INTERNATIONAL DESIGN CONFERENCE - DESIGN 2006
Dubrovnik - Croatia, May 15 - 18, 2006.

DESIGN 2006

ECODESIGN DECISION BOXES – A SYSTEMATIC TOOL FOR INTEGRATING ENVIRONMENTAL CONSIDERATIONS INTO PRODUCT DEVELOPMENT

H. O. A. Ghorabi, W. Wimmer and N. Bey

Keywords: ECO design, environmental design desicions, global warming, life cycle assessment (LCA), life cycle thinking

1. Introduction

Industry projects often show that Life Cycle Thinking and the idea of ECODESIGN are still not well established among engineers in product development. Available tools such as the ECODESIGN **P**roduct, **I**nvestigation, **L**earning and **O**ptimization **T**ool (PILOT) [Wimmer, Züst, Lee 2004] as well as its adaptations for companies, e.g. for an office furniture-developing company [Wimmer, Bey 2004], may help to implement ECODESIGN into product development considerations and to improve an already existing product for further designs. However, an application of those tools in the decisive early stages of the product development process may be difficult for design engineers.
In order to help engineers in product development to develop an environmentally sound product which already has an optimised environmental performance a systematic tool, the "Ecodesign Decision Boxes", was developed for integrating the concept of ECODESIGN into product development [Ostad Ahmad Ghorabi 2005].

2. Objective

The idea of the proposed Ecodesign Decision Boxes is to allow the implementation of environmental considerations in technical product designs. The intention was to develop a tool that allows optimizing the entire product as well as tracking and controlling the influence on environmental aspects of a product along its life cycle phases. An overall evaluation of the environmental performance of the product design as well as a detailed view on the performance of each component, part and of each material used in the components should be assured.
According to [Luttropp 1999] around 30 aspects need to be addressed in the product development process. Some of the aspects are e.g. materials, reliability, quality or profit. The environmental aspect is also one of the aspects which has to be considered in product development.
The Ecodesign Decision Boxes where developed to give special attention to this part and aspect of the product development process.

3. Method

For the developed first version of the tool, product data from a multinational company producing office chairs were taken into account.
At first, life cycle data for the product obtained in a Life Cycle Assessment (LCA) according to the EDIP method [Wenzel, Hauschild, Alting 1997] have been gathered and further processed to suit an application in Ecodesign Decision Boxes. Before an improvement or an optimization of the environmental performance of a product can be achieved, it is necessary to get an overview of the

current environmental performance of the product through its different life cycle phases. This is done in the first step of the tool. In this step graphs based on LCA data for the assembled product are generated and displayed in a so-called 'Design Box'. With the help of the Design Box those components contributing most to the environmental impact of the product can be tracked. In a second step LCA-based graphs for the most relevant components can be generated in 'Component Boxes' where the environmental performance of the considered component can be tracked more detailed for all its life cycle phases. The Component Box allows identifying the most relevant materials with respect to environmental performance. In a third step LCA-based graphs are generated for each material used in the components in a 'Material Box'. The Material Box shows the aggregated environmental impact per weight of a given material over a typical life cycle based on LCA results for the type of product the material is used for.
Figure 1 shows the procedure of the application of the Decsion Boxes in a flow chart.

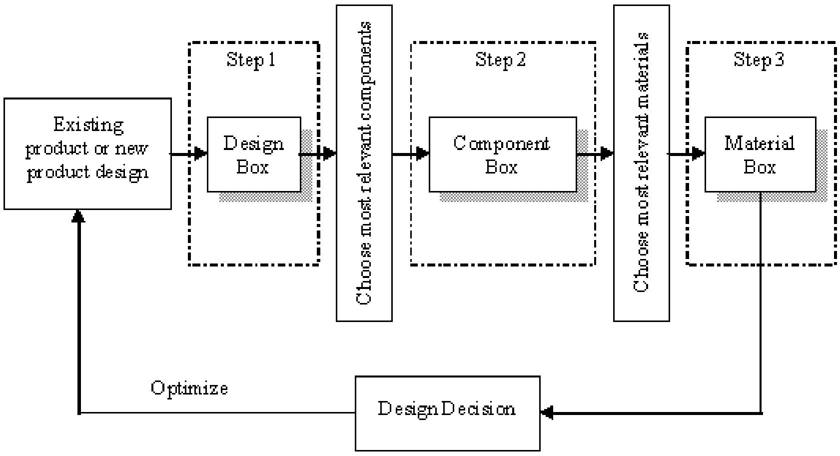

Figure 1. Flow chart showing procedure of optimizing a product in the design stage with Decision Boxes

On the one hand the introduced Design Box, Component Box and Material Box help to identify environmentally most relevant design elements, e.g. materials or parts, on the other hand they help to make decisions for the optimization of the environmental performance of the product design.
The LCA-based graphs in the different boxes consider all life cycles phases, e.g. extraction, processing, transport and end of life scenarios, of the specific material.
Figure 2 shows a Material Box for the three materials PA66, ASt35 and PP. The characterized impact for Global Warming (char. impact for GW) is drawn against the weight of the material. The graphs contain life cycle data for the materials which are listed in Table 1.

Table 1. Life cycle data for PA66, ASt35 and PP

Material	Processing	Surface	Transport	End of Life (EoL)
PA66	Injection moulding	No treatment	1000 km with Lorry	European Scenario
ASt35	Cold transforming	Painted	1000 km with Lorry	European Scenario
PP	Injection moulding	No treatment	1000 km with Lorry	European Scenario

The graph with the highest slope, in case of Figure 2 this is the graph for the material PA66, seems to contribute most to environmental impact at low weight. Using PA66 in a part or component of a product influences the environmental performance of the component and also the entire product significantly.
Regarding an environmental communication of the product to consumers, such as an environmental product declaration (EPD - type III environmental declaration) as introduced in [ISO/TR 14025 2000] and demonstrated in [Lee, Park 2001], where quantified life cycle assessment data are communicated,

the Decision Boxes can give first impression of the expected LCA values by using a ‘technical axis’ (x-axis) and an ‘environmental axis’ (y-axis).

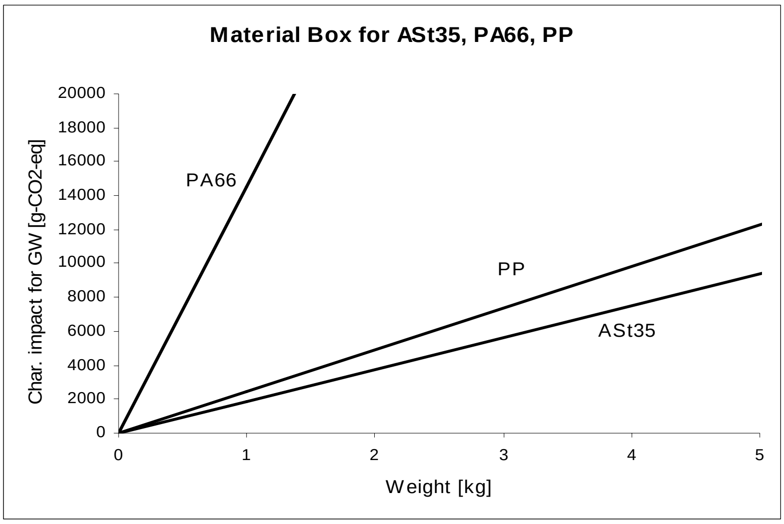

Figure 2. Material Box for ASt35, PA66 and PP

In case of Figure 2 this environmental axis is explained as the characterized impact for global warming. The environmental axis can be explained as any other characterized impact too, e.g. acidification, eutrophication or photochemical smog.

Although using other assessment values such as the EcoIndicator values [Goedkoop, Spriensma 2001] for the environmental axis would be possible, their use is not recommended here since these assement values can not be used in the intended environmental communication of the product in form of an EPD- type III declaration.

In Figure 2 the technical axis was explained by the parameter weight since this parameter was considered as most relevant during design processes of the considered product example. The technical axis can be expressed by any other relevant design parameter too, e.g. volume.

4. Application

LCA and Ecodesign projects in a multinational furniture-producing company have established a good understanding of environmental impact categories among the engineers, in particular of the impact category ‘Global Warming’ (GW). Therefore the Decision Boxes have been generated for this impact category by extracting data from the performed LCAs.

From LCAs of former products overall values for the expected potential impact on global warming of the office furniture products are known. As a target value for newer developments, the former global warming impact values should not be exceeded.

A more detailed look into to the product development process of the office chairs showed that the surface treatment of parts and components was an environmentally significant process. Therefore surface treatment was modelled separately, compare Table 1.

The design parameter ‘weight of the product” was considered as most relevant. As a target, the weight of the new product should be lower than former products.

With the help of the Decision Boxes a minimization of the product’s global warming impact by considering its weight should be achieved.

A common office chair can be described as consisting of five main parts namely: base, mechanism, seat, arm rest and back. By considering all life cycle phases of these components, drawing the current value for global warming impact as well as the value for the current weight of the office chair gives the proposed Design Box shown in Figure 3.

The LCA-based graphs, which contain LCA data of all life cycle phases of the five main components of the office chair, are also drawn into the Design Box. In the example shown in Figure 3, the improved design of the office chair should have a lower weight and it also should contribute less to environmental impact. The new target value for the characterized global warming impact as well as the new target value for weight are drawn into the Design Box.

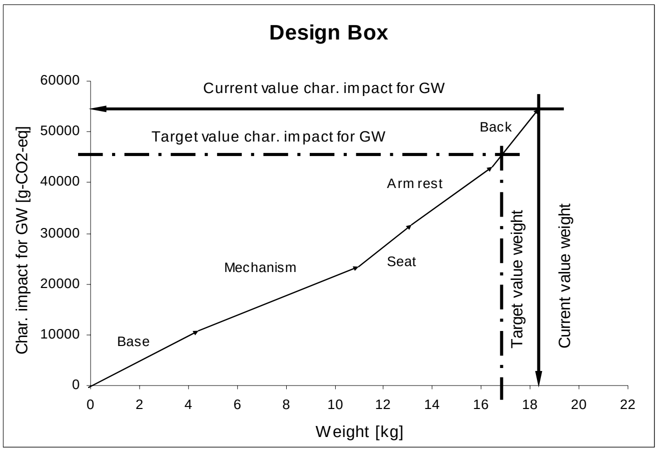

Figure 3. Proposed Design Box for an office chair

The current design exceeds the new target values set for the new design of the product. The Design Box shows that the slope of the LCA-based graphs of the components 'back' and 'seat' are the highest followed by the slope of the component 'seat'. This indicates that these components contribute most to the environmental impact. Since the design of the chair needs to be improved, it may be useful to start with the improvement of the components 'back' and 'seat'.

In order to be able to track why the slope of the LCA-based graphs of the component 'back' is so high, a Component Box and a corresponding Material Box for the back are generated in Figure 4 and Figure 5. The Component Box in Figure 4 shows the environmental performance of the component 'back' for all its life cycle phases. This component consists of the materials polyester, PP (polypropylene) and PUR (polyurethane) foam.

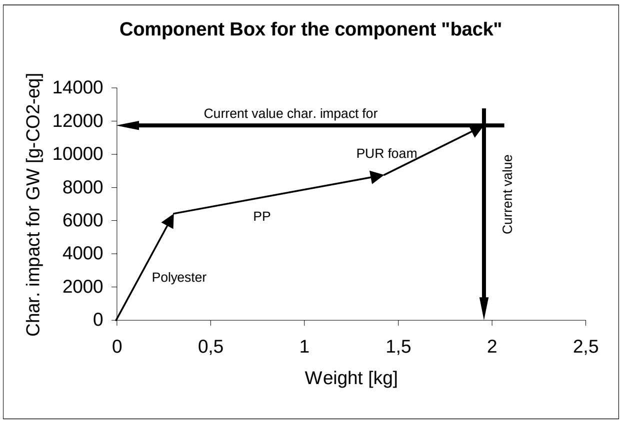

Figure 4. Component Box for the back component of an office chair

The Material Box in Figure 5 indicates that using a small amount of polyester contributes a lot to environmental impact. A possible improvement strategy for the back is to avoid or to reduce the amount of polyester used or to replace this material by some other material with less environmental

impact if possible. The LCA-based graph of PUR has also a high slope. Avoiding the use or reducing the amount of PUR used in the component may also be an appropriate improvement strategy.
Figure 6 shows an improved design of the back of an office chair, where no PUR is used. The new design of the chair is manufactured in an international office furniture-developing company. This new chair has not only an improved environmental performance by avoiding the use of PUR but has also an innovative design, which is appreciated by the market and the consumers respectively.

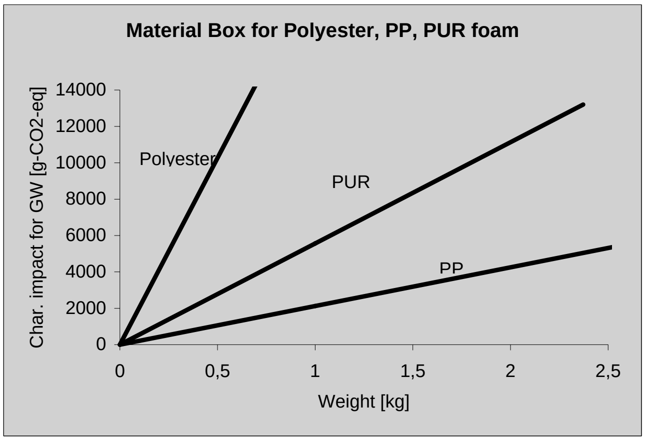

Figure 5. Material Box for Polyester, PP and PUR foam

5. Summary

With the help of the proposed Ecodesign Decision Boxes the environmental impact of a current design can be checked and controlled during design stages and, if necessary, influenced. The Ecodesign Decision Boxes provide an instrument that makes it easy for the engineer in product development to optimize a product during early design stages.
For their application, the engineer in product development does not need to know details about Life Cycle Assessment. A minimum understanding of Life Cycle Thinking and of the importance of environmental parameters and their interaction with design parameters is sufficient.
The Decision Boxes remain specific for a product type. The databases are developed for a certain product type, in this case office chairs, and even for certain technologies used in a certain company. Since the method can be subdivided into its two partitions, namely into the database part containing life cycle data and the application part where these data are used to set up the LCA-based graphs, it is expected that with the improvement and complement of the databases the use of the tool for different products will be facilitated.
Making the step between specialisation and generalisation of the method is matter of further investigations and should result in an electronic version of this tool.

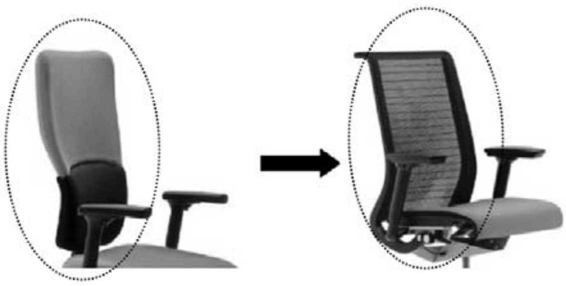

Figure 6. Left: Design of back using PUR foam,
Right: Improved design avoiding the use of PUR foam

References:

Goedkoop, Spriensma, “The Eco – indicator 99 A damage oriented method for Life Cycle Impact Assessment”, Methodology Report, Pre- Consultants b.v., Amersfoort, Netherlands, 2001.

ISO/TR 14025, “Environmental labels and declarations- Type III environmental declaration-guiding principles and development, ISO, 2000.

Lee, K. M., Park, P., „Apllication of Life Cycle Assessment to Type III Environmental Declarations“, Environmental Management, Vol. 28, No.4, 2001, 533-546.

Luttropp, C., “Eco-design in early product development”, World Conference R99, Geneva, Switzerland, 1999.

Ostad Ahmad Ghorabi, H., "Ecodesign- Decision- Boxes for a Systematic Integration of Environmental Considerations into the Product Development", Master Thesis, Institute for Engineering Design Vienna University of Technology, 2005.

Wenzel, H., Hauschild, M., Alting, L., “Environmental Assessment of Products, Vol.1: Methodology, tools and case studies in product development”, Chapman & Hall, London, UK, 1997.

Wimmer, W., Bey, N., “The way to do ECODESIGN in companies – installing a continuous improvement process”, Proceedings of the Design2004, D. Marjanovic, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, The Design Society, Glasgow, 2004, 1565-1570.

Wimmer, W., Züst, R., Lee K., ”Ecodesign Implementation – A Systematic Guidance on Integrating Environmental Considerations into Product Development”, Springer, Netherlands, 2004.

Dipl.- Ing. Hesamedin Ostad Ahmad Ghorabi
Vienna University of Technology, Institute for Engineering Design
Getreidemarkt 9, 1060 Vienna, Austria
Tel.: +43 1 58801 30752
Fax.: +43 1 58801 30799
Email: ostad@ecodesign.at
URL: http://www.ecodesign.at