IMPROVING PRODUCTIVITY OF A PRINTING INDUSTRY: NO WASTE

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Abstract. *The purpose of this action research was to identify the causes of low productivity in a flexible packaging printing company and to find out the best actions to take for achieving improvements when it comes to applying waste reduction of inputs. In addition, it could be noticed along the research, the need for a reassessment of the productive aspects of the company as it relates to the application of setup techniques. Among the factors that caused low productivity, print setup stands out because the greatest losses in this regard. In the case of the analyzed company, identifying the causes of low productivity was based on a methodology that involved field research to raise points of comparison between the analyzed company and another company in the same industry that already used innovative techniques of lean manufacturing, including the TRF in their print setups. It worked as a model to be applied by the industries under study. The improvement of the printing process had considerable reduction in setup times and waste of material and substrates, thereby generating a large attenuation in the waiting time for products and a decrease in the level of intermediate storage, improving manufacturing logistics. Reducing the waiting time was also of great importance in determining the end product delivery to the customer. It was possible to reduce the printing setup, as well as printing and supplies of scrap raw material printed in more than 90%. After this research, it was also possible to define, measure and standardize all the variables inherent in the printing setup process, which is one of the most important causes of waste. It was blocking the proper development of such a company and so was the use of paint greener.*

Keywords*: Company graphics Packaging; Improved Productivity; Waste and Rapid Tool Change Setup*

1. INTRODUCTION

Brazilian printing industry sector is today characterized by a high technological standard. Many companies have achieved significant progress in terms of innovation, contributing to productivity and quality improvements with positive effects on return and on environmental aspects. However, such changes require a substantial revision in production processes – formerly focused on large scale – by adapting these processes to batch production. Despite this need for adaptation to a new production system, a large number of companies are operating with old processes and equipments requiring substantial adaptations (Technical Guide Environmental Printing Industry - P + L, 2009). Moreover, these companies face difficulties in its production sequence, since the same machines are used for several different products. In this context, the management of production processes by reducing the lead time of all operations, in particular the machines setup time, becomes an essential part of manufacturing costs reduction and increasing gain in market competitiveness. Precise setup requirements are not limited to make readily available to production machines, all material and human resources. Such actions alone do not solve the problem for medium and long terms; they just mask, for a short time, the solution of the real issue.

This article relates how productivity improvements have been achieved in a printing company producing flexible packing materials. The major task was to recognize that productivity depends on both endogenous (controllable by the company) and exogenous (not controllable by the company) factors. Improvement in productivity - defined here as the efficiency of utilization of human and materials resources to produce goods satisfying the customer demand on quality, quantity, opportunity and cost – depends on how company's resources are used, the available technology and the management of the entire production process, including the supply chain of products and services.

In the company where these actions were undertaken, uncovering the causes of low productivity was based on a methodology that involved field research to identify points of comparison between the company under analysis, located in São Paulo, and another company where the production process employed techniques of lean manufacturing. The need to acquire new machine provided an opportunity for this phase of work. For this task, a team, which included the first author of this article, traveled to Italy. During this visit, a printing industry associated with the new machine manufacturer, was contracted to provide training of managers and a selected team.

During the training, production parameters were collected in order to compare with corresponding parameters in the company under study and the result was the awareness that major changes should be introduced to improve productivity.

The most important change concerned the setup time of the machines. This was a confirmation that setup and rapid change of graphic printing arrays in a flexible packaging printing industry is a major cause of waste. At the same time it was also observed that more than physical arrangements were needed, requiring a more extensive study of the entire production chain of the company as well as a new evaluation of environmental issues such as: the use of water based paints, varnishes and adhesives. Following this field research, it was possible to define, to measure and to standardize all variables inherent to the printing setup process resulting in both technical development of the company and a safer environment. Silva & Melo (2010) conclude that setups are responsible for preparation costs and these can be visualized into four parts, according to Fig. 1. In this figure it is noted that 5% of total time refers to tools, matrices and other items change and extraction. The additional 95% of total time is spent in internal activities which can be adapted to external activities.

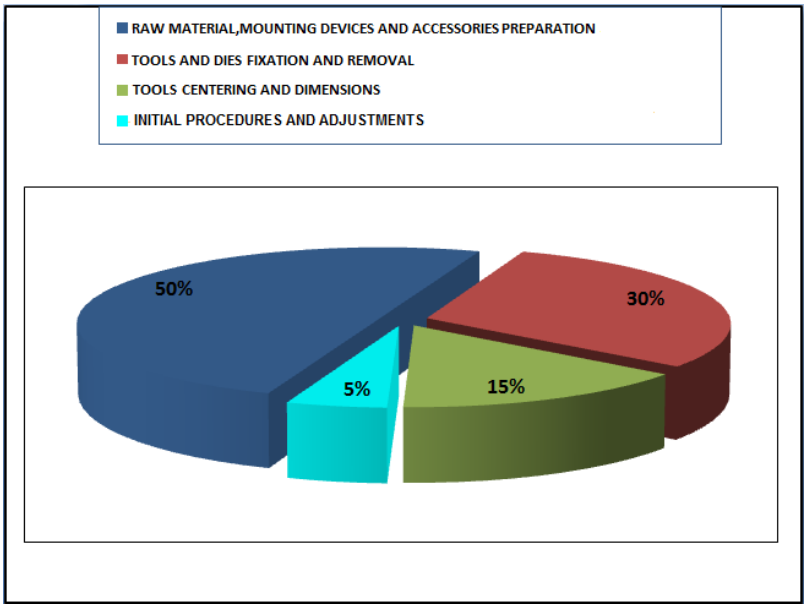

Figure 1. Defragging the setup steps
Adapted from SILVA and MELO (2010)

2. THEORETICAL BACKGROUND

The choice of a particular system of production is the result of a strategic decision taken according to the company market position objectives. The choice of this system will directly affect the performance of the production system in relation to competitive aspects as cost, quality, delivery, reliability and flexibility (GIANESI and CORREA, 1996). Therefore, the success of the production system of a company depends on factors such as technology, material and human resources and management system. By itself, the deployment of a manufacturing management system does not guarantee competitive success of the company.

Lean Manufacturing refers to a system design or production paradigm originated in the Japanese industry, specifically the Toyota Motor Company, based on the work of Taiichi Ohno and Shigeo Shingo. Lean Production has received increased attention after the 1973 oil crisis, when that company adopted a production strategy of many models in small quantities, which made Toyota competitive and efficient. The concept of Lean Manufacture follows the principle that there is waste in all areas of an organization and aims to do more with less and less, always aiming at offering customers what they really want and the time needed. The goal is to make businesses more flexible and responsive to customer needs, develop the production and distribute products with less human effort, space, resources, time and overall costs (COOPER and KEIFFER, 2010). According to these authors, in practice, the benefits that Lean Manufacturing provides are achieved mainly by means of:

- ✓ Integrated production with small stocks, using Just in Time (JIT) management;
- ✓ Customers driven production (rather than "pushed");
- ✓ Prevention and quality control emphasis opposed to detection or correction;
- ✓ Working in organized teams;
- ✓ Few hierarchical levels;
- ✓ Multipurpose teams dedicated to eliminating non-value added activities;
- ✓ Integration of the entire supply network, from raw materials to the final customer.

According to Liker (2009), Lean Manufacturing is defined as "an operating philosophy that, by improving the production flow, its goal is less time for the delivery of products and services, with high quality and low costs." All this is possible due waste elimination in the value stream. Thus, Lean Manufacturing system can bring many benefits, provided proper tools are used. Today, companies strive to achieve the above goals quickly, without forgetting their social and environmental responsibility. To this end, to begin with, it is necessary to establish a drastic change of mentality of those who have the responsibility to manage and make decisions.

The graphic arts industry, in particular, is not immune to these new requirements and therefore the introduction of new management philosophies is required, leading to a change in behavior and, hence, in results. In this industry, Cooper and Keiffer (2010) stress the need of a Lean Manufacturing approach because, despite new technological advances and new organizational and strategic thinking, printers, mostly continue using outdated methods of mass

production introduced by Henry Ford in the early twentieth century. The causes of production processes problems are rarely investigated, resulting in successive "patches" instead of conducting a final "cure" with focus on customer satisfaction.

As a related tool, Kaizen refers to a continuous improvement in business activities. This process should involve all elements engaged in production, managers and workers, as well as the overall company management. Actually, it not only refers to the progressive improvement activities but also the innovation process. To Imai (1990), Kaizen is a broad set of practices adopted in industrial activities.

Another important process that influenced the development of this study is the sense of cleanliness in the printing industry: the coaching staff should educate printers about the benefits of keeping the workplace clean, part of the measures foreseen by the 5S Ishikawa. It is a well known the influence of this issue on productivity. A program of progressive and continuous improvement certainly contains, explicitly or not, the technique of the PDCA (Plan, Do, Check, Act), for planning and the implementation of improvements must necessarily be accompanied by verification of the results obtained by the program and possible changes to correct deviations (GOULART et al., 2010). In the deviations survey phase, by adopting techniques from the Ishikawa diagram, Pareto chart and many others techniques (Okoshi et al., 2010), it is possible to identify deviations that most affect productivity and select priority actions. Therefore, the main goal of Kaizen is the direct involvement of people who feel more valued and motivated to achieve company goals in developing this very important work.

According to Womack (1997), waste, known in Japanese language as “change”, is often associated to lost of materials, but its definition goes far beyond that. According to Campos (1999), "waste is any resource that deteriorates the performance of a product or service". It is an additional cost that increases the normal cost of the product or service with no improvement to the customer needs.

Waste reduction in manufacturing means the elimination of anything that increases production costs, thus transforming waste in value. According to Shingo (1996), rapid change of tools allows, for example, reduction of lot sizes which, in turn, allows for the reduction of inventories (one of seven losses - loss from overproduction). The same author hypothesized that any setup could be performed in less than 10 minutes, calling the technique of Rapid Tools Change, which was later adopted by the Toyota Company as a major element of its system.

Therefore, Rapid Tool Change is a methodology which reduces time of tools changes, the machine setup, by establishing a goal of less than ten minutes, with the ultimate goal of making production more flexible to changes in demand. To achieve the lowest possible setup time, according to Shingo (1996) and as detailed by Cooper & Keiffer (2010), there are four steps for effective implementation of Rapid Tools Change in the printing industry:

- ✓ External from the internal setup identification and separation;
- ✓ Internal to external setup conversion;
- ✓ Relevant points simplification and improvement
- ✓ Setup elimination.

The application of the first three steps, for example, reduced from 4hs and 30 min to 2 hours total time printing presses set up in the company where this work was developed

3. DEVELOPMENT

As described in the introduction, this work was stimulated by a training period in an Italian company, which uses the same equipment of the company under study, this training being necessary to operate a new machine. This training gave an opportunity to understand and observe that a quick and correct setup, and quick change of dies, were one of the essential elements involved in the production chain of the printing industry, considering paint and varnish suppliers, raw material of printed materials (polyethylene, polypropylene, polyester, aluminum foil, etc..) providers, graphic arrays (gravure cylinders and sheets of photo polymer flexographic) and, finally, the client himself. Other points observed were environment and cleanliness related issues besides establishing a more cooperative environment between workers and managers. In this work attention is focused on the setup time reduction.

In particular, a common element was directed toward the elimination of production wastes, which were embedded in all elements of flexible packaging production, with the acquired understanding that Lean Manufacturing was the cornerstone for this venture success.

The first step to begin implementation of management and control of the setup process was an x-ray identification of all variables through filming, resulting in data that allowed basic conclusions and suggestions for improvements, with continuous participation of the teams involved, established as Project Kaizen.

The initial step of the setup standardization process was the definition of the variables involved, their identifications and separation by means of tests, practical simulations and constant training and in the shortest possible time, recording everything through filming and written reports for further analysis.

4. PRINTING VARIABLES VERIFICATION AND CONTROL

The print test was produced by international industry standards for the company particular case, ECI (European Color Initiative) who developed the test IT8. 7 / 4 used for the reproduction of Flexographic images. This test determines the tolerances and specifications for these reproductions and the balancing machine, during print campaigns, in order to equalize all the machine variables. In this print test, all elements applied to printing, such as density of solids and tonal ranges, as well as the influence of machine speed on physical characteristics and adaptations of the packaging of paints and water based varnish, were analyzed

5. METHODS AND PROCESS

The effective implementation of a program consisting of control elements represented the key step in the study reported here. The initial stage was proposed by the Board of Directors and was expanded to the company's management team, extending later to supervisors, leaders, team leaders and finally to the operating body. Its implementation began, gradually and concise, in the printing and finishing sectors. The biggest waste in these two sectors were detected upon examination of the value stream map, mainly in the packaging printing sector, following the exchange service and due to adjustments and replacements of printing arrays. Both problems, together or separately, were the main causes of waste for the company, resulting in inconvenience and loss of orders and delays in delivery of the printed material.

Initially, it became clear that the change in philosophy would encompass considerable impact in the organization as a whole and that the new attitude and concepts introduced - not only the printing process and other items - was having the desired effect. The initial work was to develop an experiment consisted of a partially isolated printing press, separate its operators from the rest of the factory and from that point, implement the entire process described above, but in a gradual manner.

After six months of work, changes and modifications procedures were expanded to the rest of the company. There was a profound impact on employees not immediately involved in the process, who quickly realized where they were and what they could achieve in the working place, their safety, equipments, production, quality and results achieved. In a few weeks, supervisors, team leaders and machine operators wanted the project to be extended to their printing presses, as well as other sectors of the company.

The activities and elements subjected to improvement through Kaizen meetings between leaders, supervisors, operators and engineering, were:

- ✓ Machine printer related elements and adjustments such as temperature, print speed, supports tension and oven design;
- ✓ Forms (parent line) and ceramic anilox rollers dosing systems, and volumetric capacity, cleaning and setting the level of wear;
- ✓ Scraping knives and rubber rollers quality control (basic cleaning);
- ✓ Paint (hue, viscosity, pH , formulation, etc) by means of density measurements (ink volume proof testing and calibration), previously tested out the machine.
- ✓ Purchase and use of digital viscometers, coupled with tubs of ink in the printer for automatic regulation of paints and varnishes viscosities used in printing process.

Another aspect related to paints and varnishes, was the adoption of water based paints and raw materials, especially for food products and drugs printing packaging. This paint is widely used in printers in Europe and was brought to the company under analysis, as a determining factor for producing packaging suitable for international standards and as a strategic advantage for winning new clients engaged in the philosophy of packing their products with more appropriate packaging environmental standards. The important aspect in using this water based technology, beyond decreasing the setup times, volumes of paints and varnishes, was to preserves and avoid corrosion of printing forms, as well of printer mechanical and electronic elements, such as end-mills, pumps, transmission gears, fiber optic cables, motors, computers among others.

Additional activities and elements subjected to improvement through Kaizen meetings between leaders, supervisors, operators and engineering, were

- ✓ Strip Test machinery purchase, a key element to standardize color standards of packaging and to determine the characteristics and proportions of paint to use in the printing operation.
- ✓ Printing forms or graphic matrices, with suitable features for the use of water-based paints. In this case was conducted an adequacy study was conducted with the provider of graphical matrices in order to adapt the depths of the wells that absorb and transmit ink to the substrate. Material for assembly.
- ✓ Environmental conditions (temperature, humidity) and cleaning and industrial organization.

- ✓ Knowledge Management (procedure to work instructions, experience of the workers, and clarity of information).
- ✓ Time and movements of operators and work well-defined standard.
- ✓ Pre-adjustments in printing machines, with correct sizing of mounting devices, and elimination of bureaucratic operations during setup were completed before final assembly in the machine (internal to external activities separation).

5.1. External and Internal Setup separation procedure

5.1.1. External setup activities:

- ✓ Clean pumps, hoses and connectors on the ink tanks;
- ✓ Pre-set pattern of colors on machine test lab;
- ✓ Preparation, timing and mixing of paints and varnishes, making them available only moments before the end of setup, the right viscosity, according to the evidence allowed by the client;
- ✓ Paints and varnishes pre-packed in their tanks;
- ✓ Movable tanks, taken to the printer, already containing paints and varnishes prepared for use;
- ✓ Assembly of knives scraping devices in fitting and correct orientation;
- ✓ Attachment of pre-registration, with pre-marked positions, starting in the same position towards the perimeter ;
- ✓ Installation of the gear shafts of the arrays, ceramic and rubber, cylinders.

5.1.2. Internal setup activities:

- ✓ Plants in the machine assemble
- ✓ Knives scraping attachment
- ✓ Ceramic cylinders – Anilox installation
- ✓ Cylinder compressors rubber machine mounts
- ✓ Reels of material to be printed (substrate) installation
- ✓ Material into the winder to the unwinder passage
- ✓ Tanks of paint and varnishes, inking devices attachment in the machine
- ✓ Hits and color adjustments (manually) and then electronically
- ✓ Color pattern adjustment with the machine.

A major factor for the setup process and the printing process improvement, as a whole, was the use water-based inks. As mentioned before, this technology was brought into the company under analysis during the training period in the Italian company, where this technology was used in the printing process producing a better packaging quality, as well as a reduction of toxic paints and varnishes and better use of print chips. These could be better used to produce the raw material required for printing process and not in the production of second-line products. Therefore, the company was able to look for alternatives of paints, free of heavy metals.

The solvent-free inks, water-based or cured by radiation, are generally considered more "green," mainly because they reduce emissions of VOCs, typically rely less on petroleum products for manufacturing or reduce consumption of energy for drying. With the use of water-based inks, the company analyzed the possibility to decrease by 60% the settlement pattern of colors in the packaging machine and to decrease packaging waste. As a consequence, the quantities of solvents used to dilute paint in the machine, allowed for a considerable saving in all aspects of the printing process. However, it is not always possible to change the paint normally used, for water-based pains, because of technical or commercial reasons. For instance, some characteristics of a particular ink printing system are inherent to this system and can not be changed easily.

With a new method of printing process, the company developed a more technical way to sample the material during process, by establishing that certain amounts to be withdrawn from time to time, for consideration, rather than prematurely, a sampling method that often may cause hasty actions, generating waste inputs of paints and solvents, to be corrected during printing, before machine stabilization.

Gradually, the project was expanded throughout the printing company, and soon after, to finishing, extrusion and lamination, volatilization and cutting, and rewinding sectors, and in some cases being in a pilot phase, in a certain area or equipment to the effective implementation of a multidisciplinary team and autonomous self-managing expert setup and printing organization and creation of Kaizen

5.1.3. Advantages in using inputs based on water

Product optimization, making the packaging simpler and less complex, with lower cost structure, due to the fact that the product being packaged is not contaminated by paint flicks, which does not happen when using paint or varnish base

solvents, requiring a more complexity and costs, not to mention the double hit of color pattern in the machine, increasing the setup time.

Another advantage of water-based ink is that during the printing process, the ink viscosity does not vary with changes in temperature, providing stability to the printing process, not allowing variations during packaging printing and avoiding waste or rework overproduction and future guarantees.

Viscosity varies with temperature in case of solvent-based paints and varnishes, causing changes in color pattern adjustment and ruining the final products. It is worth mentioning that use of water-based ink is mandatory in Europe, but it is optional in Brazil

6. RESULTS

With respect to improving the lead time, there was a general substantial gain. After the improvements had been implemented, especially in case of fast tool changes, a reduction goal of 50% for external activities and 44% in internal activities was proposed, giving a reduction, in practice, of 2 h 30 min in lead time, for external activities and 2 hours for internal activities. Besides, it increased the availability of printing machines in 45%, which would greatly increase revenues by increasing backlog, and supply commitment, increasing customer confidence and, especially, trust between company employees. From Fig. 2, the activities (in red) were reduced to about 2 hours of total time setup (green), against the previous value of 4 hours and 30 min.

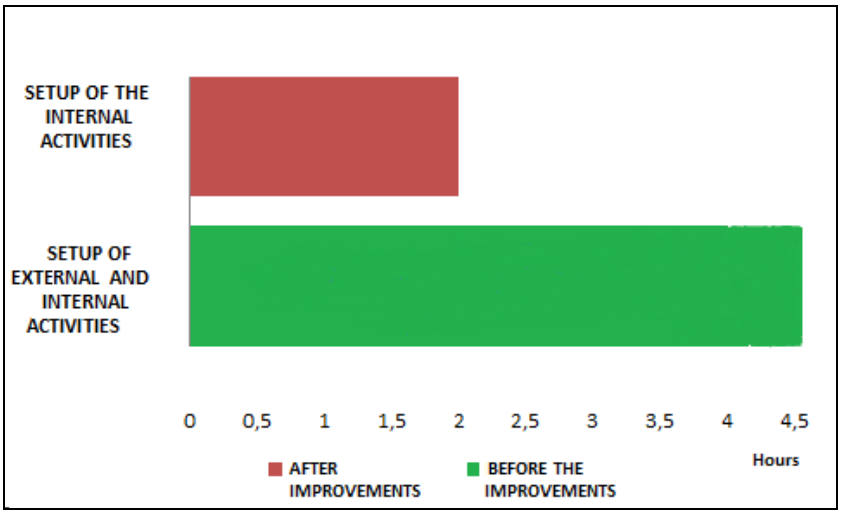

Figure 2. Setup Tasks before and after the proposed improvements

Internal and external setup separation achieved, when implementing the proposed improvements to reduce setup times, for the miners printer machines, based on Kaizen projects involved in these processes is represented in Fig.3.

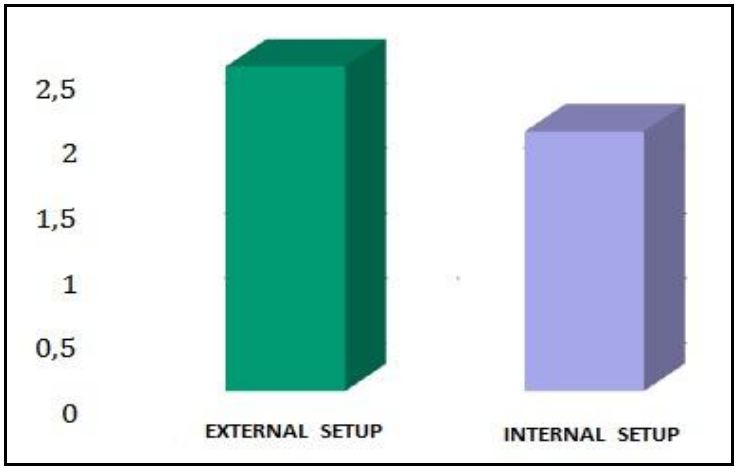

Figure 3. Setup external and internal separation

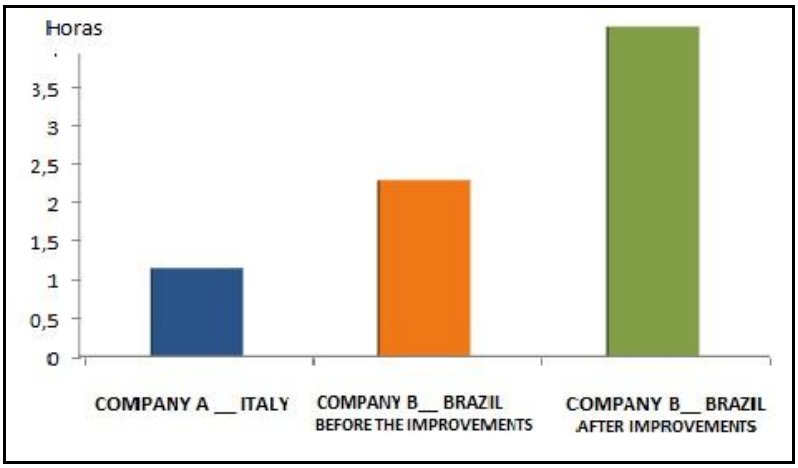

Figure 4. Reduction of setup times

7. CONCLUSIONS

The research and action developed in a printing company related in this work, with the main objective to improve market position and competitiveness was successful proving that both technology and environmental issues are valuable allies in this task. Analysis of similar companies abroad contributed substantially to this success, but the key issue was the educational process involving everyone in the company. Lean manufacturing techniques, Kaizen and Rapid Tools Change were the supporting technology of this task, but environment issues, including work environment proved to be a critical factor of achievement. Looking industrial activities as a whole, concern about environment has given way to different dynamics in organizations and in nations where these organizations are located. Market will no longer accept the misuse of natural resources. Customers are now interested in clean products. The legislation becomes more rigid, imposing sanctions for violators, forcing companies to seriously consider the responsibility of environmental impacts in their operational strategy.

In the specific case related in this work, major achievements were a substantial decrease in lead time, resulting in client satisfaction, great increase in market position, including customers from other countries, a strong synergy due to an innovative environment, confidence in a continuous improvement process, knowledge pollination among all people involved at all levels of production activities, and most of all an established belief that team working is the key to success. In fact, it was by means of a team, initially responsible for the acquisition of new printing machines and for being trained in the operations of these new equipments, that the project increased to change the whole company into a great and efficient team. Always seek the consensus even in adverse conditions experienced in certain situations such as this work, it is the main legacy for future work.

With respect to cleaner production, substantial improvement was verified in the aspect of production organization and it was also possible to observe that the amount of printing parings had decreased but also improved its reuse, especially the use of printing water-based inks, making the whole process cleaner. In this item, there were some improvements in the use of solvents and decayed material such as hoses and plastic and rubber tanks and ink from the printing press.

Regarding the use of paints and water based products, it is a technology that is growing and widely used in Europe and has significant results in the aspect of economy in printing raw materials, as well as a more specific context, the mechanical parts of machines printers and most importantly, its respect to stringent environmental standards that enabled us to be increasing our exports of food flexible packaging companies in Europe as well as for the pharmaceutical industry, and their Brazilian operations.

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9. RESPONSIBILITY NOTICES

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