

A Cleaner Production Exercise of A Leather Manufacturing Company: A Zimbabwean Experience

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Abstract:- In the leather sector different types of finished leather products are prepared from raw salted skins. About 130 different types of chemicals are used in leather manufacturing ranging from common salt (sodium chloride) to the very expensive chrome sulphate. The chrome tanning process is widely employed in many countries including tanneries in Zimbabwe. Many chemicals are used to prepare hides for tanning, and after use these chemicals find their way into the environment. All three categories of waste, i.e. gaseous, liquid and solid are generated from the tanneries.

This paper seeks to address the environmental pollution problems at a leather manufacturing company in Zimbabwe. An essential part of such a new approach is the concept of Cleaner Production (CP), an integrated preventative strategy aimed at minimising waste and improving the efficiency of processes, products and services. Raw salted skins are mainly used in Zimbabwe and these result in many salts finding their way in the tanneries effluent. This research was therefore mainly concerned with salt reduction in the effluents by incorporating a chilling unit to the tannery though they are many Cleaner Production options in the leather manufacturing industry.

Index Terms:- Cleaner Production, leather, tannery processes, pollutants, chilling.

1 INTRODUCTION

Over the past years many manufacturing companies were mainly focused on treatment of pollution once it has been released from a process (end of pipe) rather than on pollution prevention an approach that offers a lower cost means of attaining compliance. Though governments of different countries try to minimize pollution by imposing stiff penalties to the manufacturing industries that produce much waste, they still give room for the companies to continue polluting the environment to a certain extent due to disposal permits issued. So by implementing cleaner production especially in the tannery sector to tackle pollution and waste problems, the dependence on 'end-of-pipe' solutions may be reduced or in some cases, eliminated altogether. However, notwithstanding the growing recognition of the importance and benefits of Cleaner Production, there still remains great scope to improve the level of awareness, understanding and implementation of the concept throughout Southern Africa.

Cleaner Production is defined as the continuous application of an integrated preventive environmental strategy applied to processes, products and services to increase overall efficiency and reduce risks to humans and the environment (United Nations Environment Programme, UNEP).

- ✓ For production processes, Cleaner Production involves the conservation of raw materials and energy, the elimination of toxic raw materials, and the reduction in the quantities and toxicity of wastes and emissions.
- ✓ For product development and design, Cleaner Production involves the reduction of negative impacts throughout the life cycle of the product: from raw material extraction to ultimate disposal.
- ✓ For service industries, Cleaner Production involves the incorporation of environmental considerations into the design and delivery of services.

The key difference between pollution control and Cleaner Production is one of timing. Pollution control is an after-the-event, 'react and treat' approach, whereas Cleaner Production reflects a proactive, 'anticipate and prevent' philosophy. Stakeholders within Cleaner Production include both internal and external players (Beverley, 1999). A Cleaner Production Pre-assessment report is submitted to the management, highlighting areas of focus for the full CP Assessment, which would then be addressed in the full CP report (Noyes, 1997).

2. WHY CLEANER PRODUCTION?

Investing in Cleaner Production, to prevent pollution and reduce resource consumption is more cost effective than continuing to rely on increasingly expensive 'end-of-pipe' solutions. The environmental benefits of Cleaner Production can be translated into market opportunities for 'greener' products. Companies that factor environmental considerations into the design stage of a product will be well placed to benefit from the marketing advantages of any future eco-labeling schemes. The economic pressures that affect a company is to produce more so as to remain competitive. The company is much more worried by increasing its productivity rather than controlling its pollution as this consume a lot especially here in

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Zimbabwe where it is more expensive to have the waste away company to collect sludge from the effluent plants. But due to increased production also waste is increased or pollution is increased also. The company will have to produce a stated level of pollution for them to remain in business but due to poor, old processes and technology being used in companies more pollutants are produced being produced. Also due to shortage of raw materials companies opt for cheap available material that are contribute to damage the environment. If a company is also practicing poor methods of production it also results in the company facing the challenges of having to implement new methods so that the plant will always be available. Most companies concentrate on running the plant without considering the maintenance of the equipment until it breaks down that when equipment is poorly maintained it result also in polluting the environment. The company also faces the green pressure of having to use new methods of manufacturing which environmental friendly for the company to remain competitive on the market and also to be a world class manufacturing organization.

2.1 Objectives of study

- To develop a framework for the implementation of cleaner production at Leather Company processing industry.
- To achieve economic savings for industry as well as an improved environment for society.
- To lower production cost with the more efficient use of energy and raw materials.
- To increases staff motivation by relying on active worker participation in idea generation and implementation.

3. RESEARCH JUSTIFICATION

Investing in Cleaner Production, to prevent pollution and reduce resource consumption is more cost effective than continuing to rely on increasingly expensive 'end-of-pipe' solutions. The environmental benefits of Cleaner Production can be translated into market opportunities for 'greener' products. Companies that factor environmental considerations into the design stage of a product will be well placed to benefit from the marketing advantages of any future eco-labeling schemes. The economic pressure that affects a company is to produce more so as to remain competitive. The company is much more worried by increasing its productivity rather than controlling its pollution as this consume a lot especially in Zimbabwe where it is more expensive to have the waste away company to collect sludge from the processing companies. But due to increased production waste and pollution are increased also. The company will have to produce a stated level of pollution for them to remain in business but due to poor, old processes and technology being used in companies more pollutants are being produced. Also due to shortage of raw materials companies opt for cheap available material that damages the environment. If a company is also practicing poor methods of production it also results in the company facing the challenges of having to implement new methods so that the plant will always be available. Most companies concentrate on running the plant without considering the maintenance of the equipment until it breaks down often resulting in polluting the environment. The company also faces the green pressure of having to use new methods of manufacturing which environmental friendly for the company

to remain competitive on the market and also to become a world class manufacturing organization.

4. TANNERY PROCESSES

Leather manufacturing involves following major steps:

- Pre-Process
- Pre-Tanning Process
- Tanning Processes
- Wet Finishing Process
- Dry Machining
- Finishing

In pre-processing skins/hides are received and salt is applied on the flesh side of the skins/hides. Skin trimming is done to remove unwanted parts. After pre-processing, pre-tanning process starts with the soaking process in which skin are made flaccid by soaking them in water. After soaking hair are removed, lime is used to make hair loose. Unwanted flesh is removed with the help of fleshing machines after liming process. To prepare limed skin for tanning, the skins are delimed using Ammonium Sulphate and then skins are washed. Bating is done for further purification of hide. After that degreasing is done with the help of detergents. Tanning process starts with pickling which is the treatment of skin with acids and salts to bring it to desired level of pH. Tanning may be defined as the treatment of skin for preservation. Chrome tanning uses Chromium Sulphate as tanning agent. Tanning processes stabilize the collagen network of skin. After tanning skins are called wet blue and are stored for sometime and then they are sorted out according to quality. If hides of cows or buffaloes are being used for leather manufacturing, then after this they are sliced to give desired thickness. This process is not carried out on the skins of goats or sheep. After this the hair sides of the wet blue are shaved to give the desired thickness. In order to give desired softness, color, strength, and quality to the leather wet blue skins are processed further through wet finishing process. Fat liquoring process is carried out to impart desired softness and dyeing is to give it a color. After wet process different drying processes are carried out to dry the processed leather. These processes consist of smaying/setting, vacuum drying, stacking/toggling, buffing/shaving, trimming, pressing, and segregation of the leather. Finally finishing processes are carried out to impart durability and beauty to the leather. The chemicals used in the leather industry can be divided into three broad categories:

- Pre-tanning Chemicals
- Tanning Chemicals
- Finishing Chemicals

Pre-tanning chemicals are used to clean and prepare skins for the tanning process and they are mostly washed away with the wastewater. Tanning chemicals react with the collagen fibers of the skin to convert them into leather. These chemicals are retained in the skin but a good amount of these is discharged into wastewater. Chrome Sulphate is the basic tanning chemical. Apart from being expensive, Chrome Sulphate is

also a serious pollutant. Finishing chemicals are used to impart certain properties to the leather like softness, color, appearance etc. Like tanning chemicals finishing chemical also get discharged into wastewater. Only those chemicals are fully retained which are applied as surface coating. A large amount of water is used in whole manufacturing process. The collected data shows 50-150 liter water is used for conversion of one kg of raw skin into leather. In tanning process water is used as carrier to facilitate different chemical reactions and after completion of process the water leaves the system as wastewater in the same quantity as added to the system.

5. POLLUTANTS

All the three categories of waste solid, liquid, and gaseous, are emitted by the leather industry in the form of:

1. Wastewater
2. Solid Wastes
3. Air Emissions

Water is used as the carrier for chemicals to render the cleaning of raw hides and skins. The water after completion of the process is drained out in the same quantity as it was used in the process. Normally water consumption of 50 liter/kg is recommended for tanneries but it is found that tanneries generally consume more water and in some cases it is found to be as high as 150 liter/kg. Samples of water were taken from different processes of leather manufacturing and were analyzed. Tannery wastewater is highly polluted in terms of biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids, total Kjeldhal Nitrogen, conductivity, Sulphate, Sulphide, and Chromium. The major solid wastes consist of dusted curing salt, wet trimmings, dry trimmings, wet shaving, buffing, etc. These wastes are generally separated at the source. During handling of raw skins, adhered dusted salt, which is contaminated with blood, hair, dirt and certain type of bacteria is removed and dumped. Trimmings are cuttings of edges of raw skins. Fleshing is the flesh material of the limed skins generated during fleshing operation. Chrome wet shaving is produced when skins are shaved for proper thickness after chrome tanning. In tanneries air emissions are produced from the stacks of boilers and generators and during the processing of leather. Emissions from the stacks are well within the limits and pose no serious environmental impact. But hydrogen sulphide and ammonia gases which are emitted during different processes are a health hazard for the workers. According to the research done on the case study in Zimbabwe on superior Holdings which is leather manufacturing company, it mainly uses salted hides and these salts also find their way into the effluent and environment.

Table 1 Wastewater from the effluent of the company

Sam ple	Tempe rature <45°C	pH (6.5- 9)	Chlori de <500m g/l	Sulph ates <1000	Settleabl e solids <10cc/l	Cr ³ +	COD <300 0
A	23	7,7	235	290	4	-	2110
B	22	7,9	240	375	4.2	-	2180

Leather processing requires extensive use of chemicals to treat and soften hides. These chemicals are present in the firm's wastewater and can contaminate community water sources. When chemicals are improperly or inefficiently used in production, costs rise and pollution increases. More efficient chemical use can both lower production costs and reduce pollution. Leather processing uses large amount of toxic and environmentally dangerous chemicals. According to cleaner production concept that there should be reduction of raw material consumption in order to maximise efficiency and reduce risk to the humans and the environment, the company have to reduce the amount of salt. For four months when the research was undertaken, the company used more than 24019 kgs of salt.

6. REDUCTION OF SALTS

Cleaner Production involves the conservation of raw materials and energy, the elimination of toxic raw materials, and the reduction in the quantities and toxicity of wastes and emissions. Environmental problems can be avoided by replacing hazardous materials with more environmentally benign materials. To deal with the problem of sulphates and chlorides found in the effluent waste the company should install a chiller unit to reduce the amount of salt used in the tannery. Salt reduction: 40-50% salt on hide weight. For 1 tonne hide, it is possible that 500 kg less salt is used and discharged and disposed of as solid waste. For skins the salt savings are up to 80% salt on skin weight.

6.1 Evaluating CP Options

Table 2 Evaluating CP Options using weighted sum method

Evaluation criteria	weight	Chiller unit		housekeeping		Reuse/recycle		Rinsing Techniques		Management & Training	
		Score	sum	Score	sum	Score	sum	Score	sum	Score	sum
Reduction in hazardous waste treatment	3	3	9	0	0	3	9	1	3	2	6
Reduce expenses for waste water treatment	2	3	6	1	2	2	4	1	2	2	4
Reduce exposure to chemicals at work place	1			1	1	0	0	0	0	1	1
Reduce amount of water consumption	3	1	3	1	3	3	9	3	9	1	3
Reduce odor problems	3	3	9	2	6	0	0	0	0	0	0
Reduce noise problems	1	0	0	0	0	0	0	0	0	0	0
Reduce amount of solid waste	3	3	9	1	3	2	6	0	0	2	6
Weighted sum		3	6	1	5	2	8	14		2	0

Key: 0=no change, 3= highest rank(preferred)

From the above evaluation, substitution of salts with a chiller, followed by reuse/recycle and the management and training have the highest scores of the CP options focused upon. These were also prioritized in the next chapter. These options may require changes to process equipment. Superior Holdings always had to use clean water to maintain its operations instead of using recycling or reusing its waste water. Also due to the presents of sulphates in the waste water and other compounds it means the maintenance of the effluent plant was expensive. The COD of the effluent needs to be reduced to reduce expenses of maintaining the effluent plant. From the assessment section, the options were mainly on chemicals, production process, housekeeping that were identified for resources and product losses (emissions, wastewater and solid waste). These were also identified for Cleaner Production improvement opportunities, chemicals contribute to waste found in the effluent. These include sulphates, chlorides and chromium 111 compounds.

7. THE ECONOMIC BENEFITS OF IMPLEMENTED OPTIONS

7.1 Costing Of the Project

Table 3 costing of the chiller unit

item description	Total cost in Indian Rupees	Total cost USD
Blast chiller plus chilled storage (5 tonnes hide)	1345000	30076.02
Tannery chilled storage (10 tonnes hide)	600000	13416.81
Total	1945000	43492.83

Quotation from EAKCON Systems (Chiller Engineers), India. If the company runs the pre-tanning process for 15 days per month the payback period was calculated to be 38 months considering savings from salt and water: Furthermore, chilling of hides and skins can replace salting and will greatly reduce TDS in tannery effluents and the problem of disposing of evaporated salt. Hides and skins are not salted before tanning but are chilled to preserve them for up to a week during transportation and storage. This eliminates the cost of salting and the environmental problems associated with the salt. There must be no deterioration in the raw material. If hides and skins are available in large numbers in a region within a relatively short drive from a tanning centre, chilling should be feasible. Once chilling of hides is established at Leather Company, refrigerated transport would enable transport over long distances. As soon as the skin is removed from the animal it is susceptible to bacterial degradation, and the rate of degradation increases with temperature. Therefore hides and skins must be brought to a chiller within a few hours of slaughter.

The main advantages of chilling are:

- No pollution.
- Salt reduction: 40-50% salt on hide weight. For 1 tonne hide, it is possible that 500 kg less salt is used and discharged and disposed of as solid waste. For skins the salt savings are up to 80% salt on skin weight.
- Suitable for all hides and skins
- No contamination of by-products with salt
- Hides and skins can be quickly chilled in a blast chiller
- Hides and skins are good insulators and after chilling only warm up slowly

The advantage of these developments is that salt use and effluent salinity can be reduced and the problem of recovered salt can be greatly reduced. Cleaner processes are better than end-of-pipe treatments.

8 AREAS OF FURTHER STUDY IN THE TANNERY INDUSTRY.

- **Construction of screen grit chamber in Zimbabwe tanneries**

To trap the solid waste and sludge in the tannery effluents before discharge from the tanneries, grit chambers are a necessary clean production practice. The grit chambers constructed in the tanneries help to reduce the pollution load in tannery effluents.

- **Solid waste management system in Zimbabwe**

Solid waste is a big problem for tanneries anywhere in the world. Changing attitudes and limited availability of disposal options are further deteriorating the situation.

- **Products and markets**

Develop methods to encourage concurrent engineering partnerships within the leather manufacturing industry. To apply CP to suppliers of leather chemicals so as to minimize pollution at source.

- **Technology**

Development of a practical database of clean technologies for the leather industry. Development of networks of experts on clean technology for the leather industry

10. CONCLUSION

There are many opportunities within the leather industry for the promoting of cleaner production technology. When Cleaner Production and pollution control options are carefully evaluated and compared, the Cleaner Production options are often more cost effective overall. The initial investment for Cleaner Production options and for installing pollution control technologies may be similar, but the ongoing costs of pollution control will generally be greater than for Cleaner Production. Furthermore, the Cleaner Production option will generate savings through reduced costs for raw materials, energy, waste treatment and regulatory compliance. With installation of the chilling unit the advantage of the developments is that salt use and effluent salinity can be reduced and the problem of recovered salt can be greatly reduced. Cleaner processes are better than end-of-pipe treatments. Several cleaner production opportunities are available for tannery industry and these differ from place to place and are affected by socio-economic environment.

REFERENCES

- [1] Beverley T, Citizen's Guide To Clean Production, April 1999
- [2] Hunt CB, Auster ER (1990). Proactive environmental management: avoiding the toxic trap. MIT Sloan Manage. Rev., 31(2): 7-18.
- [3] Noyes R, Pollution Prevention Technology, E and FN Spon Publ. Co.,1997
- [4] Richards DJ, Frosch RA (1997). The industrial green game: overview as perspectives. In: RICHARDS, D.J. (org.). The industrial green game: implications for

environmental design and management. Washington: National Academy Press. (Eds.)

- [5] Stone LJ (2000). When case studies are not enough: the influence of corporate culture and employee attitudes on the success of cleaner production initiatives. J. Cleaner Prod., 8: 353-359. "Tanning and Leather Finishing" (1998). In Pollution Prevention and Abatement Handbook. Washington, D.C.: World Bank.
- [6] UNEP (2001). United Nations Environmental Program, Cleaner Production Homepage. Division of Technology, Industry and Economics, Production and Consumption Unit. The Electronic Farmer <http://www.uneptie.org> last accessed March 2011.