FREE LCA: THE USE OF ELCD IN THE DESIGN STAGE

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Abstract

Small and medium enterprises are more and more conscious about knowing the actual products environmental impact. However, they are coming up against two obstacles: firstly, the economic cost by the buy of specialized software; secondly, the difficulty supposed by its use.

Moreover, it is essential to provide an integrated LCA (Life Cycle Assessment) approach that considers environmental impacts of product design in CAE (Computer-Aided Engineering) programs.

This work shows an approximation to a new free LCA based in the ELCD (European Reference Life Cycle Data) system using new available web technologies such as RIA (Rich Internet Applications).

Based on the information that manages the product and process representation, the tool applies the calculation of Eco-Indicator 99 using the European Reference Life Cycle Data System (ELCD). The results are shown in a graphical user interface compatible with any CAE system.

***Keywords**: LCA, eco-design, ELCD*

Introduction

Currently, the growing importance of environmental criteria and, in turn, competitiveness in product design creates the need to incorporate in an effective LCA in the early stages of design.

It is thus essential to provide an approach that considers environmental impacts in product design through CAE programs. This is especially important in a world where the economic system is based on steady growth in industrial production, consumption and disposal of products (Marosky et al .2001; Leibrecht, 2005; Faneye, Anderl, 2001).

The actual environmental performance of a product can only be determined by considering the impact of their life cycle as a whole, thus including all known impacts in its analysis (Gabbar, 2007).

This paper describes the architecture of a tool designed to integrate information lifecycle CAE systems. The research shows the feasibility of incorporating environmental criteria into the design without the necessity of using specialized software. The fact that the proposed analysis is fully automatic analysis implies that the manuals, and in turn tedious, can be avoid showing the effects of improved design instantly.

The article is divided as follows: First we give the currently existing types of LCA and various databases such as software used by these databases to conduct the inventory analysis of the system. Then we explain the macro based on the free database ELCD. Finally it is applied to a case study of a static cogged brake of an underwater camera.

Methodology

One of the most widely accepted by the scientific community to assess the environmental impact is LCA, an analytical procedure that assesses the entire life cycle of a process or product. LCA addresses the environmental aspects and potential environmental impacts (e.g. resource use and environmental consequences of emissions) throughout the entire lifecycle of a product from raw materials acquisition, through production, usage, final treatment, recycling, until its final disposal (UNE-EN ISO 14040:2006).

Although in some cases not possible to conduct the entire product of an LCA, the analysis itself is still useful as a tool for environmental management of production systems as it enables identifying the source of the problem to optimize resource use and / or management of waste (Wrisberg et al., 1997). It can also serve to compare two or more alternative products to fulfill the same function and also as a tool in eco-design, because they can evaluate alternative materials contributing to the development of materials more environmentally friendly. Ecodesign can be defined as the systematic incorporation of environmental aspects into product design, the purpose of reducing their negative impact on the environment throughout its life cycle.

One clear advantage of LCA is to detect situations in which a particular system seems cleaner than another simply because it transfers the environmental burdens to other processes or geographic region, without a real improvement from the global point of view (known as shifting problem) (Iglesias, 2005).

Therefore, LCA can help actions such as identifying opportunities to improve performance of products in various stages of their life cycle, providing information to decision makers in industry, government organizations or NGOs, selection of environmental performance indicators and marketing (UNE-EN ISO 14040:2006).

LCA studies include four phases, namely the definition of objectives and scope, inventory analysis (LCI), impact assessment (EICV) and interpretation. Figure 1 depicts the relationship between them.

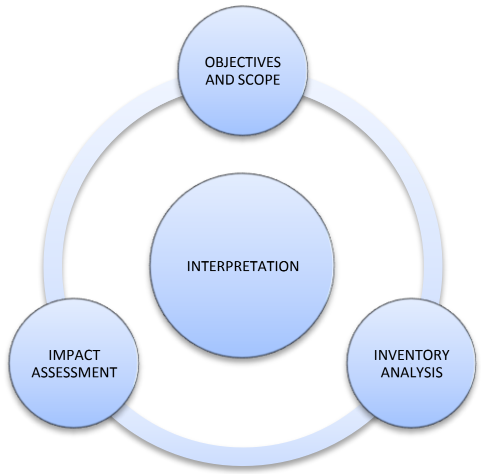


Figure 1: Stages of an LCA, adapted from UNE-EN ISO 14040:2006

In LCA studies different databases and programs available in the market can be used. It is under strain in recent years to build and standardize databases for LCA inventories as the accessibility of data remains a serious problem.

The databases used in studies of LCA available at European or even world sometimes leads to errors in applying to European technology or global average, for example in Spain.

The software uses databases of products and processes for the inventory analysis system to analyze. The most current available databases are Ecoinvent, BUWAL 250, ETH-ESU 96 collects data from Switzerland, IVAM, the Netherlands or the Franklin database, which makes the United States. Because there are substantial differences between industries in the EU, appears necessary to conduct a specific database, or the adequacy of already marketed for national implementation. Currently, there are countries which have worked or are working on developing a database for LCA itself, such as Germany, Switzerland, USA and Japan.

Another problem that exists is the availability of these databases as they are privately owned and can be an added economic effort unsupportable for certain companies or individuals. Therefore, a major step towards the realization of public databases and applications is the so-called European Reference Life Cycle Data System (ELCD). ELCD is one of the results of the European Platform on Life Cycle Assessment (EPLCA), an EU project coordinated by the JRC-IES (Joint Research Center - Institute for Environment and Sustainability) in Ispra (Italy) in collaboration with the DG Environment Directorate Integration of Sustainable Development, whose aim is to increase knowledge, acceptance and implementation of life cycle perspective (Life Cycle Thinking) and LCA in industry and government, by (Fullana, 2008): Greater consistency and quality of LCA data, methods and studies.

- An increase in the availability and exchange of information.
- A reduction in costs.
- A clear focus on research and development

The first phase of this project was implemented from September 2005 until August 2008. The main results of this project were:

- European Reference Life Cycle Database (ELCD) (one of the components of the *International Reference Life Cycle Data System* (ILCD)).

- Manual with recommendations for LCA (co-developed with the ILCD).
- EPLCA Website: http://lca.jrc.ec.europa.eu/lcainfohub/index.vm.

ELCD is a compilation of life cycle inventory data and impact assessment for LCA. Currently in included major material inventories (plastics, metals, inorganic chemicals and wood), energy, transport and waste management. The available data have been provided or approved by the industry, and are harmonized data and revised. On the website you can download the latest version of the database and are also available complete inventories available without downloading (Fullana, 2008).

As for software for the application of LCA there are several on the market, which already have embedded databases. Although each has its own characteristics, most of them are based on the same methodology and have common features. Its applications change depending on the stage of life cycle, from developing a product concept, to that the product is ready for release or should be removed for reuse or final disposal. These elements include the LCAmanager, Cyclops, Eco-it, Eco-edit, EcoScan, EcoLab, SimaPro, Umberto, Team, Gabi, Green-e, CMLCA, Athena Model, PT Pointers, LCAiT-CIT Ekologic, Design System, KLC -ECO, among others.The most commonly used by the scientific community are often the SimaPro (developed by the company PRé Consultants of the Netherlands) and Gabi Software (developed by the company PE International).

ELCD macro

Based on the information that manages to represent the goods and the process, the tool applies the calculation of the Eco-Indicator 99 using the ELCD system.

In Figure 2 one can see the architecture of this tool based on two different parts: The macro ELCD and ELCD algorithm.

ELCD algorithm is the application of an algorithm in a spreadsheet to link the values of the Eco-Indicator 99 with information from the database ELCD and the product being designed in a CAE system.

The results can be viewed in a CAE system in a ELCD macro. A Web Service provides users a CAE system the ability to request and receive ELCD data information back to the ELCD macro. The ELCD macro displays the information related to the manufacturing process, material and physical properties of the product and thus the value of environmental impact. Furthermore, this information can be displayed in a graphical interface.

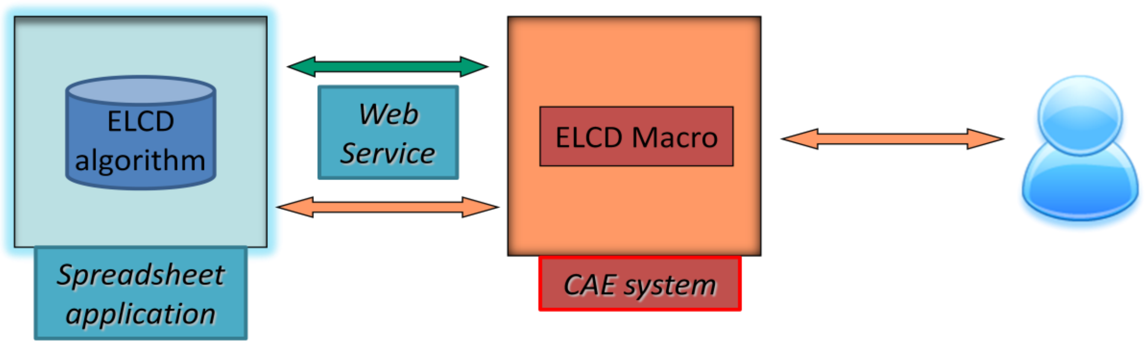
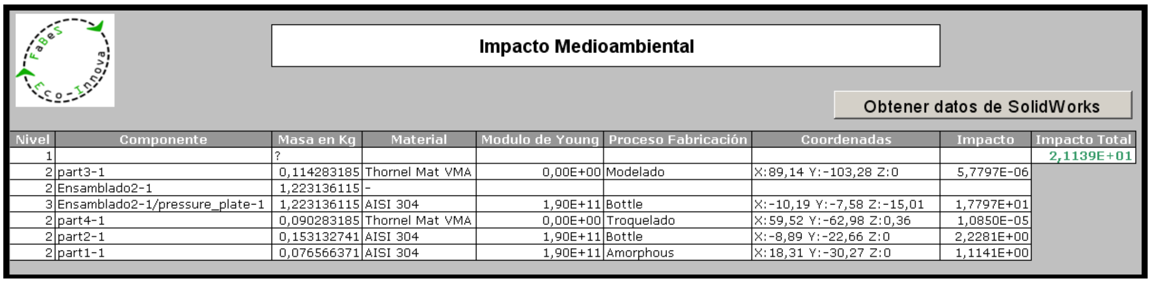


Figure 2: Overview of the architecture of the LCA.

This version is based on the automatic creation of an Excel spreadsheet for calculating environmental impact. A macro developed in Visual Basic and launched from the CAD software can assign a manufacturing process of the database ELCD each piece being designed (Figure 3).

Figure 3: Macro on the manufacturing process.

From the spreadsheet, and with CAD software opened, the macros are thrown in order to calculate the impact of the assembly in the window CAD (Figure 4).



Impacto Medioambiental

Obtener datos de SolidWorks

Nivel	Componente	Masa en Kg	Material	Modulo de Young	Proceso Fabricación	Coordenadas	Impacto	Impacto Total
1		?						2,1139E+01
2	part3-1	0,114283185	Thornel Mat VMA	0,00E+00	Modelado	X:89,14 Y:-103,28 Z:0	5,7797E-06	
2	Ensamblado2-1	1,223136115	-					
3	Ensamblado2-1/pressure_plate-1	1,223136115	AISI 304	1,90E+11	Bottle	X:-10,19 Y:-7,58 Z:-15,01	1,7797E+01	
2	part4-1	0,090283185	Thornel Mat VMA	0,00E+00	Troquelado	X:59,52 Y:-62,98 Z:0,36	1,0850E-05	
2	part2-1	0,153132741	AISI 304	1,90E+11	Bottle	X:-8,89 Y:-22,66 Z:0	2,2281E+00	
2	part1-1	0,076566371	AISI 304	1,90E+11	Amorphous	X:18,31 Y:-30,27 Z:0	1,1141E+00	

Figure 4: Macro for calculating the environmental impact.

In order to help the designer to reduce the environmental impact of the model being designed, the option of building simulations has been joined. The spreadsheet gives the ability to change one by one the materials or manufacturing processes of assembly and to simulate the environmental impact of the full model with those new features.

Un grafico de simulación generado automáticamente permite comparar el impacto medioambiental del modelo actual con el simulado (Figura 5). An automatically generated graphic simulation allows the comparison of the environmental impact of the current model with the simulation (Figure 5).

The later version will safeguard the environmental impact of a part or assembly without having to resort to using a spreadsheet. The environmental impact of the designed model can be ordered directly from the CAD user interface. Throwing a window macro from the CAD design, the user is prompted to choose a part or an assembly. The API contains the material data, mass manufacturing and transportation process previously established for each piece. Los manda por servicios web al servidor donde está alojada la hoja de cálculo de impacto medioambiental. It is sent by web service to the server where is hosted the environmental impact spreadsheet. And it returns the result of calculation in the same window of the CAD interface designer.

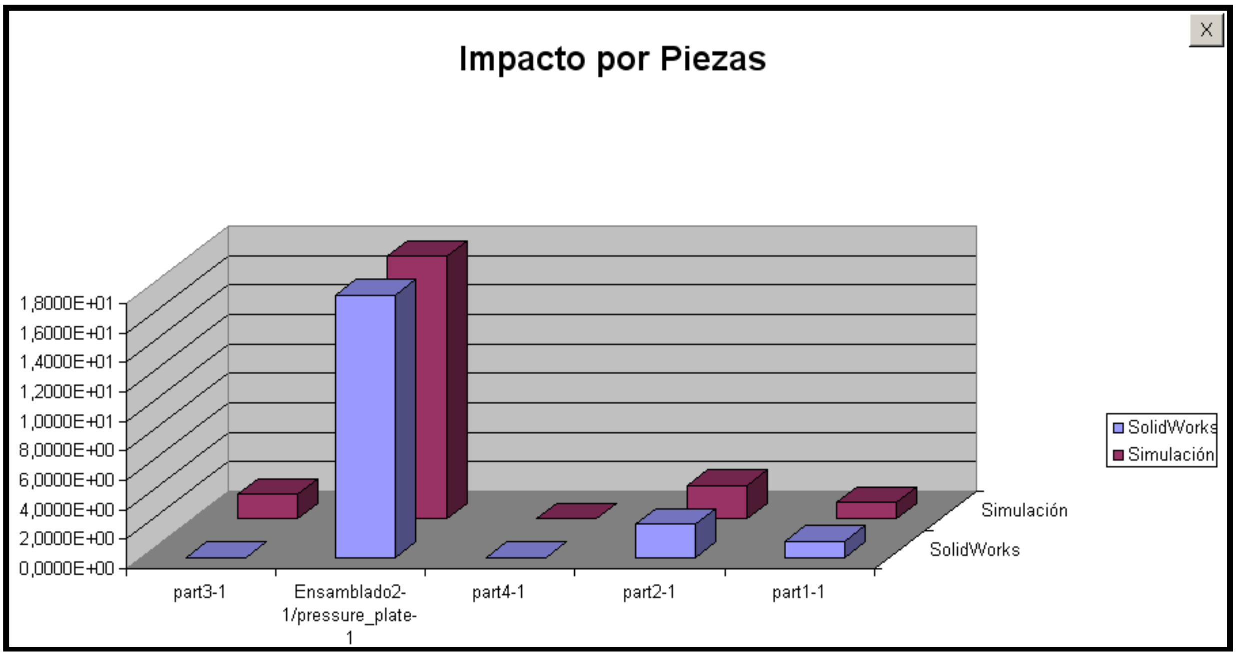


Figure 5: Graphical simulation of the environmental impact

Results

The results are displayed in a graphical user interface CAE Solidworks system. As a practical illustration, the evaluation of a static cogged brake of an underwater camera is shown.

Figure 5 shows the representation of the environmental impact of a static cogged brake in Solidworks.

Conclusions

This paper presents a new scheme in the development of new technologies applied in the field of LCA. The implementation of the ELCD database opens the possibility while allowing the development of new models which link information about a product that is being designed with its environmental impact.

En próximos meses, haciendo uso de las nuevas tecnologías web disponibles tales como RIA (Rich Internet Applications - Aplicaciones de Internet Enriquecidas), se pretende completar la disponibilidad de esta herramienta como software libre sustituyendo la necesidad de utilización de una hoja de cálculo y por tanto del programa Microsoft Excel y del lenguaje de programación Visual Basic. In the next months, making use of new web technologies available such as RIA (Rich Internet Applications) are intended to supplement the availability of this tool as free software replacing the need of using a spreadsheet and therefore, of Microsoft Excel and Visual Basic programming language.

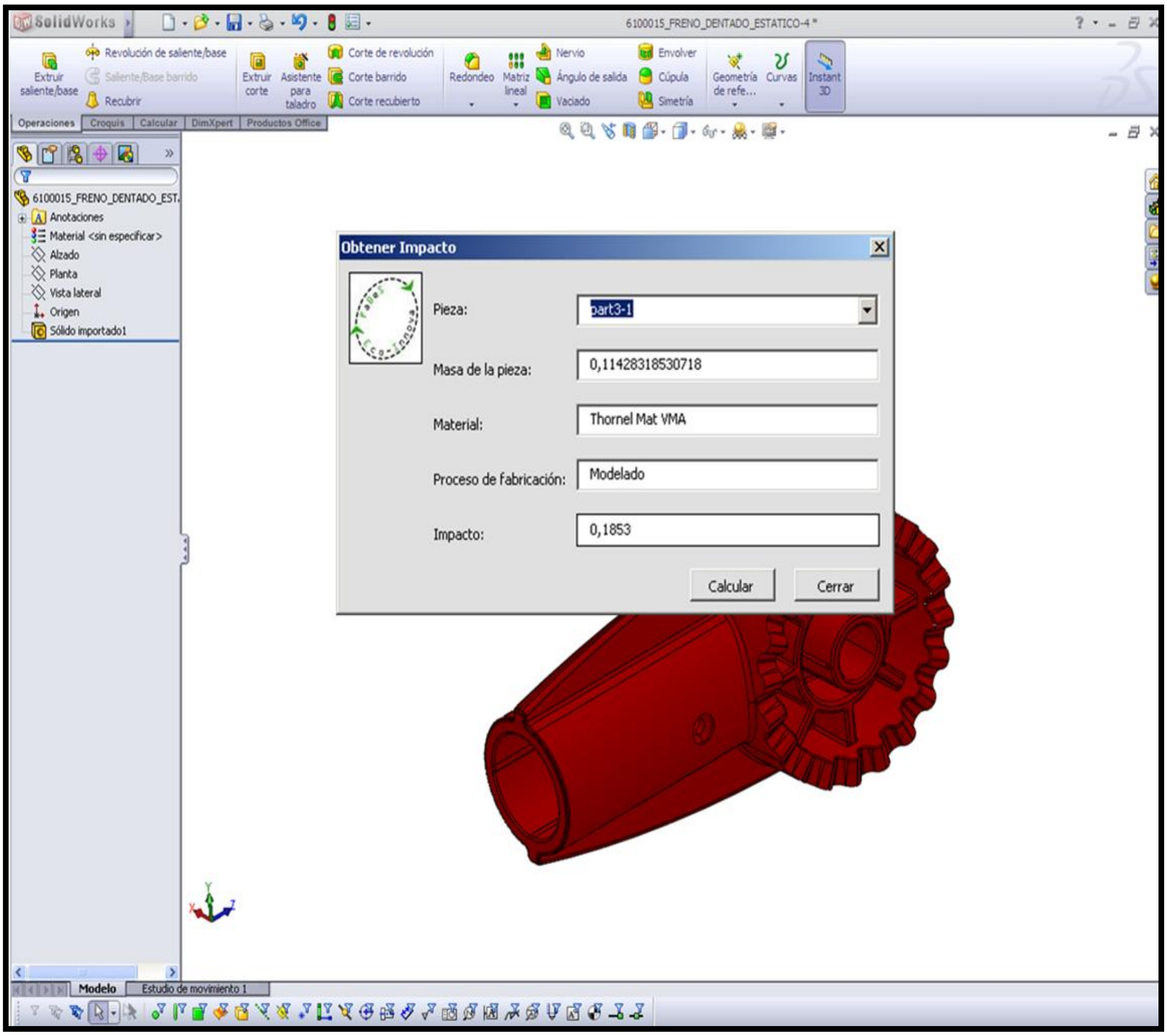


Figure 5: Representation of the environmental impact of a static cogged brake in Solidworks.

References

Marosky, N., Dose, J., Fleischer G., Ackermann R.: “Challenges of Data Transfer between CAD- and LCA Software Tools”. *3rd International Conference on Life Cycle Management. Zurich (Switzerland)*, 2007.

Faneye O. B., Anderl R. Life Cycle Process Knowledge – Application during Product Design. *Second International Symposium on Environmentally Conscious Design and Inverse Manufacturing.* Tokyo, Japan, 2001.

Fullana, P. “ELCD – European Life Cycle Data System”, Seminario “Herramientas informáticas asociadas al ACV”, Universitat de Barcelona, Bellatera, Barcelona, España, Junio 2008.

Gabbar, H.A.: Life Cycle Assessment and Environmental Impact Analysis for green energy production plants. *Proceedings of the Sixth International Conference on Machine Learning and Cybernetics.* Hong Kong, 2007.

Iglesias, D.H. “Relevamiento exploratorio del análisis del ciclo de vida de productos y su aplicación en el sistema agroalimentario”, Contribuciones a la Economía, 2005 [http://www.eumed.net/ce - acceso en noviembre de 2007]

Leibrecht, S. Fundamental Principles for CAD-based Ecological Assessments. *International Journal of LCA 10 (6) 2005*. Pages 436 – 444.

UNE-EN ISO 14040:2006, "Gestión ambiental, Análisis del ciclo de vida, Principios y marco de referencia".

Vidal R, Bovea M, Belles MJ, Montilla C: Desarrollo de una herramienta gráfica para el ecodiseño de productos, *Departamento de Tecnología. Universitat Jaume I de Castellón, 2003* - aeipro.com.

Wrisberg, N., Udo de Haes, H.A., Clift, R., Frischknecht, R., Grisel, L., Hofstetter, P., Jensen, A., Lindfors, L.G., Schmidt-Bleek, F., Stiller, H. "A Strategic Research Programme for Life Cycle Assessment", Final Document for the Concerted Action LCANET, LCA Documents, 1997, Vol. 1, pp. 15-31.

Acknowledgments

The authors are grateful to the Ministry of Education and Science for their funding under the project with reference DPI2006-15570-C02-01 and DPI2006-15570-C02-02 in the National Plan of R & D project (2004 to 2007) and FEDER funds of the European Union. Similarly, the authors are grateful for support from other staff of Design Engineering Group (GID) of the Universitat Jaume I and the technology center LABEIN Tecnalia..

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