

VII.RECOMMENDATIONS

- ❖ Energy and waste management systems are cost-effective and should be implemented in different industries.
- ❖ Employee's awareness should be included as a key factor in the success of any energy or waste management systems.
- ❖ Applying a scheduled preventive maintenance of process machinery is recommended, in order to minimize forced shut downs in production line that affects overall efficiency.
- ❖ Acidification, eutrophication and respiratory potentials due to the release of air emission from printing, dyeing, chemicals handling and boilers emissions can be minimized by using non-volatile chemicals, optimizing boiler operations and reducing the use of solvents.
- ❖ It is preferable to use incineration as a handling method for hazardous solid waste as it has less impact on human health, and ecosystem quality.
- ❖ State of the art incinerator or landfill should be used for hazardous solid treatment even if they are more cost expensive, in order to mitigate negative environmental impacts.
- ❖ It is recommended to minimize the usage of inorganic pigments and use organic ecofriendly dyes in acrylic fiber manufacturing to reduce the ecotoxicity and carcinogenic potential of generated wastes.
- ❖ LCA methodology should be an integrated part of environmental management system to ensure sustainability and better quality of life.
- ❖ It is recommended to use LCA software and develop new ones to ease the procedure and have it done more precisely.
- ❖ Further investigations are required for usage of energy from industrial wastes as renewable energy sources.
- ❖ Acrylic fiber industry is a high energy consumer; it is recommended to minimize energy requirements and use other energy sources in the different process in order to reduce both energy consumption and environmental impact of the industry.

VIII. REFERENCES

- AFCO-EIA, (2007). Environmental impact assessment for acrylic fibers plant extension: ENVIRO-INFO consultants. Alexandria, Egypt.
- Alonso, J.A., and Camargo, A. (2006). Ecological and toxicological effects of inorganic nitrogen pollution in aquatic ecosystems: A global assessment. *Environment International*, 32(2006), 831–849.
- Anderson, S.T., and Newell, R.G. (2004). Information programs for technology adoption: the case of energy-efficiency audits. *Resource and Energy Economics*, 21(1), 27–50.
- Arena, U., Mastellone, M.L, and Perugini, F. (2003). The environmental performance of alternative solid waste management options: a life cycle assessment study. *Chemical Engineering Journal*, 96(1-3), 207-222.
- Assamoi, B., and Lawryshyn, Y. (2012). The environmental comparison of landfilling vs. incineration of MSW accounting for waste diversion. *J. Waste Management*, 32(1), 1019-1030
- Austrian Energy Agency (2007). Step by step guidance for the implementation of energy management. Benchmarking and Energy Management Schemes in SMEs Project of Intelligent. Austria.
- Azapagic, A., Emsley, A., and Hamerton, I. (2003). *Polymers, the environment and sustainable development*. Wiley Publications, New York, USA.
- Badania, Z., Ait-Amara, H., Si-Salahb, A., Brikc, M., and Fuchs, W. (2005). Treatment of textile waste water by membrane bioreactor and reuse. *Desalination*, 185(1), 411–417.
- Barclay, S., and Buckley, C. (2000). *Waste minimisation guide for the textile industry: A step towards cleaner production*. Volume II. Water Research Commission of South Africa. University of Natal, Durban, South Africa.
- Bengtsson, J., and Howard, N. (2010). *A life cycle impact assessment Part 1: Classification and characterization*. Building Products Innovation Council, Sydney NSW, Australia.
- Blanco, M., Coello, J., Iturriaga, H., Maspoch, S., and Pagès, J. (1999). Use of near-infrared spectrometry in control analyses of acrylic fiber manufacturing processes. *AnalyticaChimicaActa*, 383(3), 291–298.
- Blok, K., Worrell, E., Cuelenaere, R., and Turkenburg, W. (1993). The cost effectiveness of CO₂ emission reduction achieved by energy conservation. *Energy Policy*, 21(1), 656–667.
- Boustead, I. (1996). *Theory and definitions in ecobalances. Recycling and Recovery of Plastics*. pp. 73–93. Hanser Publication, New York, USA.
- Briga-Sá, A., Nascimento, D., Teixeira, N., Pinto, J., Caldeira, F., Varum, H., and Paiva, A. (2013). Textile waste as an alternative thermal insulation building material solution. *Construction and Building Materials*, 38(1), 155-160.
- Brito, M.P.D., Carbone, V., and Blanquart, C.M. (2008). Towards a sustainable fashion retail supply chain in Europe: organization and performance. *International Journal of Production Economics*, 114(2), 534-553.

- BSR, Business for Social Responsibility (2009). Apparel industry life cycle Carbon mapping. Business for Social Responsibility Network, USA.
- Buonanno, G., Ficco, G., and Stabile, L. (2008). Size distribution and number of particles at the stack of a municipal waste incinerator. *Waste Management*, 29(2), 749-755.
- Caffal, C. (1996). Energy management in industry-Analysis Series 17. Center for the analysis and dissemination energy technologies, Sittard, Netherlands.
- Cai, Y.P., Huang, G.H., Yang, Z.F., and Tan, Q. (2009). Identification of optimal strategies for energy management systems planning under multiple uncertainties. *Applied Energy*, 86(4), 480-495.
- CAPMAS. (2014). Egypt in figures report .2014. Central Agency for Public Mobilization and Statistics, (March 2014).
- Cherubini, F., Bargigli, S., and Ulgiati, S. (2009). Life cycle assessment (LCA) of waste management strategies: Landfilling, sorting plant and incineration. *Journal of Energy*, 34, 2116–2123.
- Christoffersen, L.B., Larsen, A., and Togeby, M. (2006). Empirical analysis of energy management in Danish industry. *Journal of Cleaner Production*, 14(5), 516-526.
- Clift, R. (2013). *System approaches: life cycle assessment and industrial ecology: pollution: causes effects and control* (5th ed.): Society of Chemistry, London, UK.
- Clift, R., Doig, A., and Finnveden, G. (2000). The application of life cycle assessment to integrated solid waste management: part 1 – methodology. *Trans Ichem*, 78(Part B): 279-287.
- Costa, A., Paris, J., Towers, M., and Browne, T. (2007). Economics of trigeneration in a kraft pulp mill for enhanced energy efficiency and reduced GHG emissions. *Energy*, 32(4), 474-481.
- Derashri, S. (1999). Energy audit at Indian oil corporation. Academy of conservation of energy. Baroda, India.
- De-Smet, B., White, P.R., and Owens, J.W. (1996). Environmental life-cycle assessment. Chapter title: Integrating lifecycle assessment within an overall framework for environmental management. McGraw-Hill Publications, New York: USA.
- Doka, G. (2003). Life cycle inventories of waste treatment services. Ecoinvent Report No.13. In Swiss Centre for Life Cycle Inventories. Dübendorf, Switzerland.
- Dudić, S.P., Ignjatovi, I.M., Šeslija, D.D., Blagojevic, V.A., and Stojiljkovic, M.M. (2012). Leakage quantification of compressed air on pipes using thermovision. *Thermal Science*, 16(2), S555-S565.
- ECE, European Commission for Environment (2003). Preparing a waste management plan, A methodological guidance note. European Commission, Directorate-General Environment, Umweltbundesamt GmbH, Vienna, BiPRO GmbH, Munich, Ekotoxikologické Centrum, Bratislava.

- Ekvall, T., Assefab, G., Björklund, A., Eriksson, O., and Finnveden, G. (2007). What life-cycle assessment does and does not do in assessments of waste management. *International Journal of Integrated Waste Management, Science and Technology*, 27(8), 989–996.
- Engelhardt, A. W. (2013). World survey on textiles and nonwovens. The Fiber Year GmbH Consulting. Issue 13, April 2013.
- Finnveden, G., Johansson, J., Per, L., and Moberg, G. (2005). Life cycle assessment of energy from solid waste—part 1: General methodology and results. *Journal of Cleaner Production*, 13, 213-229.
- Fresner, J. (1998). Starting continuous improvement with a cleaner production assessment in an Austrian textile mill. *Journal of Cleaner Production* (6).
- Frischknecht, R., Jughbluth, N., Althaus, H.-J., Bauer C., Doka G., Dones, R. and Nemecek, T. (2007). Implementation of life cycle assessment methods. *Ecoinvent Report Vol. 2*. In Swiss Centre for Life Cycle Inventories. Dübendorf, Switzerland.
- Goedkoop, M., and Spriensma, R. (2000). Eco-indicator 99 methodology report: PRÉ Consultants. The Netherlands.
- Goedkoop, M., Schryver, A., and Oele., M. (2008). Introduction to LCA with SimaPro 7: PRÉ Consultants. The Netherlands.
- Gomes, L.S., Silva, F.A., Barbosasa, S., and Kummrow., F. (2012). Ecotoxicity of sludges generated by textile industries: a Review. *J. Braz. Soc. Ecotoxicol*, 7(1), 89-96.
- Gustavo, B., Kasztenny, B., and Wester, C. (2003). Capacitor bank fundamentals and protection. The Conference for Protective Relay Engineers, Texas A&M University, USA.
- Gutowski, T., Dahmus, J., and Thiriez, A. (2006). Electrical energy requirements for manufacturing processes. 13th CIRP international conference of life cycle engineering, Lueven, Belgium.
- Harris, J., Anderson, J., and Shafron, W. (2000). Investment in energy efficiency: a survey of Australian firms. *Energy Policy*, 28(12), 867-876.
- Hasanbeigi, A. (2010). Energy efficiency improvement opportunities for the textile industry. Ernest Orlando Lawrence, Berkeley National Laboratory, California, USA.
- Hassanain, E.M. (2013). Environmental evaluation of used oils recovery plant: case study Alexandria Petroleum Company. Ph.D thesis, Department of Environmental Studies, Alexandria University.
- Hertwich, E.G., Pennington, D.W., and Bare, J.C. (2002). Introduction in life-cycle impact assessment: striving towards best practice. Society of Environmental Toxicology and Chemistry (SETAC), Brussels, Belgium.
- Hirst, E., and Brown, M. A. (1990). Closing the efficiency gap: barriers to the efficient use of energy. *Resources, Conservation and Recycling*, 3(4), 267-281.
- Hong, G., Su, T., Lee, J., Hsu, T. and Chen, H. (2010). Energy conservation potential in Taiwanese textile industry. *Energy Policy*, 38(11), 7048-7053.
- Hunge, K. (2008). *Industrial Dyes: Chemistry, Properties, Applications*. Wiley Publications, New York, USA.
- IEA, International Energy Agency. (2007). Tracking industrial energy efficiency and CO₂ Emissions - Energy indicators. IEA publications, Paris, France.

- IPPC, Integrated Pollution Prevention and Control (2001). Reference document on best available techniques for the textiles industry. European Commission, Institute for Prospective Technological Studies, Technologies for Sustainable Development, European IPPC Bureau. Seville – Spain.
- ISO 14001. (2004). International Organization for Standardizations: Environmental Systems Handbook. Elsevier Butterworth-Heinemann, Geneva, Switzerland.
- ISO 50001. (2011). International Organization for Standardizations: Energy Management Systems Requirements with Guidance for use. Geneva, Switzerland.
- ISO14040. (2006). International Organization for Standardizations: Environmental Management - Life Cycle Assessment-Principles and Frameworks. Geneva, Switzerland.
- ISO14041. (1998). International Organization for Standardizations: Environmental Management -Life Cycle Assessment-Goal and Scope. Geneva, Switzerland.
- ISO14044. (2006). International Organization for Standardizations: Environmental Management - Life Cycle Assessment - Requirements and Guidelines. Geneva, Switzerland.
- ISO19011. (2002). International Organization for Standardizations: Guidelines for Quality and/or Environmental Management Systems Auditing. Geneva, Switzerland.
- Jaffe, A.B., and Stavins, R.N. (1994). The energy efficiency gap: what does it mean?. *Energy Policy*, 22(10), 60-71.
- Jones, T., Crossman, K., Eskil, J., and Wallner, Jo. (2011). The evolution of continuous energy improvement Programs in the Northwest: an example of regional collaboration. ACEEE summer study on energy efficiency in industry. Bonneville Power Administration, the Energy Trust of Oregon and Northwest Energy Efficiency Alliance. Northwest, USA.
- Kalliala, E., and Laitala, K. (2000). Comparison of Eco-labelling criteria for textile products. *The Nordic Textile Journal*, 1(1), 17-42.
- Keenan, J.B., Keyes, F.G., Bill, P.G., and Moore, J.G. (1969). Steam tables - thermodynamic properties of water including vapor, liquid, and solid phases. Wiley, New York, USA.
- Kissock, J.K., and Eger, C. (2008). Measuring industrial energy savings. *Applied Energy*, 85(5), 347-361.
- Klugman, S., Karlsson, M., and Moshfegh, B. (2007). A Scandinavian chemical wood pulp mill. Part 1. Energy audit aiming at efficiency measures. *Applied Energy*, 84(3), 326-339.
- Klugman, S., Karlsson, M., and Moshfegh, B. (2009). A Swedish integrated pulp and paper mill-Energy optimization and local heat cooperation. *Energy Policy*, 37(7), 2514-2524.
- Knackmuss, H. J. (1996). Basic knowledge and perspectives of bioelimination of xenobiotics compounds. *Journal of Biotechnology*, 51,287-295.

- Kolekar, Y.M. (2010). Isolation characterization and evaluation of dye degradation potential of the novel bacterial species *Alishewanella soli*. Doctor of Philosophy in Biochemistry, Department of chemistry and biochemistry, University of Pune, India.
- Lai-Li, W., Xue-mei, D., and Xiong-ying, W.U. (2009). The application of life cycle assessment in textile industry. *Journal of Xi' Polytechnic University*, 23(96), 630 – 634.
- Laing, G.I. (1991). The Impact of effluent regulations on the dyeing industry. *Colouration*, 12, 56 - 70.
- Lang, S., and Huang, YJ. (1993). Energy conservation standard for space heating in Chinese urban residential buildings. *Energy*, 18, 871–892.
- Lawrence, R.D. (1996). Pollution prevention in the textile industry. U.S. EPA. Pollution prevention work group. Dallas, USA.
- Law-wai, E. (2001). Mobilization and transport of arsenic by landfill leachates and contamination of groundwater at Winthrop, Maine. Master of Science in Earth Resources Engineering, Columbia University, USA.
- Lettieri, P., Evangelisti, S., Borello, D., and Clift, R.d. (2014). Life cycle assessment of energy from waste via anaerobic digestion: A UK case study. *J. of Waste Management*, 34, 226–237.
- Lightner, E. (2000). Minimize compressed air leaks - Compressed air tip. Office of Industrial Technologies Energy Efficiency and Renewable Energy, U.S. Department of Energy Washington, USA.
- Lo, C.K.Y., Yeung, A.C.L., and T.C.E. Cheng. (2012). The impact of environmental management systems on financial performance in fashion and textiles industries. *Int. J. Production Economics*, 135, 561-567.
- Manoloudis T. (2007). Promotion of energy management practices in the textile industries of Greece, Portugal and Spain - Energy management manual. Hellenic Fashion Industry - Greece, SIGMA Consultants- Greece, Textile Industry Research and Technology Centre-Portugal, Association Textile Technology Investigation - Spain.
- McDougall, F.R., White, P., Franke, M., and Hindle, P. (2001). Integrated solid waste management: A life cycle inventory. 2nd ed. Blackwell Science, USA.
- McKane, A., Williams, R., and Perry, W. (2011). Setting the standard for industrial energy efficiency. 7th International Conference on Energy Efficiency in Motor Driven Systems, 12-14 September 2011, Washington, DC, USA.
- McKinney, J. (1987). Profiting from lighting modernization pamphlet. National Lighting Bureau, Washington D.C., USA.
- Melnyk, S.A., Sroufe, R.P., and Calantone, R. (2003). Assessing the impact of environmental management systems on corporate and environmental performance. *Journal of Operations Management*, 21(3), 329-351.

- Mendes, M.R., Aramak, T., and Hanaki, K. (2004). Comparison of the environmental impact of incineration and landfilling in São Paulo city as determined by LCA. *Journal of Resources, Conservation and Recycling*, 41(1), 47-63.
- Moen, R. and Norman, C. (2009). Evolution of the PDCA Cycle. The Asian Network for Quality Congress. September, Tokyo, Japan.
- Nagesha, N. (2005). Ranking of barriers to energy efficiency in small industry clusters using analytic hierarchy process - An empirical study of three Indian clusters. *South Asian Journal of Management*, 12(2), 75-94.
- Nakamura, S., and Kondo, Y. (2002). Input-Output analysis of waste management. *Journal of Industrial Ecology*, 6(1), 39-63.
- Nieminen, E., Linke, M., Tobler, M., and Beke, B. (2007). EU COST Action 628: Life Cycle Assessment (LCA) of textile products, eco-efficiency and definition of Best Available Technology (BAT) of textile processing. *Journal of Cleaner Production*, 15, 1259-1270.
- Nieminen-Kalliala, E. (2003). Environmental indicators of textile products for ISO (Type III) environmental product declaration. *AUTEX Research Journal*, 3(4), 207-218.
- Ning, X., Lin, M., Shen, L. Zhang, J., Wang, J., Wang, Y., Yang, Z., and Liu, J. (2014). Levels, composition profiles and risk assessment of polycyclic aromatic hydrocarbons (PAHs) in sludge from ten textile dyeing plants. *Environmental Research*, 132, 112-118.
- NRC (1980). Health Effects of Fossil-fuel Combustion Products: Needed Research. National Research Council (U.S.).
- Ozturk, H. K. (2005). Energy usage and cost in textile industry: A case study for Turkey. *Energy*, 30(13), 2424-2446.
- Palanichamy, C., and Babu, N.S. (2005). Second stage energy conservation experience with a textile industry. *Energy Policy*, 33, 603-609.
- Palanichamy, C., Nadarajan, C., Naveen, P., and Sundar, N. (2001). Budget constrained energy conservation-an experience with a textile industry. *IEEE Transactions on Energy Conversion*, 16(4), 340-345.
- Radgen, P., and Blaustein, E. (2001). Compressed air systems in the European Union – Energy, emissions, saving potentials and policy actions. Stuttgart, Log-X Verlag GmbH, Germany.
- Rashid, M. (2010). Power electronics handbook. 3rd Edition. Butterworth-Heinemann Publications, UK.
- Rebitzer, G., Ekvall, T., Frischknecht, R., Hunkeler, D., Norris, G., Rydberg, T., and Pennington, D.W. (2004). Life cycle assessment: Part 1: Framework, goal and scope definition, inventory analysis, and applications. *Environment International*, 30, 701-720.
- Robertson, S. and Kirsten, N. (1993). Water and waste-water management in the textile industry. Report No 190095/3. Water Research Commission, South Africa.
- Rock, M.T., and Angel, D.P. (2007). Grow first, industrial transformation in East Asia. *Environment*, 49(4), 10-19.

- Sardianou, E. (2008). Barriers to industrial energy efficiency investments in Greece. *Journal of Cleaner Production*, 16(13), 1416-1423.
- Schönberger, H., and Schäfer, T. (2003). Best available techniques in textile industry. Environmental research of federal ministry of the environment, Umweltbundesamt Publications, Berlin, Germany.
- Šešlija, D., Ignjatović, I., Dudić, S., and Lagod, B. (2011). Potential energy savings in compressed air systems in Serbia. *African Journal of Business Management*, 5(14), 5637-5645.
- Shenai, V.V. (2001). Non-ecofriendly textile chemicals and their probable substitutes-An overview. *Indian Journal for Fiber and Textile Research*, 26(1-2), 50-54.
- Slokar, Y.M., and Le Marechal, M. A. (1998). Methods of decoloration of textile wastewaters. *Dyes and pigments*, 37, 335-356.
- Stapleton, J.P., Margaret, A.G., and Davis, S.P. (2001). *Environmental management systems: An implementation guide for small and medium-sized organizations*. Glover-Stapleton Associates, USA.
- Tantri, R. (2010). Waste handling report, Alexandria Fiber Company. Alexandria, Egypt.
- TEC. (2010). Industry report. Acrylic in Focus conference, 8-10 March 2010. Textile Export Council, Alexandria, Egypt.
- Thollander, P., and Ottosson, M. (2010). Energy management practices in Swedish energy-intensive industries. *Journal of Cleaner Production*, 18, 1125-1133.
- Thollander, P., Karlsson, M., Söderström, M., and Creutz, D. (2005). Reducing industrial energy costs through energy efficiency measures in a liberalized European electricity market - case study of a Swedish iron foundry. *Applied Energy*, 81(2), 115-126.
- Thorn, M.J., Kraus, J.L., and Parker, D.R. (2011). *Life cycle assessment as a sustainability management tool: Strengths, weaknesses, and other considerations*. Wiley Periodicals, USA.
- Tobler, M. (2000). Life cycle assessment of cotton fabrics in textile finishing. Fiber society spring conference 17-9 May, Sustainability and Recycling of Textile Materials, pp.65-70. Guimaraes, Portugal.
- Trygg, L., and Karlsson, B.G. (2005). Industrial DSM in a deregulated European electricity market — a case study of 11 plants in Sweden. *Energy Policy*, 33, 1445-1449.
- Udo de Haes, H.A., and Heijungs, R. (2007). Life cycle assessment for energy analysis and management. *Journal of Applied Energy*, 84, 817-827.
- US.DOE, US Department Of Energy. (2005). *Energy tips - pumping systems*, Sheet 4, Industrial technology program energy, energy efficiency and renewable energy, Washington D.C., USA.
- US.EPA, U.S. Environmental Protection Agency. (1993). *Air quality criteria for oxides of nitrogen*. Volume I (EPA 600/8-91-049, 1993), Washington D.C., USA.
- US.EPA, U.S. Environmental Protection Agency. (1996). *Best management practices for pollution prevention in the textile industry*. Office of research and development, National risk management research laboratory, Center of environmental research

- information and U.S. Environmental Protection Agency. Reference number EPA/625/R-96/004, Ohio, USA
- US.EPA, US Environmental Protection Agency and Network Technology Transfer. (2011). Emissions factors and AP-42, Chapter 6: Organic chemical process industry, Section 6.9 Synthetic Fibers, pp.1-21.
- US.EPA, U.S. Environmental Protection Agency. (2013). Toxicological Review Benzo[a]pyrene. Office of research and development, National risk management research laboratory, Center of environmental research information and U.S. Environmental Protection Agency. Reference number EPA/635/R13/138a , Washington D.C., USA.
- Van der Velden, N.M., Martin K.P., and Vogtländer, J.G. (2014). LCA benchmarking study on textiles made of cotton, polyester, nylon, acrylic, or elastane. *The International Journal of Life Cycle Assessment*, 19, 331-356.
- Vandana, Y.G., Ghodke, O.G, and Kumar, K. (2012). Steam system audit. *International Journal of Engineering Research and Applications (IJERA)*, 2(3), 1285-1287.
- Vandevivere, P. C., Bianchi, R., and Verstraete, W. (1998). Treatment and reuse of waste water from the textile wet processing industry: review of emerging technologies. *Journal of Chemical Technology and Biotechnology*, 72(4), 289-302.
- Vikram, S., Dave, B., and Goyal, S. (2012). Energy audit report for Alexandria Fiber Co., Egypt: Central technical cell for energy services -Adytia Birla Group, India.
- William, J., Kennedy, T., Wayne, C., and Capehart, B. L. (2003). *Guide to energy management*. 4th ed. The Fairmont Press, USA.
- Wolstencroft, H. R. (2008). Ultrasonic air leak detection: An investigation to improve accuracy of leak rate estimation. M.Sc.thesis, The University of Waikato, New Zealand.
- Woodard, F. (2001). *Industrial waste treatment handbook*. Butterworth–Heinemann Publications. USA.
- World Acrylic Fibre – Industry report: Trend in Demand & Supply. 2013. Centerac Technologies Limited, India.
- Worrell, E., Blinde, P., Neelis, M., Blomen, E., and Masanet, E. (2010). Energy efficiency improvement and cost saving opportunities for the U.S. iron and steel industry, An EnergyStar guide for energy and plant managers. Lawrence Berkeley National Laboratory, Berkeley, CA.
- Xibin, S. (2010). Analysis of acrylic fiber industry and development of new type fibers. The 7th China International Acrylonitrile and Acrylic Fiber Forum, March 2010, Shanghai, China.

IX. APPINDICES

APPENDIX (A)

APPENDIX (A1): ISO 14040:1997

International Standard for “Environmental management – Life cycle assessment - Principles and framework”

Introduction

The heightened awareness of the importance of environmental protection, and the possible impacts associated with products, manufactured and consumed, has increased the interest in the development of methods to better comprehend and reduce these impacts. One of the techniques being developed for this purpose is Life Cycle Assessment (LCA). The International Standard describes the principles and framework for conducting and reporting LCA studies, and includes certain minimal requirements. LCA is a technique for assessing the environmental aspects and potential impacts associated with a product, by

- compiling an inventory of relevant inputs and outputs of a product system
- evaluating the potential environmental impacts associated with those inputs and outputs
- interpreting the results of the inventory analysis and impact assessment phases in relation to the objectives of the study.

LCA studies the environmental aspects and potential impacts throughout a product's life (i.e. cradler to grave) from raw material acquisition through production, use and disposal. The general categories of environmental impacts needing consideration include resource use, human health, and ecological consequences.

LCA can assist in

- identifying opportunities to improve the environmental aspects of products a various points in their life cycle
- decision-making in industry, governmental or non-governmental organizations (e.g. strategic planning, priority setting, product or process design or redesign)
- selection of relevant indicators of environmental performance, including measurement techniques ; and
- marketing (e.g. an environmental claim, ecolabelling scheme or environmental product declaration).

The scope, boundaries and level of detail of an LCA study depend on the subject and intended use of the study. The depth and breadth of LCA studies may differ considerably depending on the goal of a particular LCA study. However, in all cases, the principles and framework established in this International Standard should be followed.

LCA is one of several environmental management techniques (e.g. risk assessment, environmental performance evaluation, environmental auditing, and environmental impact assessment) and may not be the most appropriate technique to use in all situations. LCA typically does not address the economic or social aspects of a product. Because all techniques have

limitations, it is important to understand those that are present in LCA. The limitations include the following.

- The nature of choices and assumptions made in LCA (e.g. system boundary setting, selection of data sources and impact categories) may be subjective.
- Models used for inventory analysis or to assess environmental impacts are limited by their assumptions, and may not be available for all potential impacts or applications.
- Results of LCA studies focused on global and regional issues may not be appropriate for local applications, i.e. local conditions might not be adequately represented by regional or global conditions.
- The accuracy of LCA studies may be limited by accessibility or availability of relevant data, or by data quality, e.g. gaps, types of data, aggregation, average, site-specific.
- The lack of spatial and temporal dimensions in the inventory data used for impact assessment introduces uncertainty in impact results. This uncertainty varies with the spatial and temporal characteristics of each impact category.

Generally, the information developed in an LCA study should be used as part of a much more comprehensive decision process or used to understand the broad or general trade-offs. Comparing results of different LCA studies is only possible if the assumptions and context of each study are the same. These assumptions should also be explicitly stated for reasons of transparency.

This International Standard provides principles and framework and provides some methodological requirements for conducting LCA studies. Additional details regarding methods are provided in the complementary International Standards ISO 14041, ISO 14042 and ISO 14043 concerning the various phases of LCA .

1 Scope

This International Standard specifies the general framework, principles and requirements for conducting and reporting life cycle assessment studies. This International Standard does not describe the life cycle assessment technique in detail.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this International Standard. At the time of the publication, the edition indicated was valid.

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1. Allocation

Partitioning the input or output flows of a unit process to the product system under study

3.2. Comparative assertion

Environmental claim regarding the superiority or equivalence of one product versus a competing product which performs the same function

3.3. Elementary flow

(1) Material or energy entering the system being studied, which has been drawn environment without previous human transformation

(2) Material or energy leaving the system being studied, which is discarded into the environment without subsequent human transformation.

3.4. Environmental aspect

Element of an organization's activities, products or services that can interact with the environment

3.5. Functional unit

Quantified performance of a product system for use as a reference unit in a life cycle assessment study

3.6. Input

Material or energy which enters a unit process

Note: Materials may include raw materials and products.

3.7. Interested party

Individual or group concerned with or affected by the environmental performance of a product system, or by the results of the life cycle assessment

3.8. Life cycle

Consecutive and interlinked stages of a product system, from raw material acquisition or generation of natural resources to the final disposal

3.9. Life cycle assessment (LCA)

Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle

3.10. Life cycle impact assessment

Phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts of a product system

3.11. Life cycle interpretation

Phase of life cycle assessment in which the findings of either the inventory analysis or the impact assessment, or both, are combined consistent with the defined goal and scope in order to reach conclusions and recommendations

3.12. Life cycle inventory analysis

Phase of life cycle assessment involving the compilation and quantification of inputs and outputs, for a given product system throughout its life cycle

3.13. Output

Material or energy which leaves a unit process

Note : Materials may include raw materials, intermediate products, products, emissions and waste.

3.14. Practitioner

Individual or group that conducts a life cycle assessment

3.15. Product system

Collection of materially and energetically connected unit processes which performs one or more defined functions

Note : In this International Standard, the term "product" used alone includes not only product systems but can also include service system

3.16. Raw material

Primary or secondary material that is used to produce a product

3.17. System boundary

Interface between a product system and the environment or other product systems

3.18. Transparency

Open, comprehensive and understandable presentation of information

3.19. Unit process

Smallest portion of a product system for which data are collected when performing a life cycle assessment

3.20. Waste

Any output from the product system which is disposed of

4. General description of LCA**4.1. Key features of LCA**

The following list summarizes some of the key features of the LCA methodology.

- LCA studies should systematically and adequately address the environmental aspects of product systems, from raw material acquisition to final disposal.
- The depth of detail and time frame of an LCA study may vary to a large extent, depending on the definition of goal and scope.
- The scope, assumptions, description of data quality, methodologies and output of LCA studies should be transparent. LCA studies should discuss and document the data sources, and be clearly and appropriately communicated.
- Provisions should be made, depending on the intended application of the LCA study, to respect confidentiality and proprietary matters.
- LCA methodology should be amenable to the inclusion of new scientific findings and improvements in the state-of-the-art of the technology.
- Specific requirements are applied to LCA studies which are used to make a comparative assertion that is disclosed to the public.
- There is no scientific basis for reducing LCA results to a single overall score or number, since trade-offs and complexities exist for the systems analysed at different stages of their life cycle.
- There is no single method for conducting LCA studies. Organizations should have flexibility to implement LCA practically as established in this International Standard, based upon the specific application and the requirements of the user.

4.2. Phases of an LCA

Life cycle assessment shall include definition of goal assessment and interpretation of results, as illustrated in goal and scope, inventory analysis, impact figure 1. LCA results may be useful inputs to a variety of decision-making processes. Applications of LCA such as the examples listed in figure 1 are outside the scope of this International Standard.

Life cycle inventory studies shall include definition of goal and scope, inventory analysis and interpretation of results. The requirements and recommendations of this International Standard, with the exception of those provisions regarding impact assessment, also apply to life cycle inventory studies.

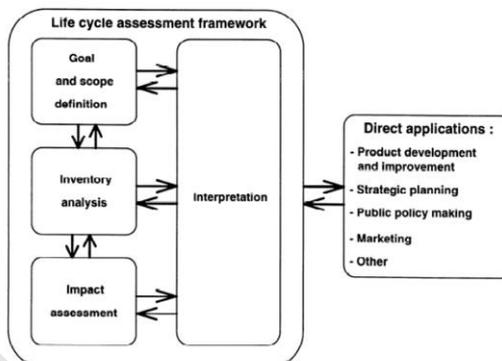


Figure A1: Phases of LCA

5. Methodological framework

In addition to the general requirements specified below, it is a requirement of this International Standard that the definition of goal and scope and the inventory comply with the respective provisions of ISO 14041.

5.1 Definition of goal and scope

The goal and scope of an LCA study shall be clearly defined and consistent with the intended application.

5.1.1 Goal of the study

The goal of an LCA study shall unambiguously state the intended application, the reasons for carrying out the study and the intended audience, i.e. to whom the results of the study are intended to be communicated.

5.1.2 Scope of the study

In defining the scope of an LCA study, the following items shall be considered and clearly described :

- The functions of the product system, or, in the case of comparative studies, the systems ;
- The functional unit
- The product system to be studied
- The product system boundaries
- Allocation procedures
- Types of impact and methodology of impact assessment, and subsequent interpretation to be used
- Data requirements
- Assumptions
- Limitations
- Initial data quality requirements
- Type of critical review, if any
- Type and format of the report required for the study.

The scope should be sufficiently well defined to ensure that the breadth, the depth and the detail of the study are compatible and sufficient to address the stated goal.

LCA is an iterative technique. Therefore, the scope of the study may need to be modified while the study is being conducted as additional information is collected.

5.1.2.1 Function and functional unit

The scope of an LCA study shall clearly specify the functions of the system being studied. A functional unit is a measure of the performance of the functional outputs of the product system. The primary purpose of a functional unit is to provide a reference to which the inputs and outputs are related. This reference is necessary to ensure comparability of LCA results. Comparability of LCA results is particularly critical when different systems are being assessed to ensure that such comparisons are made on a common basis. A system may have a number of possible functions and the one selected for a study is dependent on the goals and scope of the study. The related functional unit shall be defined and measurable.

Example : The functional unit for a paint system may be defined as the unit surface protected for a specified time period.

5.1.2.2 System boundaries

The system boundaries determine which unit processes shall be included within the LCA. Several factors determine the system boundaries, including the intended application of the study, the assumptions made, cut-off criteria, data and cost constraints, and the intended audience. The selection of inputs and outputs, the level of aggregation within a data category, and the modelling of the system shall be consistent with the goal of the study. The system should be modelled in such a manner that inputs and outputs at its boundaries are elementary flows. The criteria used in establishing the system boundaries shall be identified and justified in the scope of the study. LCA studies used to make a comparative assertion that is disclosed to the public shall perform an analysis of material and energy flows to determine their inclusion in the scope of the study.

5.1.2.3 Data quality requirements

Data quality requirements specify in general terms the characteristics of the data needed for the study. Data quality requirements shall be defined to enable the goals and scope of the LCA study to be met. The data quality requirements should address :

- time-related coverage
- geographical coverage
- technology coverage
- precision, completeness and representativeness of the data
- consistency and reproducibility of the methods used throughout the LCA
- sources of the data and their representativeness
- uncertainty of the information.

Where a study is used to support a comparative assertion that is disclosed to the public, the above-mentioned data quality requirements shall be addressed.

5.1.2.4 Comparisons between systems

In comparative studies, the equivalence of the systems being compared shall be evaluated before interpreting the results. Systems shall be compared using the same functional unit and equivalent methodological considerations, such as performance, system boundaries, data quality, allocation procedures, decision rules on evaluating inputs and outputs and impact assessment. Any differences between systems regarding these parameters shall be identified and reported. In the case of comparative assertions disclosed to the public, this evaluation shall be conducted in accordance with the critical review process of section 7.3.3. Another requirement for comparative assertions disclosed to the public is that an impact assessment shall be performed.

5.1.2.5 Critical review considerations

Critical review is a technique to verify whether an LCA study has met the requirements of this International Standard for methodology, data and reporting. Whether and how to conduct a critical review, as well as who conducts the review, shall be defined in the scope of the study. In general, critical reviews of an LCA are optional and may utilise any of the review options outlined in 7.3. A critical review shall be conducted for LCA studies used to make a comparative assertion that is disclosed to the public and shall employ the critical review process outlined in 7.3.3.

5.2 Life cycle inventory analysis

5.2.1 General description of life cycle inventory

Inventory analysis involves data collection and calculation procedures to quantify relevant inputs and outputs of a product system. These inputs and outputs may include the use of resources and releases to air, water and land associated with the system. Interpretations may be drawn from these data, depending on the goals and scope of the LCA. These data also constitute the input to the life cycle impact assessment. The process of conducting an inventory analysis is iterative. As data are collected and more is learned about the system, new data requirements or limitations may be identified that require a change in the data collection procedures so that the goals of the study will still be met. Sometimes, issues may be identified that require revisions to the goal or scope of the study.

5.2.2 Data collection and calculation procedures

The qualitative and quantitative data for inclusion in the inventory shall be collected for each unit process that is included within the system boundaries. The procedures used for data collection may vary depending on the scope, unit process or intended application of the study. Data collection can be a resource-intensive process. Practical constraints on data collection should be considered in the scope and documented in the study report.

Some significant calculation considerations are outlined in the following.

- Allocation procedures are needed when dealing with systems involving multiple products (e.g. multiple products from petroleum refining). The materials and energy flows as well as associated environmental releases shall be allocated to the different products according to clearly stated procedures, which shall be documented and justified.
- The calculation of energy flow should take into account the different fuels and electricity sources used, the efficiency of conversion and distribution of energy flow as well as the inputs and outputs associated with the generation and use of that energy flow.

5.3 Life cycle impact assessment

The impact assessment phase of LCA is aimed at evaluating the significance of potential environmental impacts using the results of the life cycle inventory analysis. In general, this process involves associating inventory data with specific environmental impacts and attempting to understand those impacts. The level of detail, choice of impacts evaluated and methodologies used depends on the goal and scope of the study. This assessment may include the iterative process of reviewing the goal and scope of the LCA study to determine when the objectives of the study have been met, or to modify the goal and scope if the assessment indicates that they can not be achieved.

The impact assessment phase may include elements such as, among others :

- assigning of inventory data to impact categories (classification)

- modelling of the inventory data within impact categories (characterization)
- possibly aggregating the results in very specific cases and only when meaningful (weighting). Note : Data prior to weighting should remain available.

The methodological and scientific framework for impact assessment is still being developed.

Models for impact categories are in different stages of development. There are no generally accepted methodologies for consistently and accurately associating inventory data with specific potential environmental impacts. There is subjectivity in the life cycle impact assessment phase such as the choice, modelling and evaluation of impact categories. Therefore, transparency is critical to impact assessment to ensure that assumptions are clearly described and reported.

5.4 Life cycle interpretation

Interpretation is the phase of LCA in which the findings from the inventory analysis and the impact assessment are combined together, or, in the case of life cycle inventory studies, the findings of the inventory analysis only, consistent with the defined goal and scope in order to reach conclusions and recommendations. The findings of this interpretation may take the form of conclusions and recommendations to decision-makers, consistent with the goal and scope of the study.

The interpretation phase may involve the iterative process of reviewing and revising the scope of the LCA, as well as the nature and quality of the data collected consistent with the defined goal.

The findings of the interpretation phase should reflect the results of any sensitivity analysis that is performed. Though subsequent decisions and actions may incorporate environmental implications identified in the findings of the interpretation, they lie beyond the scope of the LCA study, since other factors such as technical performance, economic and social aspects are also considered.

6. Reporting

The results of the LCA shall be fairly, completely and accurately reported to the intended audience. The type and format of the report shall be defined in the scope phase of the study. The results, data, methods, assumptions and limitations shall be transparent and presented in sufficient detail to allow the reader to comprehend the complexities and trade-offs inherent in the LCA study. The report shall also allow the results and interpretation to be used in a manner consistent with the goals of the study. When the results of the LCA are to be communicated to any third party, i.e. interested party other than the commissioner or the practitioner of the study, regardless of the form of communication, a third-party report shall be prepared. This report constitutes a reference document, and shall be made available to any third party to whom the communication is made. The third-party report shall cover the following aspects:

a) general aspects :

- 1) LCA commissioner, practitioner of LCA (internal or external)
- 2) date of report
- 3) statement that the study has been conducted according to the requirements of this International Standard.

b) definition of goal and scope

c) life cycle inventory analysis : data collection and calculation procedures

d) life cycle impact assessment : the methodology and results of the impact assessment that was performed

e) life cycle interpretation :

- 1) the results

- 2) assumptions and limitations associated with the interpretation of results
- 3) methodology and data related
- 4) data quality assessment.

f) Critical review :

- 1) name and affiliation of reviewers
- 2) critical review reports
- 3) responses to recommendations.

For comparative assertions, the following issues shall also be addressed by the report :

- analysis of material and energy flows to justify their inclusion or exclusion
- assessment of the precision, completeness and representativeness of data used
- description of the equivalence of the systems being compared in accordance with 5.1.2.4
- description of the critical review process.

7 Critical review

7.1 General description of critical reviews

The critical review process shall ensure that.

- the methods used to carry out the LCA are consistent with this International Standard
- the methods used to carry out the LCA are scientifically and technically valid
- the data used are appropriate and reasonable in relation to the goal of the study
- the interpretations reflect the limitations identified and the goal of the study
- the study report is transparent and consistent.

Since this International Standard does not specify requirements on the goals or uses of LCA, a critical review can neither verify nor validate the goals that are chosen for an LCA, or the uses to which LCA results are put. The scope and type of critical review desired shall be defined in the scope phase of an LCA study.

7.2 Need for critical review

A critical review may facilitate understanding and enhance the credibility of LCA studies, for example by involving interested parties. The use of LCA results to support comparative assertions raises special concerns and requires, critical review, since this application is likely to affect interested parties that are external to the LCA study. In order to decrease the likelihood of misunderstandings or negative effects on external interested parties, critical reviews shall be conducted on LCA studies where the results are used to support comparative assertions. However, the fact that a critical review has been conducted should in no way imply an endorsement of any comparative assertion that is based on an LCA study.

7.3 Critical review processes

If an LCA study is to be critically reviewed, the scope of the critical review should be defined during the goal and scope definition phase of the study. The scope should identify why the critical review is being undertaken, what will be covered and to what level of detail, and who needs to be involved in the process. Confidentiality agreements regarding the content of the LCA study should be entered into as needed.

7.3.1 Internal expert review

A critical review may be carried out internally. In such a case, it shall be performed by an internal expert independent of the LCA study. This expert should be familiar with the requirements of this International Standard and have the necessary scientific and technical expertise. A review statement is prepared by the person conducting the LCA study and then

reviewed by the internal, independent expert. The review statement may also be prepared in its entirety by the internal, independent expert. The review statement shall be included in the LCA study report.

7.3.2 External expert review

A critical review may be carried out externally. In such a case, it shall be performed by an external expert, independent of the LCA study. This expert should be familiar with the requirements of this International Standard and have scientific and technical expertise. A review statement is prepared by the person conducting the LCA study and then reviewed by the external, independent expert. The review statement may also be prepared in its entirety by the external, independent expert. The review statement, comments of the practitioner and any response to recommendations made by the reviewer, shall be included in the LCA study report.

7.3.3 Review by interested parties

An external independent expert is selected by the original study commissioner to act as chairperson of a review panel. Based on the goal, scope and budget available for the review, the chairperson selects other independent qualified reviewers. This panel may include other interested parties affected by the conclusions drawn from the LCA study, such as government agencies, non-governmental groups, or competitors. The review statement and review panel report, as well as comments of the expert and any responses to recommendations made by the reviewer or by the panel, shall be included in the LCA study report.

APPENDIX (A2): SimaPro Software



Figure A2: SimaPro 7 software package

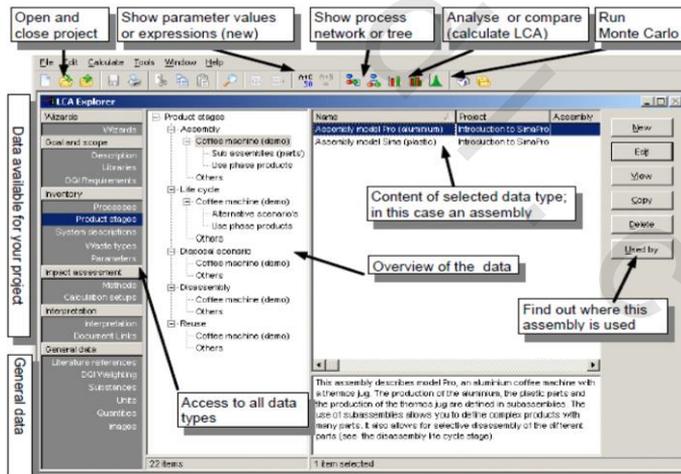


Figure A3: User interface

A software package developed for implementing life cycle assessment, developed by PRé Consultants Company, the Netherlands. Since 1990, SimaPro has been the market-leading life cycle solution all over the world.

Address: Plotterweg 12, 3821 BB Amersfoort, the Netherlands

phone + 31 33 4555022, fax + 31 33 4555024

e-mail support@pre.nl

web site www.pre.nl

- SimaPro comes with loads of data. Around 10,000 inventory data records are available for SimaPro. Most are included for free with a license.
- SimaPro7 software contains a number Ecoinvent libraries. These libraries contain over 2500 processes, covering a very wide range of processes. It contains a number of impact assessment methods as well.
- It is distinguished from other softwares which develop life cycle assessment by the ability to develop waste handling scenarios for different approaches.
- SimaPro includes input-output datasets. Use cost data to define the LCA model. Ideal data for screenings, or for estimating and assessing services. Combine cost and environmental data.
- SimaPro evaluates uncertainties in such a way that determine the significance of the differences in a comparison between product systems.
- SimaPro is designed for LCA teamwork. SimaPro is the only commercial LCA software that supports true multi user implementations. LCA team can work on a single database at the same time, even if they are in very different locations (using a network, Citrix or a similar solution).

APPENDIX (A3): Impact Indicators Matrix For The Two Waste Streaming Approaches

Impact Indicator*	Waste streaming approach	
	Incineration	Landfill
Global Warming Potential (GWP)	√	√
Acidification Potential (AP)	√	√
Eutrophication Potential (EP)	√	√
Carcinogens Potential (CP)	√	√
Ecotoxicity Potential (ETP)	√	√
Respiratory Inorganic Formation Potential (RIFP)	√	√
Respiratory Organic Formation Potential, Radiation (ROFP)	x	x
Ozone Layer Depletion (OLD)	x	x
Minerals Depletion (MD)	x	x
Land Use (LU)	x	x
Fossil Fuels Depletion (FFD)	√	√

* Effect on impact indicator at cut off criteria 0.1%

APPENDIX.(B): Audit Sheets

Date of Inspection :											
Area:											
Inspectors Name:											
Sr. No.	Leakage Place				Leakage Type				Job type		Remarks
	Dept.	Area	Equip.	Description	Air	water	Steam	RM	Online	Shutdown	

Figure B1. Template of internal audit for leakages

Data Collection Sheets	
Unit:	Section:
Date:	Time:

Major Leakages Observed In the System

S.no.	Major headers / branches	Pressure kg/cm ²	Location	Extent of leakage	Energy wasted
1					
2					
3					

Figure B2. Template for data collection sheet used during the audit

MOTOR DATA								Doc.	
								Rev. No.	
Name of Unit :									
Sr. No.	Equipment No.	Description of Driven Equipment	Location	Motor Sr.No.	Make	Rating KW		Design Efficiency	Rated Speed
						Rated	Actual		
CRITICAL LOAD									
1									
2									
3									

Figure B3. Motors data collection sheet

VARIABLE SPEED DRIVES DATA							Doc.	
							Rev. No.	
Name of Unit :								
Sr.No.	Location / Driven Equipment	Make	Rated KVA	Type of		Motor Rating, kW	Filter Installed	
				Drive	Motor			
1								
2								
3								

Figure B4. Variable speed drive data collection sheet

CAPACITOR DATA							Doc.	
							Rev. No.	
Date								
Name of Unit :								
Sr.	Location	Make	Type	Rated Voltage	KVAR		Power Factor	
					Installed	Operation	Before Cap.	After Cap.
1								
2								
3								

Figure B5. Capacitor data collection sheet

LIGHTING DATA						Doc.	
						Rev. No.	
						Date	
Name of Unit :							
Sr. No.	Location (Section)	Type of Fitting	No. of Fittings	kW Installed	Actual Lux		
					Actual	Level	

Figure B6. Lighting data collection sheet

ENERGY METERS DATA						Doc.
						Rev. No.
						Date
Name of Unit :						
Sr.No.	Location	Type	Sr.No. of Meter	Make	Accuracy	Last Calibration Done (date)

Figure B7. Energy meters data collection sheet

APPENDIX. (C)

Egyptian standards concerning wastewater discharge to non-fresh water drains (key parameters).

Parameter (mg/l unless otherwise noted)	Law 48/82 Industrial Discharge
<i>BOD₅ (5 day, 20° C)</i>	60
<i>COD (Permanganate)</i>	50
<i>COD (Dichromate)</i>	100
<i>pH (units)</i>	6-9
<i>Oil & Grease</i>	10
<i>Temperature (deg.)</i>	35
<i>Total Suspended Solids</i>	60
<i>Settleable Solids (ml/l)</i>	-
<i>Total Dissolved Solids</i>	2000
<i>PO₄</i>	10
<i>NH₃-N (Ammonia)</i>	-
<i>NO₃-N (Nitrate)</i>	40
<i>Total Recoverable Phenol</i>	0.005
<i>Fluoride</i>	0.5
<i>Sulfide</i>	1
<i>Chlorine</i>	-
<i>Surfactants</i>	-
<i>Probable counting for the colon group in 100 cm³</i>	5000

الملخص العربي

شهدت صناعة ألياف الأكريليك تطورا كبيرا في عملية الإنتاج ولكن تعتبر هذه الصناعة من الصناعات المستهلكة للطاقة والملوثة للبيئة. من أهم التحديات التي تواجه الصناعة العالمية في الوقت الحالي هو تطوير تكنولوجيا صديقة للبيئة. تهدف الدراسة الحالية الى التعرف على نظم فعالة لإدارة الطاقة والمخلفات الصلبة و السائلة في صناعة ألياف الأكريليك وتطبيقها في شركة محلية لصناعة ألياف الأكريليك (شركة إسكندرية للقيبر)، في نفس الوقت فإن من الأهمية تحديد الأثر البيئي لتلك الصناعة ولهذا فقد هدفت الدراسة الى تصميم نظام فعال لإستخدامات الطاقة وطرق ترشيدها. كما هدفت الدراسة إلى دراسة المخلفات بأنواعها مع اقتراح أنسب الطرق للتعامل معها، وقد تم استخدام تقنية تحليل دورة الحياة لعناصر الإنتاج في هذا الصدد.

❖ تلخص نتائج الدراسة في الآتي :

١. تم الاستناد الى معايير النظم القياسية (ISO 50001:2011) و (ISO 14001:2004) لإدارة الطاقة ولإدارة المخلفات في إطار دائرة التطوير المستمر (التخطيط – التنفيذ – التقييم- المراجعة). تم وضع أهداف محددة لكل منهما كالتالي: تحقيق خفض مباشر في التكاليف من خلال تقليل إستهلاك الطاقة بنسبة 15% على الأقل وتقليل المخلفات الناتجة من العملية الإنتاجية لأقل من 1% من جملة الإنتاج.

٢. إقتضت خطة العمل الآتي:

أ. جمع بيانات الطاقة والذي أظهر أن الإجمالي السنوي لإستهلاك الكهرباء حوالي 26,3 جيجاوات ساعة، متوسط معدل إستهلاك الكهرباء (كيلوات /طن ألياف) يتراوح ما بين 1,311 – 1,592 خلال 2009 – 2012. متوسط معدل البخار (طن/طن ألياف) يتراوح ما بين 13,4 – 13,7 خلال 2011-2012. المعدل الشهري لإنتاج المخلفات يتراوح بين 2,3 – 4,3 % من الانتاج خلال 2012.

ب. أظهر تحليل البيانات أن متوسط إستهلاك الكهرباء الشهري يبلغ حوالي 73,9 ميغا وات ساعة وأعلى إستهلاك للكهرباء في عملية التصنيع كانت في منطقة المرافق (68.1% من إجمالي الاستهلاك)، يلي ذلك منطقة الإنتاج (19.7%)، ثم منطقة إعداد المواد للتصنيع (11.4%)، بناء على ذلك تم إعتبار منطقة المرافق أهم المناطق التي تحتاج الى تحسين وتطوير.

ج. أظهر من تحليل البيانات لباقي المناطق أيضا التالي:

١) كان أعلى إستهلاك للكهرباء في منطقة إعداد المواد هو قسم البلمرة (45.2%) من إجمالي الاستهلاك في هذه المنطقة، يليه قسم إعادة استخدام المذيب (44.3%) ثم قسم إعداد المعجون (10.5%).

٢) كان أعلى إستهلاك للكهرباء في منطقة الإنتاج هو قسم الغزل (72.9%)، يليه قسم التجفيف (13 – 14%) حسب نوع المجفف وأخيرا قسم إعداد البالات (4.5%).

٣) كان أعلى إستهلاك للكهرباء في منطقة المرافق هممردرات الماء الملحي (42.7%)، يليها أبراج التبريد والمبردرات المائية (39.9%) ثم المكابس الهوائية (17.3%) ثم وحدات معالجة المياه (7.8%) ثم محطة ضخ الماء (7.7%) وأخيرا وحدة معالجة مياه الصرف الصناعي (5.4%).

د. بلغ إستهلاك البخار في 2012 إجمالا 222,473 طن استهلكت لإنتاج 16,556 طن من الألياف الأكريليك. لم تتوفر بيانات تفصيلية لإستهلاك البخار في كل منطقة على لحد لعدم وجود عدادات قياس سريان البخار بالشركة. ويظهر التصميم أن توزيع البخار هو كالتالي: منطقة البلمرة (1.1 طن لكل طن ألياف منتجة)، منطقة تجهيز العجين (1.0 طن لكل طن ألياف منتجة)، إعادة المذيب (3.0 طن لكل طن ألياف منتجة) وخط الإنتاج (4.7 طن لكل طن ألياف منتجة). أوضح التحليل الشهري لهذه البيانات أن أعلى معدل إستهلاك للبخار كان في شهر يناير حيث تزداد الحاجة لإستخدام البخار في عمليات التسخين وكان أدنى استهلاك في شهر أغسطس. إزداد أيضا معدل إستهلاك البخار كنسبة من الإنتاج الفعلي خلال شهري أبريل وسبتمبر نتيجة للتوقف الإجباري بسبب الأعطال المتكررة بخط الإنتاج.

٣. في يناير 2012م تم إعداد برنامج إدارة الطاقة بالمصنع وإجراء عمليات القياس والمراجعة حتى أبريل 2012م، بدأت الخطة التنفيذية التي أنتهت بنهاية 2012م. وأظهرت النتائج المتحصل عليها عام 2013 أنه حدث إنخفاض في المتوسط الشهري لإستهلاك الطاقة بنسبة 3.9% وهي مما يقدر ب919,500 جنيه/سنويا. وكان ذلك من خلال الإجراءات التالية:

أ) حقق إضافة مكثفات الى زيادة معامل القدرة من 0.94 الى 0.98 وهو خفض مباشر في التكاليف بما يعادل 148,608 جنيه/سنويا.

- (ب) حقق تطبيق نظام إضاءة موفر للطاقة خفض مباشر في التكاليف يعادل 138,999 جنيه/سنويا.
- (ج) التعرف على أماكن تسرب الهواء المضغوط ومعالجتها رفع من كفاءة عمل ضواغط الهواء وحقق وفرة لطاقة مهدرة تكلف 97,500 جنيه/سنويا.
- (د) يوفر إعادة استخدام البخار المكثف عن طريق التجميعة التغذية في خزان الغلايات 441,637 جنيه/سنويا.
- (هـ) إستبدال مضختنا ماء بمضخة واحدة ذات كفاءة أعلى يؤدي الى رفع كفاءة ضخ المياه بنسبة حوالى 20% وخفض استهلاك الكهرباء لوحدة المياه بنسبة حوالى 18% مما يؤدي الوفير يقدر ب79,400 جنيه/سنويا.
- (ر) ويأتى باقى الإنخفاض فى إستهلاك الطاقة من اتباع العاملين النظم المحددة لترشيد الاستهلاك مثل وقف الآلات عند عدم الاحتياج.

٤. أجريت دراسة عن المخلفات الصلبة والسائلة والانبعاثات الغازية بدأت بحصر الناتج من التصنيع وأوضحت التالى:

- (أ) يتم معالجة المخلفات السائلة الناتجة من عملية الإنتاج (3600 م³/اليوم) فى محطة معالجة الصرف الصناعى قبل صرفها على مصرف النوبارية. تم تحديد نسبة المخلفات السائلة لكل مصدر وكانت منطقة الإنتاج تمثل 43.3% ومنطقة المرافق تمثل 56.7%، أما عن نوعية مياه الصرف الصناعى المعالجة فوجد انها فى نطاق الحدود المسموح بها.
- (ب) تم عمل حصر المخلفات الصلبة الناتجة من العملية الإنتاجية، وجد أن أهم المخلفات الصلبة اليومية الناتجة هي مخلفات الألياف من خط الإنتاج (نسبة % من الإنتاج اليومي)، مخلفات الأصباغ (50 كجم تقريبا)، مواد كيميائية (150 كجم تقريبا) ومخلفات وحدة معالجة الصرف (50 كجم تقريبا).
- (ج) وجد مصدر لانبعاثات الغازية يشمل بخار ماء من منطقة التجفيف وهو ما يتم التخلص منه بالتهوية أما أبخرة منطقة البلمرة فتعاد الى العملية الإنتاجية عن طريق وحدة تنقية الغازات gas scrubbers.
٥. أظهر تحليل البيانات أن المتوسط الشهري للمخلفات الصلبة الناتجة من خط التصنيع هو 5.4% من الإنتاج وكانت أعلى نسبة خلال أبريل ويوليو وديسمبر 2012.
٦. هدفت خطة إدارة المخلفات الصلبة الى خفض الكمية المتولدة لإقل من 1% من كمية الإنتاج كالتالى:

- (أ) خفض إنتاج المخلفات من خلال توعية العاملين وتدريبهم على مختلف طرق خفض المخلفات، (ب) إعادة استخدام المخلفات الصلبة غير الخطرة (ج) إعادة استخدام مخلفات الألياف بإدائها ثم إعادتها الى العملية الإنتاجية.
٧. عند تطبيق النظام إنخفضت نسبة المخلفات الى 2.9% خلال العام الاول، يمثل هذا الخفض وفر يقدر 854,700 جنيه/سنويا.
٨. تم تحليل دورة الحياة لتحديد التأثيرات البيئية لإنتاج ألياف الأكريليك بدأ من مرحلة استخراج المواد الخام وحتى نهاية العملية الإنتاجية، تم أخذ فى الاعتبار أيضا إستهلاك الماء ومصادر الطاقة والمخلفات السائلة والصلبة المتولدة.
٩. أوضحت النتائج أنه يوجد تأثير معنوى على سبع مؤثرات بيئية: الإحتباس الحرارى Global Warming Potential، الترسيب الحامضى Acidification Potential، الإثراء الغذائى Eutrophication Potential، التأثير المسبب للسرطان Carcinogens Potential، السمية Ecotoxicity Potential، التأثير على الجهاز التنفسى للإنسان نتيجة المواد غير العضوية Respiratory Inorganic Formation Potential وإستهلاك الوقود الاحفورى Fossil Fuel Depletion. وقد أتضح الأتى:
- (أ) يحدث أعلى تأثير على "الموارد الطبيعية" (82%) نتيجة للأستهلاك العالى للوقود الحفرى خلال عملية إنتاج مادة الأكريلونتريل. يليه ثانى أعلى تأثر على "صحة الإنسان" (15.9%) نتيجة لأستخدام المواد الكيميائية غير العضوية والأصباغ خلال الإنتاج. كانتاقل التأثيرات على "النظم البيئية" (2.1%) نتيجة التأثير الحمضى بسبب استخدام مواد خام كيميائية كالأكريلونتريل خلال عملية الإنتاج. لم يظهر تأثير معنوى على العوامل المتحكمة فى طبقة الأوزون، التأثير الإشعاعى، أستغلال الأرض، إستهلاك المعادن أو الجهاز التنفسى للإنسان نتيجة للمواد العضوية.
- (ب) تشير نتائج التحليل أيضا أن إنتاج طن من الألياف الأكريليك يؤثر على الإحتباس الحرارى نتيجة إنبعاث 5.4 طن مكافئ ثانى أكسيد الكربون. ينطلق ثانى أكسيد الكربون أثناء استخدام الوقود الحفرى فى توليد البخار والكهرباء اللازمان لمختلف المراحل الإنتاجية.

ج) يظهر التأثير الحمضى والتأثير على الجهاز التنفسى من إنتاج طن ألياف الأكريليك نتيجة لإنبعاث 13.46 كجم مكافئ ثانى أكسيد الكبريت و 6.86 كجم ثانى أكسيد النيتروجين أثناء مرحلة الطباغاتوالصبغاتوتداول المواد الكيميائية ومن أنبعاثات الغلايات.

د) يظهر تأثير عناصر السمية على البيئة والتأثير المسبب للسرطان نتيجة لإنبعاث الزرنيخ، الكادميوم، الكروم، النيكل والزنك من الأصباغ المستخدمة.

ر) يعتبر إستهلاك الوقود الحفرى أعلى التأثيرات البيئية للصناعة. حيث تم استهلاك حوالى 133 جيجا جول لإنتاج طن أكريليك. وذلك نتيجة لإنتاج مادة الأكريلونيتريل حراريا.

١٠. تم استخدام تقنية تحليل دورة الحياة للمقارنة بين طريقتين للتخلص منمخلفات الصلبة للخطرة لألياف الأكريليك هما التخزين طويل الأجل فى مدافن صحية أو الحرق. كانتالأخيرةهى الأفضل من حيث التأثير على البيئة. أما فى حالة وضع أسوء الاحتمالات Worse - case scenario فى الاعتبار إذا كانت المدافن غير مصممة بصورة صحية أو فى حالة حدوث تسرب (على المدى الطويل) فيمكن توقع حدوث تأثير سام وسرطانى عالى ناتج من إنتشار العناصر المعدنية الموجودة فى مخلفات الأصباغ الى المياه السطحية والجوفية.

١١. أوضح تحليل دورة الحياة أن تأثير عناصر السمية الناتج عن وجود النحاس، الزنك والنيكل. عند إتباع طريقة الحرق تكون أعلى من إتباع طريقة الدفن الصحى للمخلفات حيث بلغت الأولى 68.4% كتأثير على النظم البيئية مقارنة ب51.3% فى حالة البديل الثانى وهو المدفن الصحى.

١٢. كان مؤشر "صحة الإنسان" هى ثانى العوامل المتأثرة عند إختيار الحرق كبديل للدفن حيث بلغ الحرق 28% بينما كان الدفن 46.8% ويعزى ذلك لوجود العناصر الثقيلة فى ماء الرشح فى الحالة الثانية.

١٣. بالنسبة للتأثير على "المصادر البيئية" فإن أعلى البديلين تأثيراكان الحرق حيث مثل نسبة 3.5% من إجمالى التأثيرعلى البيئة مقارنة بالدفن الذى يبلغ نسبة 2.0%. يرجع ذلك الى أن استهلاك الوقود الحفرى المستخدم فى الحرق أعلى من المستخدم فى التخزين فى الدفن. حيث أن 95.0% من الوقود المستهلك فى الإحراق يستخدم فى عملية الإشعال والإحراق نفسه، فى حين أن 94% من من الوقود المستهلك فى الدفن يستخدم أثناء النقل وتوزيع المخلفات.

١٤. بإختبار معيار احتمالية التأثير على ظاهرة "الاحتباس الحرارى" نتيجة لإستخدام طريقة الدفن وجد انهينتج عنها 32.9 كجم مكافئ ثانى اكسيد الكربونلكل طن انتاج من الألياف. أهم العوامل المؤثرة فى هذه الحالة هو انبعاثات غاز الميثان من المدفن. أما فى حالة الحرق فانهينتج 513.1 كجم مكافئ ثانى اكسيد الكربون/طن ألياف أكريليك، من ذلك يتضح أن الانبعاثات الناجمة من الوقود الحفرى أثناء عملية الحرق هى الأكثر تسببا فى التأثير على مؤشر "الاحتباس الحرارى".

١٥. عند دراسة معيار "التأثير الحمضى" و"التأثير على الجهاز التنفسى" نتيجة لإنبعاثات عملية الحرق مقارنة بالدفن يتضح أن تأثير الأول أعلى حيث ينبعث 46.8مليجرام ثانى أكسيد الكبريت فى مقابل 35.1 مليجرام فى حالة الدفن. كما أن إنبعاثات ثانى أكسيد النتروجين تصل لخمس مرات أعلى فى حالة الحرق عنها فى حالة الدفن حيث بلغت: 488.5 و88.0مليجرام/طن إنتاج على الترتيب.

١٦. تظهر النتائج أيضا أن "التأثير السام على البيئة" و"التأثير المسبب للسرطان" يكون عشر مرات أعلى فى حالة الدفنمقارنةبالحرق نتيجة تسرب عناصر الزنك والزرنيخ والكادميوم الموجوده فى مخلفات الأصباغ الى المياه السطحية والجوفية.

من أهم ما تم التوصل اليه فى هذه الدراسة إن تطبيق نظم إدارة للطاقة والمخلفات يحقق حماية للبيئة وخفض مباشر فى التكاليف كما أنه يمكن تحديد أكثر العوامل تأثيرا على البيئة ونسبة هذا التأثير كميًا. تعتبر الدراسة نموذج قابل للتطبيق فى صناعات أخرى عديدة.

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إدارة الطاقة والمخلفات فى صناعة الألياف الصناعية

دراسة حالة : شركة الأسكندرية للفيبر

رسالة مقدمة من

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إدارة الطاقة والمخلفات فى صناعة الألياف الصناعية دراسة حالة : شركة الإسكندرية للفيبر

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كمتطلب جزئى للحصول على درجة دكتوراه الفلسفة

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