CHEMICAL ENGINEERING TRANSACTIONS
VOL. 67, 2018
A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet
Guest Editors: Valerio Cozzani, Bruno Fabiano, Davide Manca

ISBN 978-88-95608-64-8; **ISSN** 2283-9216
DOI: 10.3303/CET1867072

Application of Cleaner Production for Environmental Management in Mezcauchos SAS

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Mezcauchos S.A.S, is a medium-sized manufacturing company with negative environmental impacts in the production of rubber soles. As part of their corporate responsibility, it requires alternatives for an environmental management, through a cleaner production.
The environmental impacts are generated in the manufacturing process and are caused by many reasons: raw material waste, water expenditure for the drying process, strong odours in the injection and painting processes. The polyurethane waste is generated in different compositions, as well as the high rates of defective products that must be reprocessed, which brings with it a loss of time, high costs, and unnecessary material expenses, delay of the production process and decreases the profitability. In order to reduce these negative environmental impacts, were developed cleaner production tools that involves alternative solutions like the use of recycling water, the replacement of faucets and flushometers in bathrooms, the maintenance of pipes and connections to the hydraulic network. In addition, the company installed electronic ballasts (T8), 32 W lamps, a RYMEBUS inverter and, movement sensors in bathrooms and corridors. As recommendations that not are installed jet, were found that the company need to establish an appropriate route for the transport and separation of hazardous waste, the installation of containers for disposal, training the personnel for source separation practices. The purchase of a WINTECH injection machine is required to reduce the impact of noise. The internal rate of return (IRR) for the proposed alternatives is 26 % with an annual effective discount rate of 12 %.

1. Introduction

In order to improve the technologies and competitiveness in the footwear industry, considering sustainable development goals, companies require implementing cleaner production standards. For this reason, the present paper analyses the environmental impacts generated by Mezcauchos S.A.S. This is a small company dedicated to the manufacture of shoes and has 25 workers. Nowadays companies must establish internal politics, mechanisms and alternatives for the reduction of negative environmental impacts. (Fresner & Engelhardt, 2004). One of the most effective way to improve an environmental performance in industry is the design and implementation of cleaner production technologies and strategies, because they contribute to the conservation of natural resources, reduce the expenses in raw materials and manage solid residues (Villalón, 2010), creating well-being for consumers, workers, the environment and making companies more competitive.
On the other hand, according to the National Pollution Prevention Roundtable (NPPR) of the United States, (2013), the pollution prevention consists in the reduction or elimination of contamination from its point of origin instead of at the end of the tube. It means that the prevention of pollution occurs when raw materials, such as water, energy and other resources are used more efficiently in operations, protecting public health, growing the economy and conserving the environment (Panamá National Center for Cleaner Production, 2012).
The present paper proposes cleaner production implementation to improve and to control the current environmental problems. In the industry, the condition of sustainability implies the technological reconversion to turn the process most efficient (Fúquene, 2008). That is why cleaner production strategies are proposed for the implementation of eco-friendly processes, which generate a reduction in the environmental impact of products and processes (Espinosa, 2014)

Please cite this article as: Gracia J., Cepeda J., Lopez L., Acevedo P., 2018, Application of cleaner production for environmental management in mezcauchos sas, Chemical Engineering Transactions, 67, 427-432 DOI: 10.3303/CET1867072

2. Materials and method

The research was developed in three main stages: diagnosis stage, analysis stage, and proposal formulation. The diagnosis started with an initial environmental review. Were visited the company in many occasions and during the visits, were collected information using a checklist in order to evidence all the environmental issues in the different areas of the company. Through surveys to the personnel, were collected information such as the amount of materials used in the process, the process times, the temperature needed to make soles, the amount of waste produced and the costs associated with the manufacture of soles. With the information collected, it was possible to analyse environmental aspects of the process like energy consumption, water use, wastewater characterization, atmospheric emissions, the noise and the residues. All these aspects are related to the operation and maintenance of machinery and equipment necessary for the productive processes of the company. Likewise, were analysed the lay out and aspects of occupational health and safety.
In the second stage, the analysis phase, cleaner production tools were applied: flow analysis, ecomap, Material- Material-Energy-Waste matrix, ecobalance, inefficiency costs, critical points diagnosis and five-year financial analysis of solution alternatives (Van Hoof et al., 2008). Thanks to the application of all these cleaner production tools, were generated objectives and goals that helped to minimize or eliminate part of environmental negative impacts that the company was producing. Finally, in the last phase, were formulated improvement proposals that allow eco-efficiency and benefits for Mezcauchos S.A.S. (Torres, 2009).

3. Results and Analysis

By analyzing, the flow diagram of the process was possible to obtain a general vision of the raw materials using during the shoe soles transformation process (United Nations Organization for Industrial Development UNODC, 2009). The above served to identify the losses of each of the raw materials and inputs, which are required in each process. This process is fundamental for the analysis of environmental impacts generated in Mezcauchos S.A.S.
The main source of water spent in the company for the production of soles comes from the municipal aqueduct network. The main processes that use the water are the cooling molds, sanitary use, and locative cleaning, among others. The activity that consumes the most amount of water is the cooling process, as the company does not have the necessary mechanisms to avoid wasting water resources such as industrial refrigeration systems (Motawa et al, 2007) (Figure 1). Due to its age, the impact of the noise generated by the injection machine ORCA has analyzed since it generates an average intensity of 85 decibels.

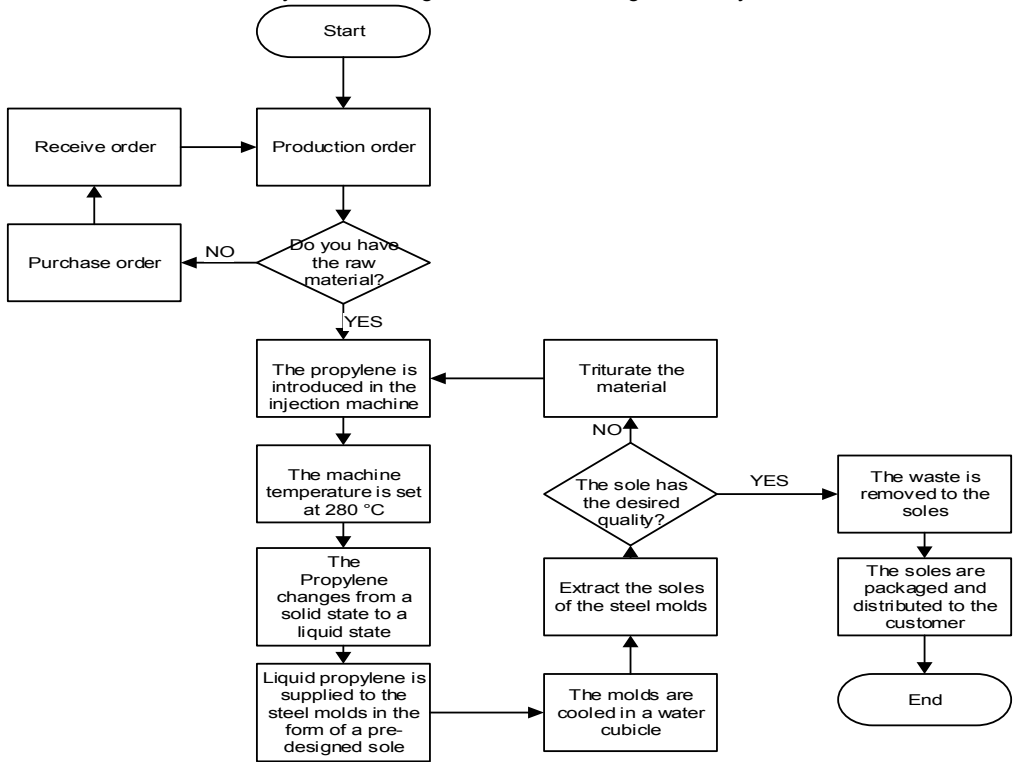

Figure 1: Process diagram of MEZCAUCHOS S.A.S

On the other hand, the company generates approximately fifteen kilograms per week of solid waste from the injection and cooling process. Two kilograms per month of cardboard boxes and plastic waste from the containers of chemicals used in the manufacture of soles. This generates storage costs. Given the above, it is necessary an association with recycling companies to implement some strategies to collect such waste. In order to find the global balance of all the processes and to take into account the complete life cycle of the products and services, an industrial ecology policy based on recycling and reuse is developed. (Madariaga, 2013).

To identify and locate the areas of critical points and of the high risk of contamination (Robayo, 2010), it was necessary to perform the Eco-map of Mezcauchos (Figure 2). The Lucidchart version 2.1 program helped to perform the map.

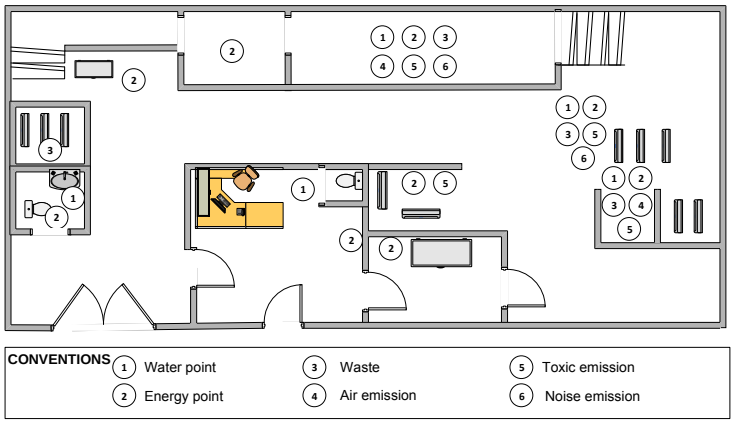

Figure 2: Eco-Map MEZCAUCHOS S.A.S

The inlet and outlet streams involved in the process were analyzed through an eco-balance (Table 1). The streams considered were raw materials, energy, finished products, sub-products, wastes and atmospheric emissions (Pardo, 2012).

Table 1: Eco-Balance MEZCAUCHOS S.A.S

Equipment	Inlet	Activity	Outlet	Environmental aspects
Injectors	Ground polypropylene spheres 12.5 gm	The injector is turned 180 degrees to start the process.	Liquid polypropylene	Odours
Orca	Liquid polypropylene	Molds filling with polypropylene.	150 filled mold with polypropylene.	Energy consumption 88 kWh/day
Orca	Water 11.87 m^3/day	Molds cooling using water.	150 soils from cooled molds filled with polypropylene. Water with some solids (11.87 m^3/day) Water pH 7.52	Wastewater and water loses.
Painting stage	150 soles Stabilizers (2 per day) Neutralizing (1 per day)	Polishing and painting of the soles	150 pairs of polished and painted soles.	Chemical contaminants. Energy consumption 15 kWh/day.
Sewing machine	150 pairs of soles almost finished.	Sew of soles by client request.	Finished product. 150 pairs of soles. 0.16 Kg of soles residues 10 boxes/ month. Plastic bags. Chemical recipients.	Residues.

The matrix with material, energy and wastes (Table 2) allowed to realize the life cycle assessment of the soles and to measure the environmental impacts generated during the process (Pardo, 2012). The direct relation of the effects generated by the environmental impacts caused by the manufacturing activities were determined (Van Hoof et.al, 2008).

Table 2: Matrix with material, energy and wastes from MEZCAUCHOS S.A.S

	Material type and quantity	Energy use	Wastes and emissions
Raw material	Polypropylene, 80 packs with 25 Kg. Stabilizer, 20 bottles of 3 L. Neutralizing, 15 bottles of 2 L. Dry agent: 30 bottles of 2 L.	5 gallons of fuel	10 Boxes Plastic bags. Plastic bottles.
Production	Liquid polypropylene and unpolished soles.	Electric energy 21000 kW/h Natural Gas 220.36 kW/h	Sole residues: 5 Kg Water: 2200 L
Distribution	Truck transportation: 2 trucks Packaging Packing	Fuel: 7 gallons	Combustion Gases Packaging residues Packing residues
Use	Protect the foot and prevent falls		Packing
End of live	Damaged sole	Fuel/incineration	Discarded soles to the land fill. Combustion gases.

Table 3 shows the process critical points and the proposed indicator to evaluate the cleaner production alternatives proposed for Mezcauchos S.A.S.

Table 3: Critical points in MEZCAUCHOS S.A.S

Process	Environmental critical point	Objectives	Indicator		Unit
Injection	Use of electric energy	Reduce consumption	Difference of consumption	(Actual consumption – Consumption before process changes)	m^3
	Noise	Decrease the noise level produced by the Orca machine	Noise level	(Noise level before changes – Noise level after changes)	dB
Cooling	Use of tap water	Reduce the consumption	Difference of consumption	(Water consumption before changes – Water consumption after changes)	m^3
	Electric energy use	Reduce electric energy consumption	Specific energy consumption	(Total energy consumption/ units produced)	kW/UP
Painting	Volatile compounds emissions	Reduce atmospheric emissions	Emissions to atmosphere.	(k of CO2, NOx, VOC, SO2 / Units produced)	k/UP
Wastes disposal	Wastes generation	Increase the recycled items	Rate of recycled items.	(Recycled items recycled in a time period / Quantity of residues generated along the process)	%
	Disposal of dangerous wastes	Management of dangerous residues produced along the process .	Rate of dangerous residues	(Quantity of dangerous residues produced in a time period / Quantity of dangerous items generated along the process)	%
			Rate of dangerous residues properly treated	(Quantity of dangerous residues properly treated in a time period / Total quantity of dangerous residues treated properly in a time period)	%

The cost analysis of the inefficiencies in Mezcauchos S.A.S., allows visualizing the money value and the resources spent in the Company during the productive sector (Solano & Vasquez, 2008). Using this tool, were evaluated in a qualitative way the environmental impacts of the manufacturing process of soles (Van Hoof & Herrera, 2007). The cost associated to the water consumption was the highest (593.5 m^3, COP$1537669 / month). The second major cost identified was the associated to energy use (2526 kWh, COP $995143 / month). The administrative area of the company consumes 278 kWh (COP$131426). Finally, the natural gas consumption quantified was 593.5 m^3 with cost associated COP$42400 / month. The summary costs associated to energy is COP$2706638. Respect to water, the areas with major expenses are injection and cooling, due to the nonexistence of mechanism to control the water waste. Therefore, it is necessary to find environmental mechanisms that reduce the high costs of services and recommend sustainable innovation. Cleaner production alternatives were formulated for the significant environmental aspects: For the energy component, replacement of T8 electronic ballasts and 32W lamps, achieving technological modernization and at the same time improving the visual quality of the workspace. In addition, the company must to install a RYMEBUS inverter, movement sensors and change the electric cables to reduce loses. In the injection and refrigeration processes, a corrective and preventive maintenance was made periodically to the machines and equipment, besides installing control and regulation devices of the electric power, to know the consumptions and to realize control. It is necessary to consider the replacement of old equipment to improve the efficiency of the entire process (Valencia et al., 2017). With the aim to reduce the water use, the cooling process was modified to include the reuse and recycling, for which it the company change the cooling cabin of the Orca fuel transfer, by a cooling tower that allows water to be recycled, to achieve a decrease of 5,935 m3 / month in water consumption and discharges. (Shi, et al 2008). In addition to studying the possibility of using rainwater for this process. Inspections must be carried out periodically to verify that there are no leaks in the pipes and tanks. It is also recommended, the replacement of taps and flushometers in the bathrooms of the company, to generate savings of 237.4 m^3 / month in the use of water for bathrooms and kitchen and finally, perform maintenance and monitoring of damage to the pipes and connections of the hydraulic network.

For hazardous solid waste, establish an appropriate route for the transport and separation of waste and installation of containers for disposal. Regarding noise, the purchase of a new WINTECH injection machine is required, to reduce occupational accidents and diseases, and increase production

4. Conclusions

By using cleaner production tools, it was possible to determine the initial environmental indicators in the by using cleaner production tools, it was possible to determine the initial environmental indicators in the production processes and in the product. Also with the use of these tools, were designed strategies and environmental systems that after the consideration of the management department were implemented in the company (Nunhes et al., 2016).

The production alternatives and cleaner technologies were formulated for the company Mezcauchos SAS, in order to increase its environmental performance, improve the production process, with a more efficient use of resources (Arroyave, 2007). The management approved the alternatives proposed because analysing the results obtained according to (Baca, 2005) the operating costs and the VPN give favourable numbers. The internal rate of return calculated is 26 %. All the alternatives designed follow the principles of sustainable and ecological consumption principles, ethical consumption and solidarity.

With the cleaner production program developed for Mezcauchos, the company have profitable alternatives and mechanism to give an optimal solution to the environmental problems. It is fundamental that Mezcauchos develops subprograms such as processes improvements, good operative practices, equipment maintenance, reuse, recycling, change of raw materials and technology changes, (United Nations Programs for the Environment UNEP, 1999), so that it will be at the forefront of the environmental and legal requirements established in Colombia.

Acknowledgments

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