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INTEGRATING ENVIRONMENTAL CONCERNS INTO PRODUCT DESIGN

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ABSTRACT

This article focuses on the product design and the role played by environmental concerns over the life cycle. In this case, 3D modeling of a wooden ironing board by using CATIA is proposed. Thus, to evaluate design all alternatives and identify that best satisfying the environmental requirements, it is necessary to make use of suitable tools able to quantify the environmental performance into product design.

KEYWORDS: environment, ecodesign, wooden ironing board, LCA, CATIA.

1. INTRODUCTION

Excessive consumption of these energy sources has a devastating effect on the environment, the planet life and thus on the quality of life, both present and future. The solution of these problems found by designers is creating and modelling some eco-products using CAD systems. A good designer takes into account environmental concerns but one important problem in green design is to create products which are lasting and likely to be recycled. This paper focuses on the product design process and the role played in ecodesign.

Ecodesign depends on identifying the environmental aspects of the product and includes these issues to design process already in the early stage of product development. In the foreign literature, the notion of ecodesign can be found as: environmental design, ecological design, sustainable product design, green design. Ecodesign is an approach to design of a product with special consideration for the environmental impacts of the product during its whole life cycle. [7], [10]

Life Cycle Assessment (LCA) is "an objective process to evaluate the environmental burdens associated with a product, process, or activity by identifying energy and materials used and wastes released to the environment, and to evaluate and implement opportunities to affect environmental improvements." (ISO, 1999). [19].

LCA is a technique that allows a environmental analysis of the whole product, giving an evaluation of the performance in relation to the entire life cycle. [8]

2. LIFE CYCLE ASSESSMENT (LCA)

The objective of this work is to show the importance of LCA and its necessity for all decisions concerning environmental performance of the product design. Firstly, we start by highlighting the theoretical foundations on the integration of environmental aspects into product design. LCA is based on several principles. In the life cycle of design aimed at improving the environment of the product, evaluation results must be distributed in all phases of the design process. Figure 1 provides an approach based on the life cycle focusing on the integration of all stages of product life. [9]

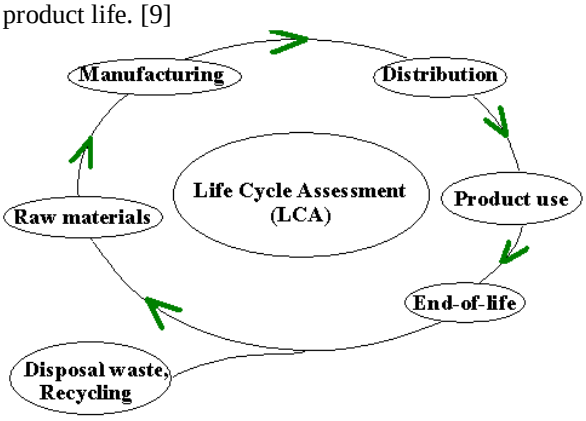

Fig.1. Life Cycle Assessment

The life cycle of a product is described as a series of stages from raw material extraction, processing, transportation, manufacturing, distribution, use, re-use and recycling to final disposal as it can be seen in figure 1. [14]

3. THE LIFE CYCLE ASSESSMENT (LCA) METHODOLOGY

In recent years, LCA has been identified as one of the most interesting tools for environmental assessment. LCA evaluates all stages of a product's life and considers each stage interdependently. Recognition of the validity and utility of the LCA methodology led to international standardization into ISO 14040/14044. The methodological framework for LCA is an iterative process and consists of four phases which are outlined in figure 2. [12], [17]

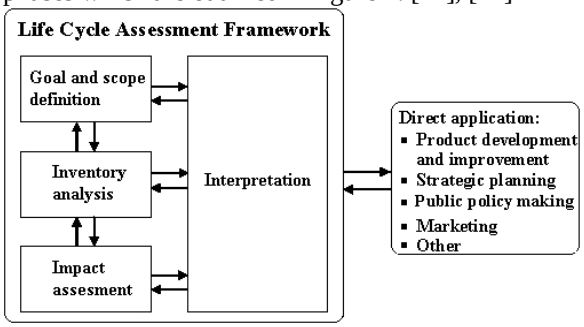

Fig.2. Life Cycle Assessment Framework

1. **Goal and scope definition** - defines how a big part of product life cycle will be taken to assessment and to what the assessment will be serving.
2. **Inventory analysis (LCI)** - is considered to be the most developed of all and indicates the relevant inputs and outputs of a product system. Figure 3 presents a schematic of a typical product manufacturing process. According to this figure, the inputs include raw materials, water and energy. The outputs, that usually have a negative impact on the environment, include air emissions, soil pollution, waterborne wastes, coproducts, solid wastes and other releases. [15], [18]

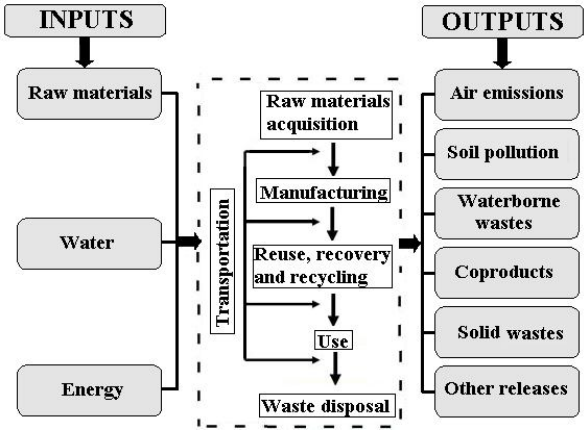

Fig.3. Inputs and outputs for a Life Cycle Assessment

3. **Impact assessment (LCIA)** - aims to assess the significance of potential environmental impacts using all inventory analysis results. All the information from inventory analysis serves for impact assessment.

For a proper impact assessment, the following steps are required [16] :

- *Selection and Definition of Impact Categories* - identifying relevant environmental impact categories (for example: smog formation, aquatic and terrestrial toxicity, global warming, acidification, etc.).
- *Classification* - assigning of inventory data to the impact categories (for example, classifying carbon dioxide emissions to global warming).
- *Characterization* - conversion of LCI results to common units and finally aggregated within each impact category. This results in a numerical indicator result, namely, the LCIA profile for the product system.
- *Normalisation* - "Calculation of the magnitude of category indicator results relative to reference information", according ISO 14042, (for example, old products constitute baseline when assigning a new product).
- *Weighting* - includes aggregation of indicator results into a single value which represents an overall impact value.
- *Grouping* - consists of sorting and possibly ranking of the impact categories.

The international standard for life cycle impact assessment, ISO 14042, considers that *Selection and Definition of Impact Categories*, *Classification* and *Characterization* are mandatory elements for an LCIA. Optional elements are normalization, weighing and grouping.

Table 1 provides a list of the impact categories based on global, regional, local and other criteria.

Table 1- Impact categories

Global	use of resources renewable and nonrenewable water resource use; land use; global warming; stratospheric ozone depletion; release of persistent toxic substances (PTS).
Regional	acidification of water and soil; waste disposal, etc.
Local	human toxicity; photochemical ozone formation, etc.
Other	noise pollution; chemical smell,etc.

4. **Interpretation** - is an iterative process that includes drawing conclusions and making recommendations from the life inventory analysis (LCI) and impact assessment (LCIA). ISO 14044 defines life cycle interpretation as the "phase of life cycle assessment in which the findings of either the inventory analysis or the impact assessment, or both, are evaluated in relation to

the defined goal and scope in order to reach conclusions and recommendations". [20]

4. LCA AS ECODESIGN TOOL FOR WOODEN PRODUCTS

LCA is a methodology for assessing the environmental performance of process, products or materials during the life cycle, from extraction through manufacturing, transportation, use, maintenance and disposal or recycling. LCA is an important tool for assessing and reducing the impact of human activities on the environment. The most important objectives of LCA are: conserve nonrenewable resources; develop and utilize cleaner technologies; maximize recycling of materials and waste; adopt the most appropriate emission prevention and abatement techniques, etc.

Environmental impact of a product is determined at the design stage, therefore, the implementation of ecodesign and LCA is more than necessary.

A major requirement in ecodesign consists in choosing green materials. The concept of "green" is becoming increasingly important in today's world, as concern about environmental impact becomes widespread. Nowadays, very few of the materials that we use in lives are sustainably produced.

Wood is considered to be one of the "greenest" materials available. It is versatile and beautiful with a positive environmental profile. The wood products perform better with respect to energy use and "global warming potential" than other products.

In terms of its energy- and environment-related life cycle assessment, wood is a renewable raw material, that has a positive effect on the environment compared to other materials. Wood uses much less energy for harvesting and processing than other raw materials. Since most of our energy is produced in a way which creates greenhouse gases, the less energy used in processing, may result in less greenhouse gases. In addition, at the end of its life, wood can be completely recycled. Also, an increased use of wood will have a positive effect on energy consumption and emissions of greenhouse gases.

In this paper, we will present a conceptual model of a wooden ironing board, highlighting the importance of connecting ecodesign with LCA.

This type of a wooden ironing board can be realised using any graphic software. In this case, we have chosen CATIA program, which, at present is one of the most used CAD/CAM/CAE Systems. [1]

CATIA can provide a large variety of integrated solutions to satisfy all the aspects related to design and manufacture. This software gives us a variety of tools that allow us to easily document designs during any stage of drawing production. CATIA divides in more modules the Sketcher, Part Design and Drafting ones being emphasized in a special way.

CATIA Part Design is used to construct individual part models. Part models are constructed by adding and removing material from a base feature. [6]

We will start by opening Part Design application and we will create the final profile, using the following commands: Pad, Edge Fillet, Plane, Pocket, Mirror, etc. as shown in figure 4.

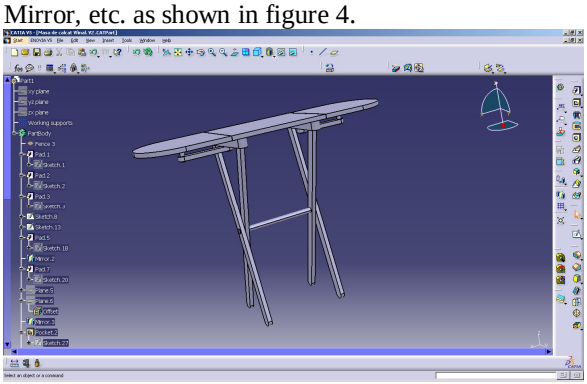

Fig.4. 3D geometric modeling of an ironing board

Thus designed, the ironing board includes a main ironing surface and two extendable ironing surfaces. This ironing board can be transformed into a table that can be placed in the bedroom, living room or kitchen. The ironing board is made of wood that is considered one of the best ecological material. In addition, the wood is a material which can be recycled at 100% . [2], [3]

Applying some materials or colors to a 3D model to enhance graphical detail is a common technique in the field of computer graphics. By applying material on the entire surface of the model the final product is obtained. We selected the Shiny Wood material from the Library dialog box as shown in figure 5. [5]

Fig.5. Applying the Shiny Wood material from the Library dialog box

A high quality of the image in terms of color to the final model can be obtained by calling the Properties command that is illustrated in figure 6.

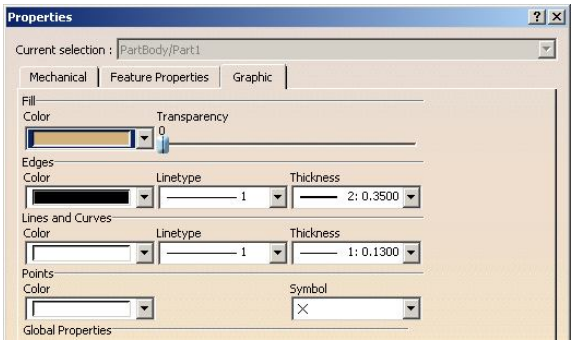

Fig.6. The Properties command

The final colour for the wooden ironing board is obtained by applying the Properties command as it can be seen in figure 7.

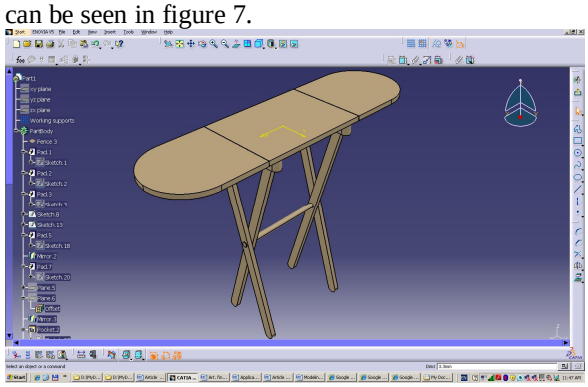

Fig.7. 3D geometric modeling of a wooden ironing board

In conclusion, 3D modeling of a wooden ironing board is considered to be the best choice, with regard to ecodesign requirements and of the LCA principles over the whole life cycle. Ecological materials are considered as having a high recycling rate and low impact on the environment. Where possible, the abuse of products should be actively prevented. [4]

3. CONCLUSIONS

LCA is a rigorous method of quantifying sustainabile development for estimating a product environmental impact at every stage of its existence, starting from extraction of raw materials to final disposal and recycling or reuse.

It is one of those tools necessary to make the right decisions concerning the environmental part of sustainable development taking into consideration the whole life cycle of a product which includes extracting and processing raw materials; manufacturing; transportation and distribution; product use; reuse, recycling and final disposal. [13]

The present article is a conceptual proposal of a wooden ironing board by applying ecodesign requirements and the LCA principles, maintaining their aesthetic characteristics. This wooden ironing board is designed to improve energy and resource efficiency, to fulfill growing international requirements with regard to environmental protection.

In recent years an increasing number of designers recognize that they can play an important role in creating "green" products.

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