4.28%; Printers Sector = 3.01 %; Commercial Sector = 0.55% and Logistics Sector = 0.03%), taking into account the figures up to September 2017. Also, the corrugation sector is the place where operational improvement actions affect, with opportunities for the intervention of low-cost actions.

Table 1 – Types of waste in the corrugating sector

Types of waste	**%**
Curved plates	0,54%
Peeled plates	0,39%
Dried plate with bubbles	0,25%
Simple side	0,20%
Wave Kneading	0,18%
False Folded Cardboard	0,18%
Glued Plates	0,13%
Bushing	0,08%
Wet plates	0,04%

Source: Author

Table 1 shows the largest types of scrap in the corrugating sector in decreasing order by percentage about the gross cardboard production of company X, with curved plates (0.54%), peeled plates (0.39%) and dried plates with Bubbles (0.25%) were the main causes of scrap.

The waste shown in Table 1 can impact other indicators and sectors of the plant. When poor quality sheets are not filtered in the corrugator, they cause enormous inconvenience in the printer sector, making their work more difficult. Figure 4 shows the number of hours the printers stopped due to bad material coming from the corrugator.

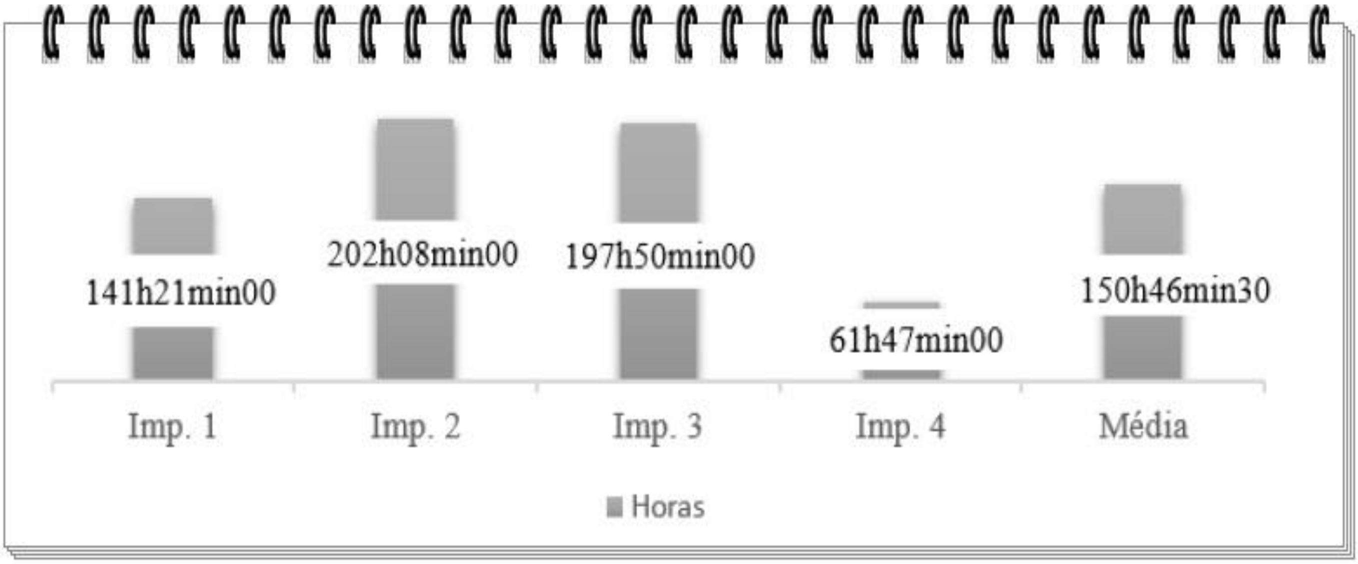

Figure 4 – Machine downtime per printer
Source: KiwiPlan (2017)

To be aware of the impact size, printer 2, which was the most affected, the number of hours stopped is equivalent to 14 days of production, if you consider all printers, there are 43 days with production stopped. Figure 4 shows the time (in hours) of machine stops caused by the poor quality of cardboard coming from the corrugator between January and September 2017.

4.2 Influence of parameters on waste generation

All the wastes shown above are directly related to the process parameters shown in the methodology of this study. These parameters are always adjusted at the beginning of each order.

Chart 4 shows the influence of the parameters on the largest types of scrap, with the left column showing the parameter that influences the scrap in the right column.

It can be seen that the lack of control of the temperature parameter in several parts of the machine and the wrong amount of glue application (glue crack) are causes of many process non-conformities.

This is because each composition requires different temperatures and glue levels, due to the weight characteristics of the cover and core papers.

Parameters	***Influenced parameters***
Cover and core temperature in the cylinder head and “forradeira”	Curved plates
	Dried plate with bubbles
	Bushing
	Wet plates

Press Pressure	Wave Kneading
Corrugated pressure	Wave Kneading
	Curved plates
Glue crack	Peeled plates and Glued plates
Coil door brake pressure	Simple side and false folded

Chart 4 – Relationship of parameters to the reasons for scrap in the corrugation sector
Source: Author

4.3 General characteristics of the compositions

The composition is the name given for the union of the kraft papers that will be used in the cover and core, where the combination of both will give peculiar characteristics to the cardboard depending on its weight. Company X uses 4 types of paper, its weights are 110g, 117g, 165g, and 190g. The inner and outer covers of the kraft papers used are O2, O3, and O5. So if the cardboard formed by the inner and outer covers of type O2 and the core of type 165g with type B wave, then the reference of this composition will be O2O2/B-R.

The rule for parameterization is simple, the greater the weight of the elements that make up the cardboard, the greater the values of the parameters. This means that the temperature applied to a composition containing O5 paper must be higher than the temperature applied to a composition containing O2 paper.

Chart 5 shows the 10 compositions with the highest production volume in 2017, which will be the first to be standardized and will serve as a pilot test. Also, this table shows the main characteristics of these compositions.

And Chart 6 (Appendix A) does not present exact values of the parameters, but variations, due to the particularity of this type of production process, as the paper corrugating process is not 100% reliable. It is worth noting that there are many equal values for various parameters between the compositions, this is due to the similarity of the compositions that often only change the quality of one of the covers or the type of the wave.

Composition	Characteristics
O3O3/C-R	Simple wall cardboard with intermediate weight paper
O2O2/B	Simple wall cardboard with light weight paper
O3O3/BC	Double wall cardboard with intermediate weight paper
O5O3/C-R	Simple wall cardboard with between high and intermediate weight paper
O3O3/C	Simple wall cardboard with intermediate weight paper
O3O3/B-R	Simple wall cardboard with intermediate weight paper
O5O5O5/BC	Double wall cardboard with high weight paper

O2O2/C	Simple wall cardboard with light weight paper
O5O5/C-R	Simple wall cardboard with high weight paper
O5O5/BC	Double wall cardboard with high weight paper

Chart 5 – The characteristics of ten compositions
Source: Author

5. Conclusions

The objective of this study was to investigate the best standard of the parameters to be applied to the manufacture of corrugated sheets, aiming to reduce the amount of scrap from the factory. Therefore, this article sought to investigate the state of the art concerning standardization and statistical control of similar processes, to propose the ideal parameters for the manufacture of the main types of cardboard used in this industry.

After data collection and analysis, the Chart 6 was generated with the necessary parameters for the production of the 10 most corrugated cardboard compositions manufactured by company X. It is worth emphasizing the importance of the reporting system and indicators that company X provided, allowing access to all information necessary for decision making. The participation of employees who are directly involved with the operation was of great value so that in this first moment the parameters are more reliable and accurate.

Therefore, it is concluded that the parameters that most influence the generation of approximately 9 types of scrap are: (a) Temperature of the cap and core in the cylinder head and "forradeira"; b) Press pressure; c) Corrugate pressure; d) Glue crack; e) Pressure of the coil door brakes. To reduce factory waste, a standardized list was proposed containing the parameters for each composition, observing the peculiarities of this production process. The proposal, if adopted with other management measures, has the potential to assist in the reduction of waste in the process, as these problems are centered on the lack of control of the parameters raised by this study. Also, the company can gain in productivity, since the problems generated by the lack of standardization of the corrugator parameters generate many hours of stoppages in the printer sector.

This study was limited to a specific process of corrugating paper, without addressing the entire production chain of corrugated cardboard, from the manufacture of kraft paper, which is a major influence on the quality of cardboard, and it is recommended to conduct research to address these processes.

In this first moment, the opportunities for improvement in the machinery were not taken into account. Besides, the study did not focus on processes related to post curling (storage, printing, etc.). Thus, it remains a proposal for further studies for the creation of process control charts more suitable for the peculiarities of the factory. It is also recommended to research the raw materials used, their specifications and formulate quality control tests for them.

6. Appendix A

LIST OF PARAMETERS	COMPOSITIONS				
	O3O3/C-R	**O2O2/B**	**O3O3/BC**	**O5O3/C-R**	**O3O3/C**
Cylinder Head Parameters					
Cover temperature	60 to 90 ºC	65 to 75 ºC	75 to 85 ºC	65 to 90 ºC	60 to 90 ºC
Core temperature	65 to 85 ºC	70 to 80 ºC	80 to 90 ºC	70 to 85 ºC	65 to 85 ºC
Press Roller Pressure	45 to 55 Kfg	50 to 55 Kfg	56 to 59 Kfg	47 to 54 Kfg	45 to 55 Kfg
Corrugator Pressure	55 to 60 Kfg	50 to 55 Kfg	55 to 60 Kfg	57 to 60 Kfg	55 to 60 Kfg
Glue crack	10 to 20 mm	25 to 30 mm	30 to 35 mm	15 to 20 mm	10 to 20 mm
Paper reel brake pressure of the inner cover	1 to 2 Bar	1 Bar	1 Bar	1,5 to 2 Bar	1 to 2 Bar
Paper reel brake pressure of the core paper	1 to 2 Bar	2 Bar	1 Bar	1 to 2 Bar	1 to 2 Bar
Forradeira Parameters					
Inner Cover temperature	80 to 100 ºC	80 to 100 ºC	90 to 100 ºC	90 to 105 ºC	80 to 100 ºC
Outer Cover temperature	50 to 65 ºC	68 to 65 ºC	60 to 65 ºC	70 to 95 ºC	50 to 65 ºC
Glue crack	21 to 25 mm	18 to 20 mm	21 to 25 mm	25 to 35 mm	21 to 25 mm
Paper reel brake pressure of the outer cover	1 to 2 Bar	2 Bar	1 to 2 Bar	2 Bar	1 to 2 Bar
Simple side brake pressure on the bridge aligner	50 to 60 Bar	50 to 55 Bar	59 to 62 Bar	55 to 60 Bar	50 to 60 Bar
List of Parameters	Compositions				
	O3O3/B-R	O5O5O5/BC	O2O2/C	O5O5/C-R	O5O5/BC
Cylinder Head Parameters					
Cover temperature	75 to 85 ºC	75 to 95 ºC	65 to 75 ºC	75 to 95 ºC	75 to 95 ºC
Core temperature	80 to 90 ºC	70 to 85 ºC	55 to 75 ºC	70 to 85 ºC	70 to 85 ºC
Press Roller Pressure	56 to 59 Kfg	50 to 55 Kfg	45 to 51 Kfg	50 to 55 Kfg	50 to 55 Kfg
Corrugator Pressure	55 to 60 Kfg	57 to 62 Kfg	50 to 55 Kfg	57 to 62 Kfg	57 to 62 Kfg
Glue crack	30 to 35 mm	20 to 30 mm	10 to 15 mm	20 to 30 mm	20 to 30 mm
Paper reel brake pressure of the inner cover	1 Bar	2 Bar	1 Bar	2 Bar	2 Bar
Paper reel brake pressure of the core paper	1 Bar	2 Bar	1 a 2 Bar	2 Bar	2 Bar
Parâmetros da Forradeira					
Inner cover temperature	90 to 100 ºC	95 to 105 ºC	80 to 94 ºC	95 to 105 ºC	95 to 105 ºC
Outer cover temperature	60 to 65 ºC	80 to 95 ºC	50 to 60 ºC	80 to 95 ºC	80 to 95 ºC
Glue crack	21 to 25 mm	28 to 35 mm	18 to 22 mm	28 to 35 mm	28 to 35 mm
Paper reel brake pressure of the outer cover	1 to 2 Bar	2 Bar	1 Bar	2 Bar	2 Bar
Simple side brake pressure on the bridge aligner	59 to 62 Bar	57 to 62 Bar	50 to 58 Bar	57 to 62 Bar	57 to 62 Bar

Chart 6 - List of compositions and their parameters.

Source: Author

7. Acknowledgments

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8. References

[1] ASSOCIAÇÃO BRASILEIRA DE EMBALAGEM – ABRE. Disponível em <http://www.abre.org.br/setor/documentos/manual-orientativo-de-especificacoes-tecnicas-da-embalagem-de-papelao-ondulado/ > . Acesso em 10 set. 2017.

[2] ASSOCIAÇÃO BRASILEIRA DE PAPEL ONDULADO – ABPO. Disponível em <http://www.abpo.org.br/infor_tec_po.htm>. Acesso em 10 set. 2017.

[3] BRYMAN, A. Integrating Quantitative and Qualitative Research: how is it done? Qualitative Research, v. 6, n. 1, p. 97-114, 2006.

[4] CAVANHA FILHO, A. O. Estratégia de Compras, Rio de Janeiro: Editora Ciência Moderna, 200.

[5] CREMONESE, M.. Abordagem para implatação integrada e da gestão à vista na indústria. Revista GEINTEC, São Cristovão, 2014, Vol. 4/n.2/ p.884-901.

[6] DENNIS, P. Produção Lean Simplificada. Porto Alegre: Bookman, 2008.

[7] FORNO, et al. A padronização do processo como primeiro passo para a implementação do desenvolvimento lean de produtos – evidências da indústria têxtil. Revista TECNO-LÓGICA, Santa Cruz do Sul, 2015, v. 19/n. 2/p. 36-41.

[8] JUNIOR, et al. O processo de padronização como metodologia de diminuição de custos. ENEGEP 2009. Salvador. 2009.

[9] KONDO, Y. Innovation versus standardization. The TQM Magazine, v. 12, n. 1, p. 6-10, 2000.

[10] MARCCELLI, R. P. O papel dos indicadores de desempenho na estratégia das organizações para o aprimoramento de processos: um estudo de caso. Dissertação de Mestrado. Florianópolis: Universidade Federal de Santa Catarina, 2000.

[11] MARIZ, R. N.; PICCHI, F. A. Método para aplicação do trabalho padronizado. Ambiente Construído, Porto Alegre. v.13/n. 3/p. 7-27. 2013.

[12] OTTOBONI, C.; PAGNI, T. E. M. A importância do mapeamento de processos para a implementação do Balanced Scorecard. XXIII Encontro Nac. de Eng. de Produção - Ouro Preto, MG, Brasil, 21 a 24 de out de 2003.

[13] PARAIBUNA EMBALAGENS. Guia prático em papelão ondulado. Disponivel em: < http://www.paraibuna.com.br/ > Acesso em 10 set. 2017.

[14] PERIN, P. C. (2005). Metodologia de padronização de uma célula de fabricação e de montagem, integrando ferramentas de produção enxuta. Dissertação (Mestrado) – Escola de Engenharia de São Carlos, Universidade de São Paulo, São Carlos, 2005.

[15] ROBERT, N. T. F. Dossiê Técnico: Produção de Embalagem de Papel. Rede de Tecnologia e Inovação do Rio de

Janeiro – REDETEC, Serviço Brasileiro de Respostas Técnicas. Rio de Janeiro, 2007.
[16] SANDOFF, M. Customization and standardization in hotels: aparadox or not? International Journal of Contemporary Hospitality Management, v. 17, n. 6, p. 529-535, 2005.
[17] SÉKULA, P. Uso de modelo de referência para melhoria do processo de fabricação de papel kraft. Dissertação de Mestrado. Ponta Grossa. Universidade tecnológica federal do Paraná. 2011.
[18] SINTIPEL. Manual de Segurança e Saúde do Trabalhador em Máquinas de Papel e Papelão em Piracicaba. Piracicaba, 2016.
[19] TEIXEIRA, et al. Padronização e melhoria de processos produtivos em empresas de panificação: estudo de múltiplos casos. UNESP, Guaratinguetá, 2012.