

A Comprehensive Environmental Analysis in a Company of the Graphic Arts Sector

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The global trends, the causes and consequences of social-environmental problems, and the need to respond to the environmental regulations revive interest in organizations to consider environmental criteria as a part of business management and the search for sustainable development. The company in this study is a medium-sized company in the graphic arts sector, attached to the District Environmental Excellence program, and it has an environmental management system. Therefore, it is in continuous search of strategies that allow it to promote the reduction of its environmental impacts. The primary purpose of this contribution was to evaluate the environmental impacts of the company, using cleaner production tools. The research was developed in two phases: an initial diagnostic phase, by collecting the most relevant information on production and environmental matters; at this stage, essential tools for cleaner production were applied, such as flow diagrams of the printing processes and product, as well as an eco-map analysis for the identification of critical points, development of eco balances and a MED matrix for the quantification of inputs and outputs during the flexographic process, such as the identification of the flows that are part of the production chain of the self-adhesive label and finally consolidate the matrix of environmental aspects and impacts, following the requirements of the environmental authority and the ISO 14001 norm. It was identified that the flexographic process is the company's primary method that contributes to the greatest generation of environmental impacts.

This work seeks to contribute to improving the environmental performance of productive activities through the corresponding analysis of products and processes. The applicability of said evaluation is a support methodology to the company in decision-making during the design, optimization of its production systems, and the operation of its processes; also, with it, it improves competitiveness in the market through the adoption of policies and practices that improve or increase sustainability.

Keywords: Lithography Industry, Cleaner Production, Environmental Management.

1. Introduction

In the 11th century, with the invention of the Chinese printing press, the graphic arts industry began, and the publication of printed documents was seen for the first time. However, the technology used in this production process has evolved (Medaglia and Vargas, 2013), and the most widely used technique is lithography, which involves offset printing (García, Leone and Williams, 2014). Traditional lithography is generally divided into three phases: prepress, printing, and post-printing. Pre-printing includes design, layout, and editing activities, transferring the design to an image carrier or plate. This operation involves physical or chemical processes such as exposure to ultraviolet (UV) or laser light, photoengraving, developing, and post-processing. Then, in printing, the plate is placed in the printer, and finally, post-printing includes the final finishing of the materials for marketing (Villalobos et al, 2021). The raw materials used include paper, inks, plates, water, and chemical products (García, Leone and Williams, 2014).

Likewise, because of the production process of the lithographic industry, wastewater, gaseous emissions, and ordinary and extraordinary solid waste are generated (García, Leone and Williams, 2014; Dimate and Chirley, 2014). Wastewater from the printing industry is highly variable in chemical composition due to the diversity of products used in the processes. In general, they are characterized by high chemical oxygen demands (COD), color permanence, total suspended solids (Prisca et al 2016); which results in a low biodegradability index, toxicity higher than 90 %, and a high concentration of organic matter (Ding, Chen and Fan, 2011; Torresano, 2017). Solid waste from the printing industry can be classified into four main groups: recyclable, non-recyclable, hazardous, and handling waste. The main ones are paper and cardboard scraps, cleaning rags with solvent and ink, used or defective plates, empty solvent containers, ink and toner cartridges, and damaged plastic packaging (García, Leone and Williams, 2014).

The amount of waste generated by the graphic communication industry has generated 3.1 million kilograms of hazardous waste. By type of waste, 51% is related to the use of inks, followed by other chemicals and solvents with a share of 33% in the amount of waste. Furthermore, the manufacturing industry is one of the most energy-demanding sectors, as the operation of machinery and equipment depends on it. For 2017, the national energy consumption in Colombia's manufacturing industry was 16,429 GWh, according to information obtained from the Annual Manufacturing Survey (Villalobos, et al, 2021).

It is considered of great interest to evaluate the environmental impacts of the printing industry in order to identify its main effects and generate preventive, corrective, and compensatory measures towards the environment (Mora, Molina and Sibaja, 2016). The main environmental impacts of the lithographic industry include

- Gaseous emissions from volatile liquids from ink thinners and cleaners (García, Leone and Williams, 2014; Dimate and Chirley, 2014)
- Wastewater discharge (Prisca et al, 2016)
- Use of hazardous materials and the generation of solid waste (Bautista, Toloza and Sanes, 2019)

In this work, the main environmental impacts generated in a lithographic industry in Bogotá were identified, assessed, and prioritized through the development of cleaner production tools.

2. Materials and methods

This research focused on analyzing the label production process, intending to estimate the environmental impacts of the company's flexographic printing process. This evaluation was carried out for one year in the stages described below: Diagnosis of the environmental impacts of a graphic arts industry using cleaner production tools, for which the company's facilities were visited to recognize the development of its production processes and achieve the Initial Environmental Review, to identify the inputs and outputs of materials and energy of the flexographic process, In order to identify the inputs and outputs of materials and energy of the flexography process, the Materials, Energy and Waste Matrix was made and to record the balance of volume and composition of the flow of materials and energy that exist in the processes, flow diagrams, and the Eco-balance were made, while to identify and locate areas or critical points of high risk of contamination the Eco-maps were made, and the Matrix for the identification of aspects and assessment of environmental impacts was also constructed. (Marin, 2014).

3. Results and Analysis

The company's flexography process was analyzed using the necessary tools to assess the environmental impacts of the process. It began with the recognition of the production stages, which are detailed below:

-Pre-printing: The pre-printing process is broken down into two main stages: image processing and plate processing. The first stage is the design and preparation of the film in order to subsequently print the plate that will serve as a mold for the repetition process. This pre-printing stage does not generate significant environmental issues; however, it generates solid and liquid waste such as developers, fixers, cleaning product containers, and dirty rags derived from obtaining printing films. Due to their characteristics, the residues are not usable waste and are deposited according to their classification based on their integrated solid waste management program.

-Printing: This is the main operational stage, starting with preparing raw materials according to the production order, the printing process, and the first quality control. The printing is carried out by the OMET machine on a substrate or support (polypropylene, polyethylene, or PCV) using fast-drying inks using UV technology which does not generate volatile compounds. One of the flexographic process characteristics is the issue of the range of colors or Pantone that meets the requirements of the order. In the proofing phase, up to 200 or 300 linear meters of a printed substrate can be wasted due to a color error, paper mismatch, or printer failure; therefore, it

is a complex operation that requires a lot of control and attention from the operators present. It was also identified that some waste is generated during the printing stage from cleaning the rollers and surplus ink, which are correctly classified as hazardous waste and stored in their respective areas under the provisions of the integrated solid waste management program in force. Table 1 resume the main information for this first stage.

Table 1: Time taken to print according to production order

Type of print	Order	Number of labels	Characteristics	Average time
Flexography	Bona ropa floral	15000	Width:83 Capacity 2 Repetition 4 M22 6500	4 – 6 h

-Finishing: In the flexo process, unlike the digital process, the OMET printing machine can print, laminate and die-cut at the same time, which optimizes transfers to other machines. The die-cutting process stands out for the finishing stage, which generates the most significant amount of waste known as discarded waste and glassine in the guillotining process, which is a potentially usable waste with the potential for transformation or reincorporation of its life cycle. This can be seen in detail in figure 1.

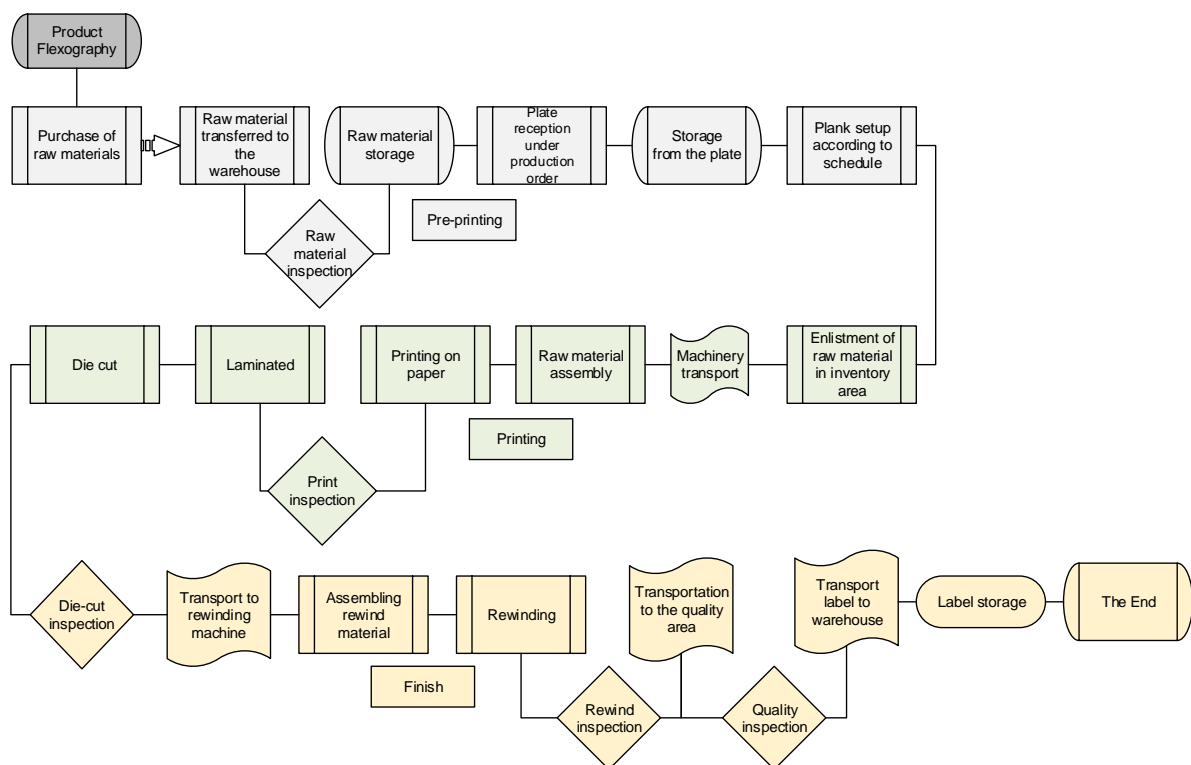


Figure 1: Flexographic process diagram

The central environmental aspect of flexo label printing is the energy consumption of all the equipment involved in the production, including OMET FX 330-2, OMET FX 330 -2, OMEGA, Rewinder FG40CP Slitter, Practic-Satur, Guillotine.

The high consumption is since they are high-powered machines with an average running time of 16 hours, the OMETs run 24 hours a day for six days a week, there are three flexo printers, and depending on demand, there are two running on average. The production order and its characteristics, such as different finishes, size determine which machines, materials, or additional inputs are needed to fulfill the order.

The following phases of the production process were considered for preparing the eco-balance: Pre-printing, printing, and finishing, over one year. As for pre-printing, this is divided into two unitary processes, image processing, and plate processing; the printing processes include the preparation of the order form, flexo printing,

and quality control; and concerning finishing, this is subdivided into the following processes: die-cutting, rewinding and quality control.

The inputs and outputs were identified to construct the balance sheet flow diagram shown in Figure 2. This diagram is a structured method for reporting the flow of inputs and outputs of resources, raw materials, energy, products, by-products and waste in a given organization and over a while.

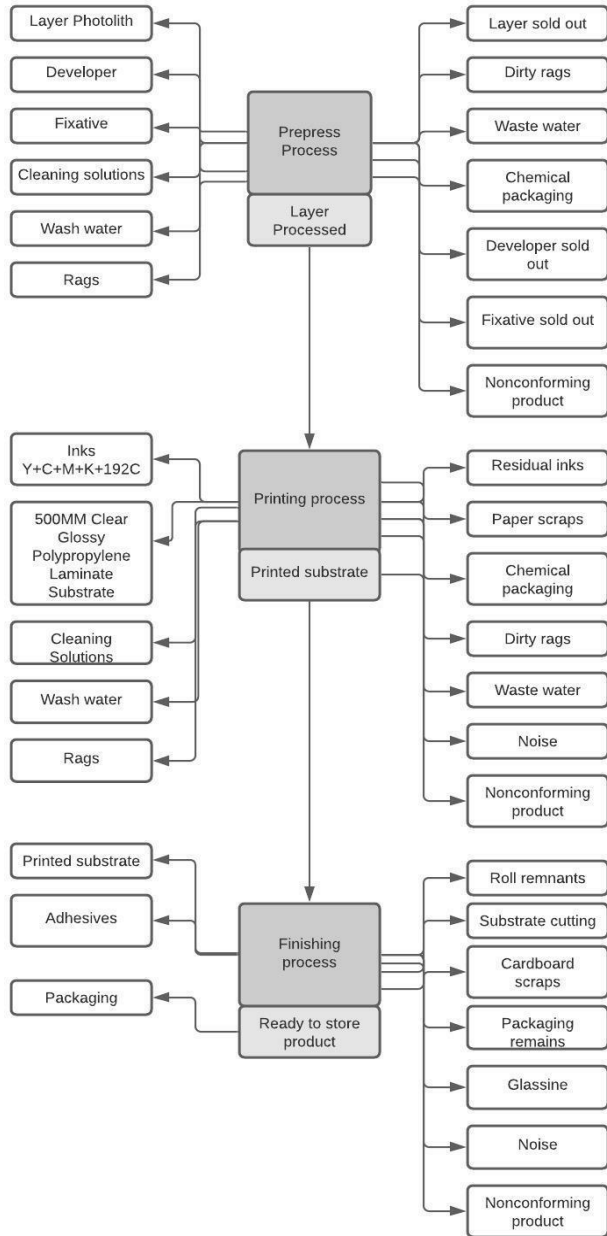


Figure 2. Flow diagram Sheet of Label Flexographic Printing Process

One of the tools used to detail the company's environmental profile in its production processes was the materials, energy, and waste matrix, which allows a qualitative diagnosis by crossing the stages of the life cycle of the company's printing processes concerning the environmental effects that occur at each stage.

Table 2 shows the materials, energy, and waste matrix of the flexographic printing process, in which the critical points that generate the most significant environmental impacts due to energy consumption or the generation of waste and toxic waste are determined.

Table 2: Materials, energy and waste matrix flexographic printing

STAGES	M	E	W
Procurement of raw materials	Renewable wood fiber (pulp) Vegetable oils Mineral oils Metals (Aluminum) Chemicals Inorganic salts		Kg of CO ₂ from the production of capital goods transport to plant.
Pre-printing	Art Design; Enamelled Paper Polypropylene, polyethylene, polyvinyl chloride and nitrocellulose, Varnishes, Polyester PVC.	Energy in the printing of the technical package	Paper waste (substrate), polymer waste.
Print	Anilox Moulds Cleaning Foil Aluminium Foil Inks Acetate Water, Developer, Fixative, THINNER Industrial Alcohol	Electrical energy consumption in printing No. hours x power Net energy used (kWh) Electrical energy consumption in printing (kWh)	Aluminium plate Used moulds Contaminated plastic packaging of inks and ink additives Contaminated metal containers of liquids and solvents Contaminated rags. Paper waste Noise
	Machine and equipment OMET unit of use in hours		
Finishing	Printed Substrate Adhesives Polyethylene in rolls CARDBOARD CORE net packaging use (Kg)	Electricity consumption in finishing	Finished Product Recyclable Waste Glasin Scrap -Paper -Plastic -Cardboard -Noise
	Machine and equipment OMET unit of use in hours		
Distribution	Land transport	CO ₂ from petrol production Fuel	Kg CO ₂ from transport

To produce 4170 linear meters of printed labels in 6.2 hours, the energy consumption of 4037.5 Kw/h is estimated. Used 4170 m of white polypropylene, 47 kg of inks, wypall, prime, and core, generating 260m of Descartone, 1.5 contaminated wypall, two inkjet containers, and 341m of Glassine.

4. Conclusions

The environmental impacts of the production of self-adhesive labels using flexographic and digital printing technologies were identified and evaluated in a manufacturing company in the graphic arts sector located in the city of Bogotá D.C., which is continuously improving its environmental performance. The results of this study contributed to its costs System, as well as to the decision-making process of senior management to achieve international certification standards, since the company has been working on its environmental aspects over the last few years (Aguilar & Costilla, 2018; Anampi, et al, 2018). With the application of cleaner production tools, the main environmental impacts of the flexographic printing processes were diagnosed, including the high

energy consumption required in the processes, the solid waste generated, especially waste contaminated by inks and solvents. It is necessary to complement this study in a later phase by carrying out an inventory analysis and the evaluation of environmental impacts using simulators, in order to find alternative solutions to the most significant environmental impacts in such a way that they are also sustainable for the company. Furthermore, it is recommended to integrate the results of this contribution with the company's integrated management system (Cárdenas et al., 2018) in order to achieve a positive impact on the company's strategy.

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