POLLUTANTS MINIMISATION AND INNOVATIVE MONITORING TECHNIQUES TOWARD A SUSTAINABLE LEATHER INDUSTRY

ADRIAN-BOGDAN HANCHEVICI[1, 2], LUMINITA ALBU[1], GABRIELA MACOVESCU[1], GHEORGHE COARA[1], ELENA BUCUR[3], MARIANA POPESCU[4]

[1] *INCDTP – Division: Leather and Footwear Research Institute, 93 Ion Minulescu, Bucharest, Romania, e-mails: icpi@icpi.ro; bogdan.hanchevici@icpi.ro*

[2] *"Politehnica" University of Bucharest, Faculty of Automatic Control and Computers, Bucharest, Romania, e-mail: bogdan.hanchevici@acse.pub.ro*

[3] *National Research and Development Institute for Industrial Ecology, Bucharest, Romania, e-mail: ecoind@incdecoind.ro*

[4] *SC PIELOREX SA, Jilava, Ilfov, Romania, e-mail: pielorexsa@yahoo.com*

Sustainable development is a deep-seated value of the EU and encompasses issues of great importance to citizens, whether it be maintaining and increasing long-term prosperity, addressing climate change or working towards a safe, healthy and socially inclusive society. It is an overarching objective of the EU set out in the Treaty, governing all the Union's policies and activities. It aims at the continuous improvement of the quality of life and well-being on Earth for present and future generations. It promotes a dynamic economy with full employment and a high level of education, health protection, social and territorial cohesion and environmental protection, in a secure world, respecting cultural diversity as set out by Brundtland in 1987. Leather production fulfils a fundamental role in our society. It recovers the hides and skins resulting from the production of meat (for human consumption) and transforms them into a noble material that finds applications in a myriad of consumer goods. It thus prevents a difficult waste disposal problem and contributes with a useful and appealing material to our modern lifestyle, generating wealth and employment. Leather industry is, however, an environmentally intensive activity that can carry adverse effects to water, air and soil if the plant does not apply pollution prevention techniques. The new innovative technological & monitoring system for pollutants minimization, presented in the paper, will catalytically act for: improving the quality of the working environment, reducing/eliminating the pollutants, facilitating the implementation of the EMS and eco-labeling in the Romanian leather sector, contributing directly to its competitiveness and sustainable development.

Keywords: tanning & footwear industry, monitoring system, emissions, sustainable production

INTRODUCTION

Leather processing is one of the mankind's oldest occupations in the world. The tanning industry provides a high added value material to a number of value chains, notably in the fashion, furniture and automotive sectors.

The raw materials of the European tanning industry are hides and skins of which over 99% are derived from animals that have been raised primarily for milk, meat or wool production. This is revealing one more the important ecological role of tanneries: they recover a by-product (a food industry's waste which in the absence of the leather industry would have to be disposed of) transforming into a wonderful and spectacular material that all of us find in everyday goods which make our lives better and beautiful.

In Romania, the leather and footwear industry has a long tradition and many historical records.

In 2013, the leather sector (Tanneries and footwear companies) accounts for the following shares of Romania's macroeconomic indicators.

Table 1. Indicators of the Romanian leather & footwear industry

Indicators	Leather & Footwear industry
% of Romanian GDP	0,85
% of Romanian industrial production	1,34
% of Romanian exports	2,85
% of Romanian imports	2,14
% of Romania's industrial employment;	3,86
Number of companies	about 1900

Source: Ministry of Economy, Romania

While being a final product for tanneries, leather represents a "raw" material for other industries such as: footwear (about 62%), clothes (about 24%), leather goods (about 12%), upholstery and automotive leathers (about 2%) (Figure 1).

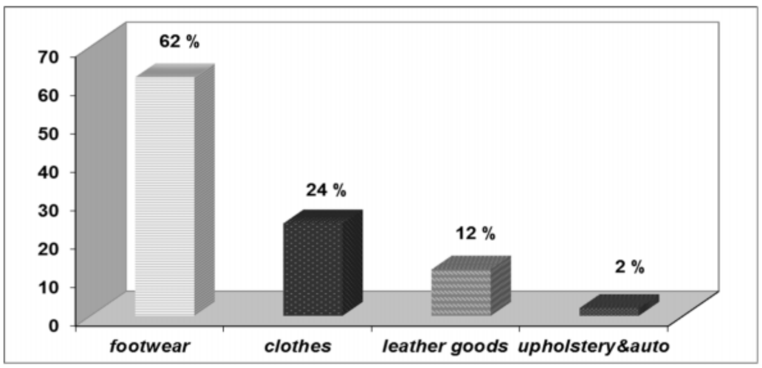

Figure 1. Leather destinations

In our days, the sustainability of production processes, both in tanning and footwear sectors, became a key factor in companies' competitiveness and general economic growth. So, for each company it's increasingly important to obtain certifications, according to the specific standards, for their performance in quality, environment and ocupational health & safety. In recent years a public awareness is also represented by the energy efficiency improving and CO_2 emissions reducing (COTANCE, 2012).

Romanian tanning and footwear companies have the same goals and concerns regarding their production sustainability.

EXPERIMENTAL

Having in view all these considerations, the general objective of the research is the development of an innovative minimization concept and of an integrated, computer aided-monitoring system for pollutants to aid a sustainable production in the leather industry. The major scientific and technical objectives were: (i) identification of the significant environmental aspects for each activity by monitoring emitted pollutants; (ii) identification of new ecological techniques for minimizing pollutants in leather manufacturing process and implementation of an innovative monitoring system; (iii) optimization of pollutant control/analysis methods by designing and implementation of an innovative monitoring system.

In order to prevent, reduce and as far as possible eliminate pollution arising from industrial activities in compliance with the ‘polluter pays’ principle and the principle of pollution prevention, it is necessary to establish a general framework for the control of the main industrial activities, giving priority to intervention at source, ensuring prudent management of natural resources and taking into account, when necessary, the economic situation and specific local characteristics of the place in which the industrial activity is taking place.

Hide processing results in environmental pollutants which are toxic to both human health and the environment and need to be carefully and closely monitored.

The leather making process is the transfer of a 100 % renewable ressource to a highly valuable and toxicological safe substrate:

- ✓ In fact, leather manufacturing is part of a big recycling industry and solves a huge waste problem of the meat industry;
- ✓ Leather can be made without sustainable damage of the environment if best available technologies are followed. (2010/75/EU Directive IPPC, 2010)

The tannery operation consists of converting the raw hide or skin, a highly putrescible material, into leather, a stable material, which can be used in the manufacture of a wide range of products. A significant amount and variety of chemicals and specific products are used in the processes. The whole process involves a sequence of complex chemical reactions and mechanical processes. Amongst these, tanning is the fundamental stage, which gives leather its stability and essential character.

The tanning industry is a potentially pollution-intensive industry. The environmental effects that have to be taken into account comprise not merely the load and concentration of the classic pollutants, but also the use of certain chemicals: e.g., biocides, surfactants and organic solvents.

Environmental issues associated with tanning sector include the following: waste-water, air emissions, solid wastes and hazardous materials.

Due to the wide versatility of tanneries, both in terms of the types of hides and skins used and the range of products manufactured, the reported emission and consumption levels are generally indicative. The environmental impacts of tanneries originate from liquid, solid and gaseous waste streams and from the consumption of raw materials such as raw hides, energy, chemicals and water. The main releases to waste water originate from wet processing in the beamhouse, the tanyard, and the post-tanning operations. The main releases to air are due to the dry-finishing processes (Albu, 2005).

For footwear and leather goods companies the most important ecological issues are: air emissions, solid wastes and hazardous materials.

In order to establish the initial environmental impact of the most important environmental factors from a tannery (SC PIELOREX SA, Jilava, Ilfov), a footwear & leather goods company (SC MUSETTE SRL) have been monitored. The levels of emission analytically determined are presented in the following graphs and tables.

In tannery the hydrogen sulphide and ammonia levels were monitored for 18 hours into the beamhouse & tanyard workshop (Figure 2) and in wet finishing (post-tanning) area the ammonia emissions were registered for 24 hours (Figure 3).

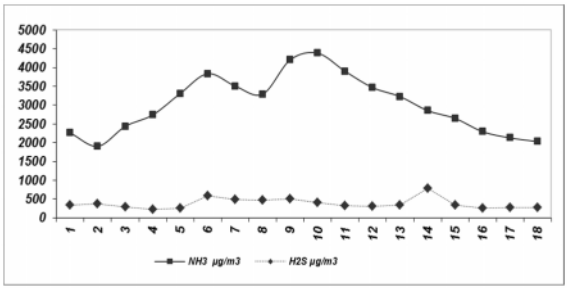

Figure 2. Emissions in beamhouse & tanyard workshop

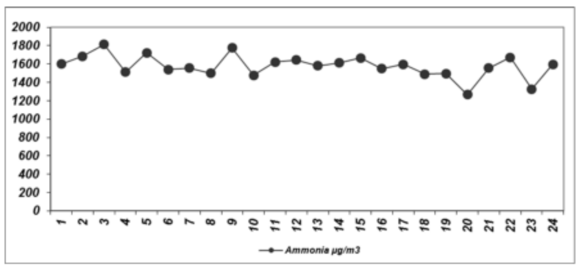

Figure 3. Emissions in wet finishing workshop

For finishing operations buffing dust and volatile organic compounds (VOCs) were measured (Table 2).

Table 2. Emissions in finishing workshop

Operation	Measurement point	Dust	VOCs as total organic Carbon
Buffing	Buffing equipment	2083 µg/mc; 845 µg/mc	-
	Exhaust cart from buffing	42.6mg/Nmc	-
	Entrance on finishing spraying line		7.1 mgC/Nmc
Surface finishing	Exit from finishing spraying line		6.9 mgC/Nmc
	Environment area of finishing spraying line		2.5 mgC/Nmc

The tannery waste waters and the characteristics for each operation and for final treated effluent were registered too.

For footwear and leather goods company the emissions measured – dust and VOCs - are presented in Table 3.

Table 3. Emissions in footwear & leather goods company

Measurement point	Dust	VOCs as total organic Carbon
Stitching area	-	450 mgC/Nmc
Lasting & Finishing	0.32 mg/mc	420 mgC/Nmc
Spraying cabin for adhesives	-	250 mgC/Nmc
Bonding area	-	450 mgC/Nmc

RESULTS AND DISCUSSION

The quantity of air emissions depend on the substance used in each industrial process (EPA, 1993). The purpose of the developed process is to minimize the quantity of emissions driven into the atmosphere in order to respect both environmental restrictions and occupational health and safety.

Having in view the emissions identified and measured in tanning and footwear & leather goods companies an intelligent system have been designed, patented and the prototype implemented.

Other monitoring systems (Filip, *et al.*, 2007; Moldovan, *et al.*, 2009; Clotan-Turcu, 2003) were studied and a series of disadvantages were identified: (i) the coupling of sensors to a single microcontroller, if it fails or needs to be replaced, then the whole system stops working; (ii) high difficulty in introducing a new sensor in the system this being caused by the fact that a single microcontroller can be interfaced with a limited number of sensors.

The problem solved by the new intelligent system is monitoring levels of toxic emissions resulting from industrial processing and alarming the workers when the pollutants exceed limits.

The proposed monitoring system (Figure 4) is made using sensitive specific sensors for the desired monitored pollutants. Each sensor (S) is connected to a data acquisition board (PA), which has included a microcontroller (uC). The microcontroller collects data from the sensors and, by using the industrial Ethernet communication network (CE), transmits it to the process computer (CP) which runs a software application (AS) in order to saving to the database (BD) and visualizing the acquired data. The microcontroller is connected to one acoustic alarm system (A). The alarm system is activated automatically when the toxic emission exceeds the maximum allowed values.

The new intelligent monitoring system has the following advantages:

- The system can operate with an unlimited number of sensors;
- Specific sensors can be added for other pollutants;
- Any time you can remove/add sensors as they operate independently of each other;
- The software application which runs on the process computer is modularized so that changes which should be made when a sensor is removed/added to system are minimal;
- Sensors and related acquisition boards are directly connected to AC power, ensuring continuous operation and continuous monitoring;
- Connection between modules (acquisition boards, computer process switches) is made by using UTP cable (not wireless). So, the effect of disruptive industrial environment on communications is minimized and the communication security is improved (no user from outside the company can intercept/decrypt data packets).

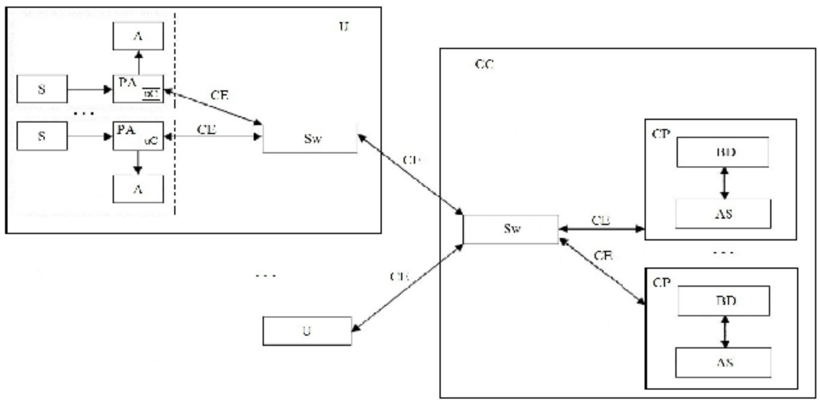

Figure 4. The basic structure of the intelligent monitoring system

Research work will continue in order to implement such intelligent monitoring systems in all companies participating in the project and to develop the systems by adding new sensors according to the specific activities and emissions.

In the same time good practice and eco-friendly technological solutions will be identified and implemented in the production processes (mainly in tanning sector), in order to minimize the ecological impact.

CONCLUSIONS

The monitoring system is intended to be a real-time one, in order to signal out any exceeding of the imposed limits.

The new innovative complex (technological & monitoring) system resulted will catalytically act for improving the quality of the working environment, reducing/ eliminating the pollutants, facilitating the implementation of the environmental management systems (EMS) and eco-labeling in the Romanian leather sector, contributing directly to its competitiveness and sustainable development.

Acknowledgements

This work was financially supported by MEN-UEFISCDI, in the frame of Romanian PN II-Partnership - Joint Applied Research Projects Program - Contract No. 56/2012.

REFERENCES

Albu, L., Mirciu, V., Bratulescu, V. (2005), The practical reality in Romanian tanneries, *Leather International Journal*, August/September, pg. 18, ISSN 1473-6314.
Clotan-Turcu, V.P. (2003), Patent RO120831B1.
COTANCE (2012), Social and Environmental Report the European leather industry, http://www.euroleather.com/socialreporting/.
EPA (1993), "Air emissions &control technology for leather tanning and finishing operations".
Filip, G., Pal, A. (2007), Patent RO122960B1.
Moldovan, A.S., Ersen S., Dane, I., Ravdan, R., Deciu, G.C. (2009), Patent RO125131B1.