Ecodesign method for office furniture with emphasis on information gathering for product environmental improvement

Juan Carlos Claros Garcia, Eduardo Romeiro Filho
Federal University of Minas Gerais
e-mails: jcclarosgarcia@hotmail.com; romeiro@ufmg.br

Abstract: This study presents the results of a research that gathers Ecodesign concepts and tools such as product environmental parameters, environmental impact assessment and Ecodesign strategies, bearing in mind the elaboration of an Ecodesign method applicable to office furniture. A case study research involving a medium-sized Brazilian office furniture manufacturer was carried out and its productive processes, design practices, and representative products were analyzed. These features were confronted with environmental parameters presented in the literature in search of instruments for the Ecodesign method elaboration. The environmental impact assessment of a workstation system, manufactured by the researched manufacturer, was also done. Specific Ecodesign strategies for furniture, among which some for office furniture were found, were also researched; these strategies were classified according to the environmental parameters. The presented method has five steps: Identify environmental critical aspects of the product; Set Ecodesign objectives; Generate Ecodesign information; Generate Ecodesign ideas, and Apply the Ecodesign ideas.

Keywords: ecodesign, office furniture, product design, design for environment, environmental impact assessment.

1. Introduction

The environmental concern is an issue whose debate has acquired high strength nowadays and, in fact, that trend tends to grow up as the environmental degradation signals increase in a potential way. The concern in different entities of the society is crescent, resulting in the frequent suggestion and adoption of measures to face the environmental issue. In the field of industry, the suggested solutions have followed an evolution: from the reactive measures adopted at the end of processes (*end of pipe* measures), passing by corrective measures focused in those processes, reaching the actual trend of considering the environmental issues from the product development. Studies shows that the design and development phases influence over than 80% of the environmental impacts caused by the product (TISCHNER; CHARTER, 2001), so that the efforts during the product design are essential for the burden imposed to the environment along the life cycle. Bearing in mind such high potential, the consideration of environmental aspects from the initial stages of the product development and product engineering must be applied in all the fields of industry, if we want to assure an effective mitigation of the environmental impacts.

Regarding specifically the Furniture Industry in Brazil, it is important to stand out the predominance of medium-sized enterprises (20 to 500 employees) considering the overall furniture production: despite they only represent 12% of overall of the manufacturers, they produce about 75% of overall of the furniture produced in the country (IBGE, 2000). Following the empiric rule: *more produces more pollutes*, we can picture the proportion of the environmental impacts caused by the medium-sized manufacturers in the region. A significant part of the Brazilian office furniture manufacturers falls precisely on that group, for this industry sector pertains exclusively to the medium and large-sized enterprises segment (GORINI, 2000).

Bearing in mind those considerations, this work presents an Ecodesign method for office furniture elaborated from data collected with a medium-sized office furniture manufacturer and with related literature. The research is focused on the Ecodesign information gathering for the environmental improvement of the product, considering that further stages (such as the generation and selection of ideas) are activities of the conventional design itself, aspect that goes beyond of the scope of this work.

2. Ecodesign

Ecodesign intends to minimize the environmental impacts direct or indirectly caused by the product, along its life cycle, whenever possible; the main objective is to include the environmental concern in the product design. It also includes assuming responsibility for the environmental consequences of the product, since they are related to specific decisions and actions executed during the design

process (LEWIS; GERTSAKIS, 2001). They are four types of Ecodesign (RATHENAU INSTITUTE, 1996): Product improvement; Product re-design; Functional innovation; and System innovation (Figure 1).

Product improvement consists in realize partial changes in an already existing product in the market. The product itself and its production techniques are generally maintained. Product re-design implies its complete improvement or change of its components, including aspects such as the use of nontoxic materials, disassembly, recycling and reuse of components. Functional innovation refers to the searching for new ways to effectuate the function of the product; for instance, replacing the use of physical products by the use of dematerialized services. A system innovation would demand the full change of the technological system, including the product, the productive chain, the associated infrastructure and the institutional structure. Each approach offers a different level of product environmental performance improvement (eco-efficiency) and different periods of implementation.

2.1. Environmental impact assessment tools

Ecodesign activity must be realized being aware about those product aspects that cause environmental impacts; it is necessary to assess the product considering the associated environmental implications. In some cases those impacts will be predictable; in such cases is not completely necessary to do an environmental impact assessment. Life Cycle Assessment (LCA) is a well known quantitative environmental impact assessment tool that consists basically in define, measure, and assess the environmental impacts of all the product life cycle associated inputs (materials and energy) and outputs (air, soil and water emissions). That information may be used to identify and prioritize the product environmental aspects that will be attended. A full LCA consumes considerable time and resources. In this sense, a streamlined approach of the life cycle assessment (GRAEDEL, 1997) consists basically in assess the product environmental impacts and its life cycle stages using a matrix approach. An alternative environmental assessment tool is the Eco-indicator 99, developed by PRÉ-CONSULTANTS (2000), which consists in the calculation of a single Eco-indicator by the use of already established environmental indicators. These indicators are supplied by the same source, and were obtained by the application of a full LCA. The Eco-indicator 99 uses five steps to assess the environmental impacts: establish the objective of the Eco-indicator calculation, define the life cycle, quantify materials and processes, fill-in the form, and interpret the results.

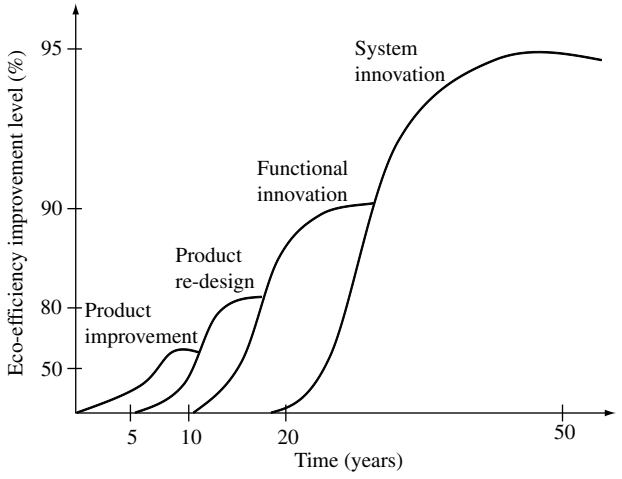

Figure 1. Four types of Ecodesign. Source – Adapted from RATHENAU INSTITUTE, 1996.

2.2. Ecodesign strategies

Ecodesign strategies offer orientation about which actions to take during the practical implementation of Ecodesign. Since it is by these actions that the reduction of the product environmental impacts will be effectively realized, the appropriated selection of the strategies is fundamental for the well succeeded application of Ecodesign. Generally the Ecodesign strategies presented by different authors are intimately related with the life cycle of the product; the approaches are very similar and usually present general and specific strategies. The Ecodesign strategies researched in the literature can be classified accordingly with the four types of Ecodesign described above; however, it is observably that most of them fall into the two first groups. It is also important to mention that some strategies, such as remanufacture and product-service systems offering, are more applicable in large-sized enterprises, since they have more control about the life cycle agents involved with the product. For instance, the furniture re-manufacture strategy is, according to Lewis and Gertsakis (*op cit.*), realized by two American large-sized furniture manufacturers: Herman Miller and Steelcase. Those manufacturers re-purchase the old furniture used by its clients and combine they parts with new ones for the furniture re-manufacturing. According with data collected in the medium-sized researched furniture manufacturer, this strategy is not possible because of restrictions imposed by its infra-structure. In the same manner, the strategy of renting office furniture – strategy that falls into the system innovation group (BREZET; ROCHA, 2001) – offers high risk of implementation considering the conditions of the researched enterprise. Some of the obstacles are: lack of a fast delivery system, lack of infrastructure and the space necessary for stocking the furniture, and lack of knowledge about the market.

Considering these and other constraints, it was prioritized the product improvement and re-design strategies for the Ecodesign method elaboration, so as to be more applicable for medium-sized office furniture manufacturers. Table 1 shows some Ecodesign strategies for office furniture, some of them are applicable for medium-sized enterprises.

Table 1. Ecodesign strategies for office furniture. Source – BESCH (2005).

Life cycle	Ecodesign strategies	
Stages	**Generic strategies**	**Specific strategies**
Materials acquisition, furniture disposition	Design for Durability	Enhance furniture resistance Lifetime extension
	Maintenance and repair services	Offer maintenance and repair services parallel to the sale of furniture
	Reutilization of components/parts	Reutilize structural components such as metal pillars or desk support frameworks.
	Remanufacture	Take back and remanufacture of used furniture Leasing / renting furniture instead of sale them
	Leasing or renting	Include maintenance, repair and upgrade services
		Include take back system after leasing/renting period
End of life	Design for Recycling	Facilitate disassembly
		Facilitate materials separation

In addition to these strategies, other ones referent to the Ecodesign of furniture were researched and adapted for the elaboration of the Ecodesign method presented below.

3. Elaboration of the ecodesign method

The Ecodesign method presented here was elaborated with a basis of different methodological approaches suggested by different authors. It was observed that most of the researched methodologies begin with the assessment of the environmental product aspects. In the proposed method, this first step was called "Identification of the product's critical environmental aspects". For the illustration of this first step, the environmental impact assessment of a workstation system manufactured by the researched manufacturer was realized, using the Eco-indicator 99 method. The results indicate that the materials production stage is the one that carries the higher environmental impact. In that stage, the production of aluminum, followed by the production of MDF and steel, presents the most significant environmental impacts. Table 2 shows a form indicating the considered life cycle stages, its quantities and indicators. The results (Eco-indicators) are obtained by multiplication of the quantities with its respective indicators. The indicators can be obtained from PRÉ-CONSULTANTS (*op cit.*).

The central part of the Ecodesign method proposed here is articulated through the Ecodesign information gathering for further generation and selection of ideas in the conceptual stage. We consider that the information gathering process for guiding the generation and selection of ideas is very important, since the proposal of different concepts can be enriched as of a solid basis of Ecodesign information. The information gathering process considered here is based on the methodology proposed by Lee and Park (2005). That methodology indicates that the Ecodesign information for generation of ideas must have three basic aspects: environmental parameters, Ecodesign objectives and Ecodesign strategies. The objectives must be set as a function of the measuring of the environmental parameters, and the strategies must be related with each parameter. In this sense, different environmental parameters for different products, including furniture, were researched in the literature. For the properly choice of the parameters, they were confronted with products manufactured by the researched enterprise. Parallel to this, Ecodesign

Table 2. Environmental impact assessment form of the work-station system analyzed.

Production (Materials, processes, transport and extra-energy)			
Material or process	**Quantity**	**Indicator**	**Score**
MDF	142.77 kg	39	5568
Aluminum	31.67 kg	780	24703
Al Extruding	31.67 kg	72	2280
Steel	11.99 kg	86	1031
Steel sheets production	11.99 kg	30	360
Steel (fittings)	1.18 kg	86	101
Steel pressing	1.18 kg	23	27
Nylon	0.91 kg	396	360
Nylon Injection	0.91 kg	30	30
Carton	3 kg	69	207
Transport	30 km	22	660
Total			35327
End of life (Waste processes for each type of material)			
Material and process type	**Quantity**	**Indicator**	**Score**
Al recycling	31.67 kg	-720	-22802
Steel recycling	13.17 kg	-70	-922
Nylon incineration	0.91 kg	1.1	1
Carton incineration	3 kg	-12	-36
MDF landfill	1/4 m^3	140	35
Total			-23724
Total (all life cycle stages)			11603

strategies for furniture (among those specific strategies for office furniture were found) present in the literature were researched. The selected strategies were classified according to its affinity with each parameter. Finally, that information (environmental parameters and Ecodesign strategies) was arranged according to each life cycle stage of the product.

3.1. Ecodesign objectives setting

For the completion of the Ecodesign information, Ecodesign objectives must be set. It is preferred that those objectives be quantitative, allowing further assessing and comparison of results. Before the quantitative goals setting, the initial characteristics of the product must be measured, taking into account the environmental parameters. The objectives must be set as of those initial measuring and the choice of parameters must be realized as of the identification of the life cycle stage that has the higher environmental impact.

The environmental improvement objectives can be set in several ways, for instance: comparing the initial characteristics of the product against concurrent products, definition of goals by the product design team, and comparison between products manufactured by the same manufacturer. The objectives setting must be considered in function of the environmental parameters. For example, bearing in mind the determination of objectives comparing products manufactured by the same manufacturer, Table 3 shows the comparison of some parameters between the analyzed workstation system and other similar took as reference, and produced by the same manufacturer (Figure 2). From this comparison, the environmental objectives (in percentage) of the analyzed system can be set.

In Table 3 it can be observed that the analyzed system has a better environmental performance referring to the weight and fittings/accessories parameters, in comparison with the reference system (the smaller the measure of those parameters, the better will be the environmental performance). Consequently, it can be assigned a 0% environmental improvement objective in those parameters. On the other hand, the number of parts/components must be reduced in 2.7%, for the reference system has a better environmental performance considering this parameter. For an effective implementation of Ecodesign, it is recommended to set Ecodesign objectives for all the parameters involved with the higher environmental impact life cycle stage.

3.2. Generate Ecodesign information

It was explained previously that Ecodesign information is composed by three basic elements: environmental parameters, Ecodesign objectives, and the necessary strategies for orienting the Ecodesign activities. It is as of that information that the design team can begin to generate new design solutions, select them and apply them.

Before the identification of the product's environmental critical aspects (through the environmental impacts assessment), that is, once identified the life cycle stage with the higher environmental impact, the Ecodesign objectives set in the previous step must be merged with the Ecodesign parameters and strategies. It was explained previously that the environmental parameters presented here were arranged with its respective Ecodesign strategies, according with each stage of the product's life cycle. Referring to the analyzed workstation system, the Ecodesign information including the Ecodesign objectives set previously is presented below (Table 4). Other Ecodesign strategies with its respective parameters and product's life cycle stages can be found in Garcia (2007).

3.3. Generate Ecodesign ideas

Once the design team is provided with the environmental parameters, the objectives to be achieved, and the respective strategies, that information can be used for the generation of Ecodesign ideas and its respective selection. The generation of ideas could follow specific methods, such as *brainstorming* or other related.

3.4. Apply the Ecodesign ideas

Finally, once achieved the previous steps, the selected ideas can be applied for the product design. The objectives

Figure 2. Workstation systems. a) Analyzed system b) reference system. Source – Researched manufacturer.

Table 3. Determination of objectives comparing two products manufactured by the same manufacturer.

Environmental parameter	Analyzed system	Reference system	Ecodesign objective
Total weight	188.5 kg	245.6	0%
Number of parts/components	37	36	-2.7%
Fittings/accessories quantity	175	320	0%

Table 4. Ecodesign information for the analyzed workstation system

Life cycle stage	Environmental parameter	Objective	Ecodesign strategies
Materials production	Hazardous/toxic substances content		Select materials with low environmental impact
			Eliminate the use of solvent-based adhesives, coatings and finishes
			Eliminate the use of coatings and finishing with metal content
			Avoid wood materials with harmful or toxic substances content, with particular attention to the reduced use of urea-formaldehyde
	Surface area of the wood boards		Specify use of materials and alloys that are of the minimum quantity required to meet structural and/or functional needs
			Reduce the number of components and assemblies
	Quantity of fittings/accessories	0%	Minimize materials diversity or types
			Avoid glues, metal clamps and screws in favor of 'push, hook and click' assembly methods (e.g. snap fits)
			Reduce the number of components and assemblies
	Number of components/parts	-2.7%	Minimize materials diversity or types
			Integrate functions and simplify assemblies
			Minimize material quantities without compromising function, quality, aesthetics or applicable standards
	Total weight	0%	Reduce the number of components and assemblies
			Integrate functions and simplify assemblies
	Number of material types		Minimize materials diversity or types
			Integrate functions and simplify assemblies
			Select materials with low environmental impact
			Materials substitution
	Material's environmental indicator		Use environmentally improved materials wherever possible
			Source wood-based materials that are from sustainably managed plantations and that are certified accordingly
			Use materials with recycled content (preferably post-consumer)
	Recycled material content		Reuse of metal pillars and desk support frameworks
			Specifying use of recycled materials in non-critical components where performance, color, surface, design or other visual qualities are not pivotal design features
	Number of surfaces with adhesives		Eliminate the use of solvent-based adhesives
			Avoid glues, metal clamps and screws in favor of 'push, hook and click' assembly methods (e.g. snap fits)

set will guide the Ecodesign activities and further could be use as parameters for the comparison of the achieved results. The generation of ideas and its selection are activities of the conventional design itself; so, it was procured to emphasize the assessment of the product's environmental critical aspects, objectives setting, and generation of Ecodesign information.

4. Conclusions

As of the bibliographic data, we can conclude that the Brazilian medium-sized furniture manufacturers cause the most part of the environmental impacts generated by the furniture industry in the country, for they produce the most of the furniture. The office furniture manufacturers would not be the exception, since the sector is exclusive of the medium and large-sized manufacturers. According with data collected in the researched manufacturer, we conclude that the medium-sized office furniture manufacturers have constraints that difficult the application of some Ecodesign techniques such as re-manufacture and the offering of product-service systems. Those strategies are more applicable in large-sized manufacturers, since they have the required infrastructure. For the elaboration of the proposed Ecodesign method, Ecodesign strategies applicable in medium-sized manufacturers were considered. Taking into account the four types of Ecodesign, the proposed methodology provides procedures referent to product improvement and re-design, so it can be used for medium-sized furniture manufacturers.

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