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LCA Software for Engineering Training on Product Development

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Abstract:

Environmental awareness has been growing gradually in recent decades. Legislation is introducing ecodesign measures in products. Because of that, ecodesign is becoming an important discipline in engineering, to take into account the environmental impact of the product during its development, performing Life Cycle Assessment, but it is not still a common discipline in engineering. Training focused on LCA for product development is essential to introduce ecodesign between engineering students, who are not used to work with environmental concepts. The best tool for this training is LCA software to learn through the practice how to calculate the environmental impact of a design.

This work presents the ECOTOOL, software designed to train engineers in LCA methodology. Current existing LCA software are not prepared to be used by untrained engineers, sometimes because they are difficult to be used due to large databases and the complex working environment, and sometimes they are extremely simplified, not sensitive to design modifications. ECOTOOL allows complete LCA performing with a working environment similar to other engineering tools, like professional CAD software, well known

by engineers. It is provided with reduced databases, training helps, simplified results and a working environment designed to allow students to easily analyze the environmental impact of their designs and apply design actions to optimize it, at the same time they learn the concepts of environmental impact assessment process.

Keywords: training, software, ecodesign, LCA.

1. Introduction

Minimum environmental impact is a designing criterion, which is starting to be taken into account when developing new products. Increasingly companies want to incorporate ecodesign in their processes, and legislation is starting to demand ecological actions over the products [1]. This is a consequence of the increment of the environmental conscience in the recent decades.

The European Union analyses the public opinion in the Members States through Eurobarometer surveys, and shows that over the 75% of European think that environmental issues affects directly their quality of life, and they will pay more for environmentally friendly products, and think that it is necessary the European Union to protect the environment by means of new legislation [2] [3].

During the last decade, environmental factor got more rooted in the society, and ecodesign was fomented in different competitions, like the UK Design Sense, the German IF, the Austrian Ecodesign or the Australian Sustainable Living Design Awards [4]. Several authors also remark the necessity of incorporate environmental criterion into design procedures to ensure a sustainable product development [5] [6].

Legislation and Normalization experienced an evolution around environmental issues. During the last decade, the directive ErP 2009/125/CE (Energy related Products) [7] was approved, setting ecological requirements for these kind of products. Also the regulation REACH 1907/2006 was approved to control the use of chemicals in Europe [8]. Actually, we can find the Standard ISO14006 [9], which establish an application frame for Ecodesign in companies. This is just a brief extraction of the Legislation and Normalization directly linked with Ecodesign, and they are the main pusher for companies, especially for big companies, to include Ecodesign in their processes [10] [11].

The development of software for environmental assessment is contributing to the expansion of the ecodesign discipline in companies. Some of the most famous software like Simapro or GABI are focused on the ACV calculation, using information from databases like Ecoinvent. To help introducing ecodesign in the product development world, simplified tools are being developed to apply ecodesign. The UNEP (United Nation Environment Programme) recommend the using of ecodesign tools like MET matrix, Ecocompass or Golden Rules [12].

Several authors remark the necessity of training on ecodesign through environmental assessment software, to introduce this discipline into the product development culture [13] [14]. To increase the effectiveness of the training, it is recommended to develop this ecodesign tools with a didactical character and oriented to designers, so, at the same time they are using the software to calculate the environmental impact of the product, they are learning the basis of ecodesign and Life Cycle Assessment [15].

This paper presents the Software Ecotool, developed in the University of Zaragoza as an Environmental impact assessment tool specially designed to be used in a product development process.

The program can be customized for a specific product, so the databases are easier to be used, instead of the public databases existing in the market.

This software has been adapted to be used in a training context. Its user interface has been carefully designed to be its way of working easy to use when being used by engineering students, and it is provided with helping commands that explain the way of working of the program and also teach about the environmental impact assessment and the LCA method at the same time the user is calculating the environmental impact of the product.

2. ECOTOOL environmental assessment methodology

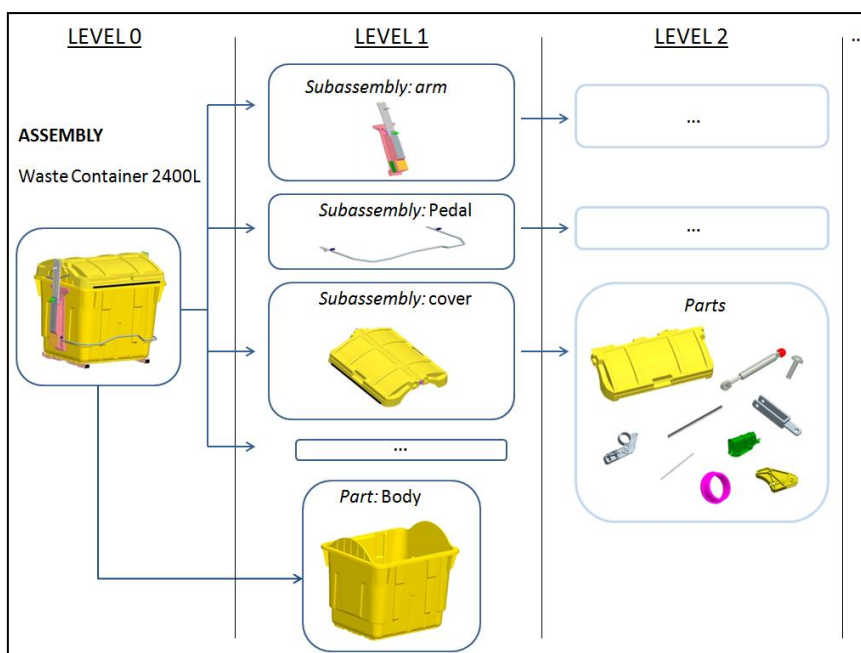
The software structure is divided in three main blocks, which are: Calculation, Databases and Results module. All this blocks are followed by the helping files, which explain the working of the software. The relation between these three modules is the basis of the software.

2.1 Calculation module

The calculation methodology implemented in the software has been adapted to designers working environment, using data input structures similar to other software known by designers, and simplifying the required information, being data that is easy to be collected by engineers while they are designing the product. This will help the training on ecodesign, not applying difficulty to the use of the software and the data input, so students can focus on the analysis of the design from an ecological point of view.

The software allows introducing the information of the product in a tree structure, introducing the different parts of the product in different levels. The level 0 represent the complete product, and the product is discomposed until the most simply parts are introduced. The following picture shows, as an example, the breakdown of a waste container (Figure 1).

Figure 1. Breakdown example of a waste container



This is a simple and organized way of decomposing the product for students, which will help them to learn how to organize a product structure, and manage the bill of materials of a product. For mechanical engineers, it is a useful way of organizing the product assembly.

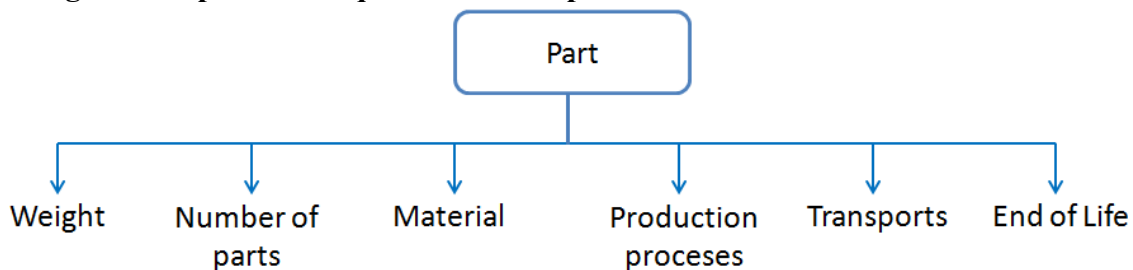
The software calculates the environmental impact of the product by means of an additive procedure, calculating the impact of each part individually, and adding the environmental impact of each one to obtain the total impact of the product. This calculation is made by means of the calculation of an LCA for each part, obtaining the environmental impact of the materials, the transports, production processes and the End of Life of the product. The following picture (Figure 2) shows the diagram of the calculation of the total environmental impact of one part.

Figure 2. Calculation of total environmental impact



To calculate the environmental impact, the software requires from the user the data shown in Figure 3. This data is very easy to be obtained by designers at the same time they are developing the product, and its manipulation does not generate additional difficulties to the LCA process.

Figure 3. Input data required for each part



This way of calculation helps the students to analyze individually each part, looking how the modifications of the design, the material selection, the production processes, transports and also the end of life affects to the environmental impact of the part, and then, they simply add this result to the main product structure to analyze its contribution to the environmental impact of the whole product.

2.2 Databases

The software is provided by customized databases. They include the information of the environmental burdens of materials, processes and transports, processed by the ReCiPe Endpoint (H/A) methodology [16]. The databases developed in this software encompass the selection of the burden databases and the calculation process, so the students does not need to be aware of the selection of the databases and the calculation methodology, and they can be focused on the design impact calculation.

ReCiPe methodology has been selected due to the complete calculation process, which takes into account the environmental impact related to damage over Human health, Ecosystems and Resources.

This methodology calculates the environmental impact giving the result in just one datum, so its interpretation is very easy for designers, just being necessary to work with one result, being very easy to compare different designs and analyze the influence of design changes over the environmental impact of the product.

Global Warming Potential has been selected too due to its extended use, and to analyze the effect of design modifications over the Carbon Footprint, and compare this effect with the endpoint from ReCiPe.

2.3 Results module

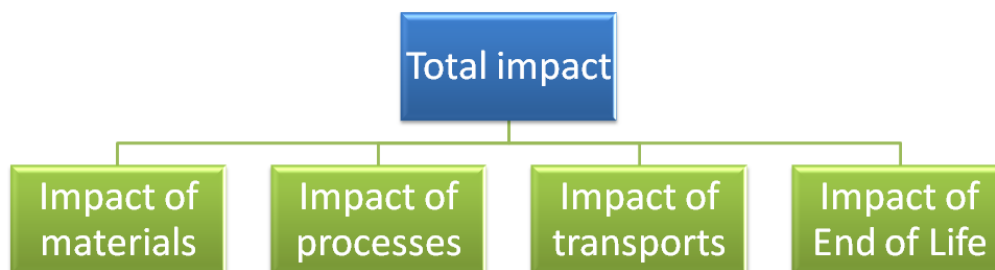
The software gives to the user different kinds of results directly on screen. These results are:

- Numerical results
- Graphical results

Numerical results

These are the results of the environmental impact of the part and the different subassemblies. These results are also presented separated in the different results corresponding to each phase of the life cycle (Figure 4).

Figure 4. Numerical results diagram



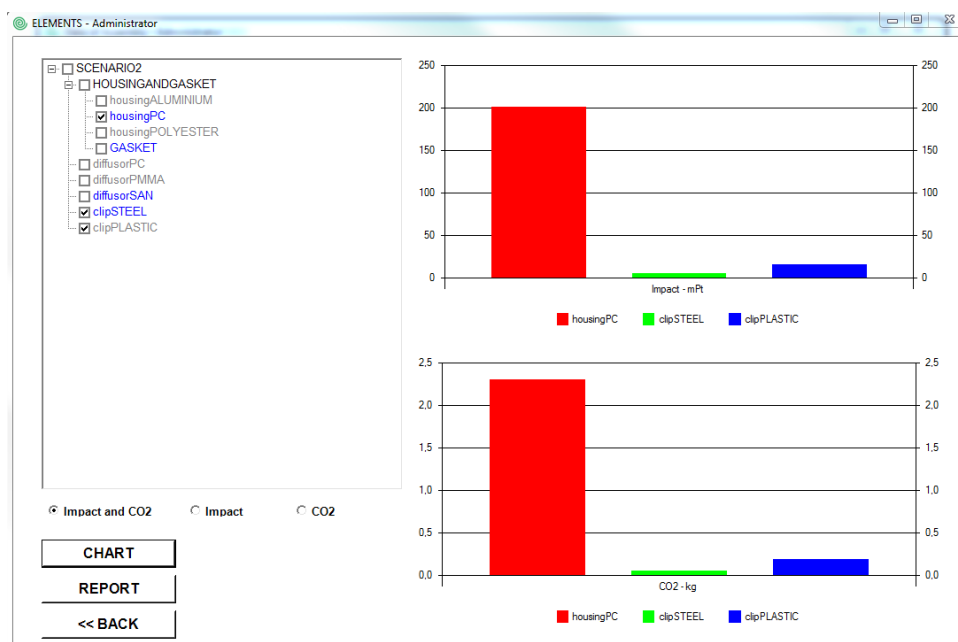
These results are shown to the user during the introduction of the information of each part. Engineering students can analyze, simultaneously to the data input process, the influence of the design actions over the environmental impact at the different stages of the life cycle, and develop design strategies to reduce the environmental impact, focused on the stage with worst results. This instant result showing makes easier to the students to try different inputs and show quickly the results, speeding up the training process.

Graphical results

These are the graphical representation of the numerical results. This kind of results help the students to compare the impact of different parts, or analyze the impact distribution depending on the materials, for example, what are the most harmful plastics, or analyze the processes. The following picture, (Figure 5), shows an example of graphical results included in the software. In this case, the chart helps to compare the results of the selected parts in the tree structure on the left side. It is a very easy way of

comparing results, giving to the students an easy tool to analyze design variants and improve their training.

Figure 5. Graphical results example

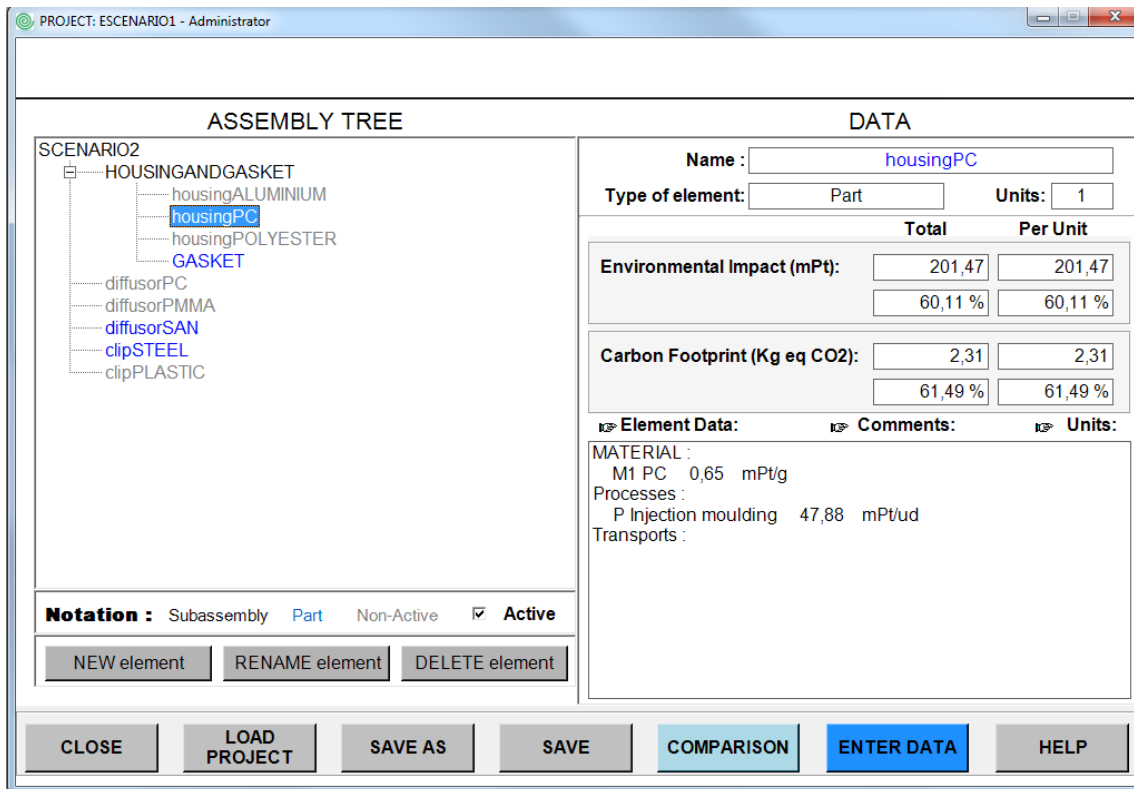


3. ECOTOOL software

The methodology explained above has been implemented in the software ECOTOOL, through an interface designed to train students, including help commands explaining each window, so students can easily use the software and learn the basis of LCA methodology.

The following picture (Figure 6) shows the Product Structure Configuration Screen, where the students introduce the different parts of the product decomposed in the different parts and subassemblies. This screen shows also the results of the selected part, and the inputs for the calculation, show in just one screen all the information can be found.

Figure 6. Product structure configuration screen



Once the product structure is introduced, the software allows the students to introduce the information of each part by means of the enter data button, and, with the help of the databases, they introduce the data related to materials, processes, transports and end of life.

During this operation, the student can see at any moment the results of the analysis while he introduces the information, and they have at their disposal HELP buttons to access to the helping screens, with all the information necessary to learn the way of working of the screen where the student is placed.

4. Conclusions

The software developed, ECOTOOL, helps engineering students to learn the basis of the Life Cycle Assessment method, and how their decisions over the design of the product can affect the environmental impact. The methodology implemented in the software allows the students to perform an LCA without the necessity of using professional software, and the user interface makes easy for students to compare different design options, with a simple calculation process, which helps them to focus just on the relation between design actions and environmental impact, avoiding the difficulties related to professional software and complex concepts about Environmental assessment.

Conflict of Interest

The authors declare no conflict of interest

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