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Engineering Design in Integrated Product Development
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PROGRESSIVE ECO DESIGN BY AN ENVIRONMENTAL INNOVATIVE PRODUCT DESIGN (EIPD)

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Abstract: *Environmental innovations unite ecological progress and product innovation. In doing so, they create competition advantages by providing auxiliary use. The paper describes a pilot project, where a methodical procedure was adopted, in order to obtain and create environmental product innovations to reach competition advantages. The procedure is especially applicable in small and medium enterprises. On the basis of a market analysis and the examination of environmental oriented product innovations as well as ecological product evaluations a framework is derived, which combines already today's methods and tools available for the application in the industrial practice.*

INTRODUCTION

Numerous examples of successful environmental conscious products show, that by an ecologically oriented product development, important competition advantages for the market success can be achieved.

The submitted contribution describes the investigation of such products as well as freely available Life Cycle Assessments. Development patterns were derived from the findings of these analyses, which flowed into procedure recommendations for a shortened, environmental oriented product innovation process.

From the results it is recognizably, that by such, primarily environmental oriented product innovation process additionally frequently as well product properties are reached, which are far beyond the environmental aspect. Thus, additional utilizable potentials for the customer are opened. Further on economic advantages for both groups, for the participants of the economic life and for the final customers are offered. This prepares the market for a stronger establishment of sustainable products. A main source for the prosperity and welfare of our society is the existence of a variety of products and services. Therefore people demand for convenient and top featured products to ease work or leisure activities or have fun at hobbies and free time doings. So we have on the one side a strong need to develop new products and deal with a growing number of products and services to ensure this level of living. On the other side a multitude of environmental damages are caused by all processes in these products life. Thus we get a strong interrelation of a growing number of products and the involved environmental burdens of the production, use and recycling of these goods.

To disrupt the growing environmental impact of an increasing number of products and services, several strategies was drafted, e.g. the strategy of Design for Environment (DFE) or the concept of sustainability.

If one observe the spreading of products, which are attributed as "environmentally friendly" and are compared with related competitor's products more environmental compatible, is it often shown, that more sustainable products frequently also features product properties, which are favorable for manufacturers, trade or user.

If however environmental aware products at the same time exhibit frequently large advantages, the question arises: It is possible to realize product properties with the consequent development of environmental conscious products, which stand out from the competitor's products and are therefore favorable for customers and/or manufacturers? It is also possible to arrange an "environmental innovative product development" ?

1. EXAMINATIONS

In order to intend the connections, dependence and boundary conditions for an environmental oriented

product innovation, extensive analyses of environmental aware products and their development process were accomplished, their characteristics were determined and made accessible by abstraction for the integration into the product development process. In the following exemplary three products of the ranges electronics, automobile, are represented whose environmental aware design leads to further advantages. Numerous further examples are represented in [1, 4, 8].

1.1. Investigation of Example Environmental Conscious Products

1.1.1 Example: Automobile starter alternator

The coherency between environmental oriented advancement and thus parallel accompanying product innovations is impressively representable by the example of starter alternators. The development of these integrated devices allows the abdication of the alternator module, the v-belt and the starter. This leads to a light weight and compact construction. Because of the fast motor start potential for this reason a possible start-stop-mode enables a reduction of the fuel consumption at city-traffic of approximately 5%. Due to dynamic characteristics these modules increase the traveling comfort. The higher attainable operating voltages in the electrical system permit the employment of new technologies - x-by-wire systems - as well as smaller cross sections of a line profiles.

1.1.2. Example: Laptop Processor

An impressing example of the advancement of electronic products is the new Intel mobile technology Centrino. The largest energy saver in pack from processor, chip set and WLAN-module is the PC processor Pentium M developed especially for mobile applications. Its capacity is on the level of a somewhat 10% more slowly clocked Pentium III, but its speed corresponds to an around 50% more highly clocked Pentium 4. Under full load the Pentium M takes up between 22 and 25 Watts. This is approximately equivalent to the energy needed by the predecessor mobile Pentium 4, if it runs in the energy savings mode throttled on 1,2 GHz by speed step technology. However it acts clearly more slowly than the Pentium M [9].

As a result of the clearly smaller capacity because of the increased efficiency as consequence arise a less complex cooling. Thus smaller, lighter and flatter housings with rarely running exhausts are possible. Therefore results likewise a less energy need and fewer noises production.

1.1.3 Example Automobile Air Conditioning

The Peltier principle cools air thanks to ceramic semi-conductors. Less energy intensive and more economic, this system consumes half of the energy or traditional air conditioning methods. It does not use ozone depleting refrigerant gases. Traditional air-condition increases vehicles fuel consumption by up to 10%, The economic an environmental benefits of the potential reduction of consuming 1000 litres less of fuel over the life of a vehicle, is a convincing argument especially when backed up by strong evidence [1].

1.2. Basic Methodological Implications and consequences

If one analyzes the relevant impacts on the environment of the respective products, for the appreciation of the connections between the environmental profile and additional connection characteristics, determined in section 2.1, during the application of an environmental innovative product development in the methodical context of the product development [3, 7], thereby above all the following measures important:

- Regarding the environmental impacts, the use phase is substantial with active products already with small rated outputs. For relevant improvement thereby the energetic effect chain which obtains the function realization has to be analyzed to improve the most important sub functions.

  Table 3. *Example for the environmental importance of the use phase in relation to other life-cycle-phases.*

Direct Currency Machine ABB DMI 180 (rate of environmental impacts of the use phase)	
Impact category	% of all
Global warming potential	99,92
Acidification potential	99,96
Oxidant depletion potential	99,90
Photochemical oxidant creation potential	99,70
Ecotoxicological classification factor for aquytic ecosystems	99,99

- The centre of the environmental impact with passive products lies in the ranges preproduction and manufacturing and considerably is affected by the assigned materials. In order to minimize these influences the selection of the basic material with the help of an ecological evaluation of possible alternatives is to be accomplished.
- The recycling phase is to be neglected regarding its contribution in the ecological evalua-

tion. However a material homogenization within the product structure to the ideal to a one material product leads to an increased material and economic substance cycle.

From this point of view it becomes clear that significant improvements are accessible only in the early phases of the product design "clarifying task" and "conceptual design". A consistent conversion can then however also lead to significant development jumps with alleged as expenditure-provokes valid products (Fig. 1).

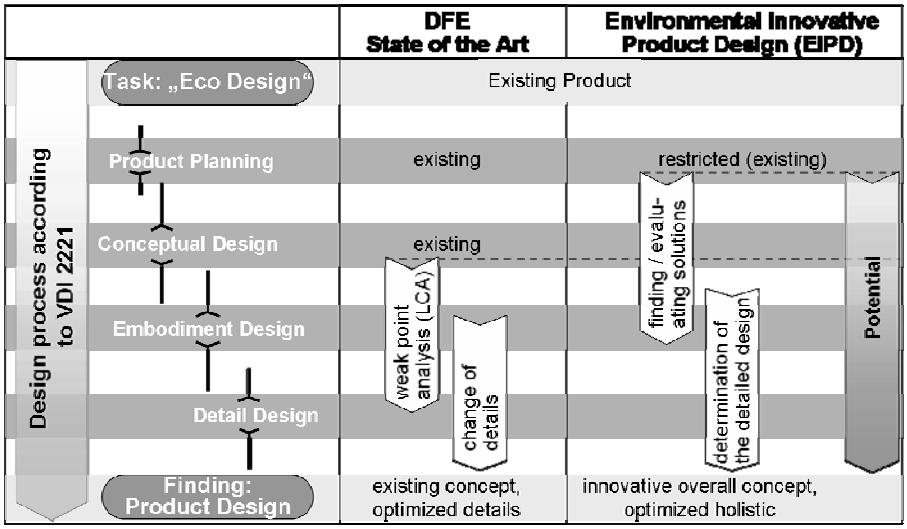

Fig. 1. *Comparison between the conventional design approach "Design for Environment" (DFE) and an Environmental Innovative Product Design (EIPD).*

On a Life Cycle Assessments, which is time consuming, can be abdicated, because the taking into consideration of the above illustrated aspects during the product development in a proactive proceeding considers the most relevant environmental effects. A LCA, performed in the early phases of the product development, is very inaccurate anyway due to only incomplete and on rough assumptions based life cycle. However, the clear possibility to separate the described influences into energy-referred aspects and material-referred aspects relieved the environmental evaluation of alternative solutions by use of elementary criteria's like energy consumption, kind of used material, mass, volume etc.. Thinking in those elementary criteria's lies in the way of thinking of the product designers, on the opposite to think in effect categories used in the evaluation of LCA's.

With the search and conversion of the necessary alternative solutions however the necessity for the interdisciplinary treatment accompanies. Only by such an interdisciplinary it can be ensured that on the one hand a large number of relevant possible solutions are found and that on the other hand these solutions can also adequately converted and designed. The controlling of the rising technology complexity, increasingly required due to the structure of modern products consisting of mechanical and electrical modules supplemental by information-technical components requires the integration of a broad knowledge base.

2. EXAMPLE PROJECT FINDINGS

How successful the concentration on substantial aspects of an environmental innovative product development can be, was impressively demonstrated in the IPP pilot project BEnefiT sponsored from the Free State of Bavaria. BEnefiT is an acronym of the German expression Bavarian development net for innovative technologies. This network built up from interdisciplinary university and industrial authority is led responsible by the Chair of Engineering Design at the University of Erlangen-Nuremberg and pursues the strategy of an Integrated Product Politics (IPP) [2].

The extensive improvements, which were obtained in the context of the project by the example of a vacuum cleaner, referred to the environment are readable from the LCA, which is accomplished project-accompanying.

The mentioned environmental referred progress is recognized in Table 2 and Table 3.

For potential customers however it might be of stronger importance that the equipment with improved environmental profile has the further following advantages during same suction power:

- Less Weight (better handling)
- Decreased device size (less storage volume, better handling)
- Approximately 50% less energy usage
- Simply to disassemble (repair, service)

A more detailed representation of the developed prototype and its advantages you will find in [5,6].

Table 2. Improvements in the use phase of an environmental oriented redesigned vacuum cleaner exemplified pictured in essential impact categories.

Impact Category	Device	Value	Improvement [%]
CO_2-Aquivalent	Reference	718,25	42
	Prototype	413,95	
Energy Consumption [kWh]	Reference	845,00	42
	Prototype	478,00	

Table 3. Improvements in the production phase of an environmental oriented redesigned vacuum cleaner exemplified pictured in different impact categories.

Impact Category	Device	Value	Improvement [%]
Renewable Energy Sources	Reference	0,0357	97
	Prototype	0,0010	
Energy Sources (non renewable)	Reference	19,3155	75
	Prototype	43,8360	
Eutrophication (NO_3)	Reference	0,0000	0
	Prototype	0,0000	
Eutrophication (PO_4)	Reference	0,0165	45
	Prototype	0,0090	
Human toxicity	Reference	0,000119	100
	Prototype	0,0000	
Ozone depletion (CFC11)	Reference	0,00000979	100
	Prototype	0,0000	
Resources	Reference	368,3840	93
	Prototype	56,2920	
Oxygen	Reference	32,0116	82
	Prototype	5,8670	
Heavy metal to air	Reference	0,0008	100
	Prototype	0,0000	
Heavy metal to water	Reference	0,0002	100
	Prototype	0,0000	
Summer smog (C_2H_4)	Reference	0,0215	-20
	Prototype	0,0270	
Greenhouse effect (CO_2)	Reference	58,9513	74
	Prototype	15,3880	
Acidification (SO_2)	Reference	0,2780	2
	Prototype	0,1370	

2. CONCLUSION

From the results it is recognizably that by an primarily environmental oriented product innovation process often additionally product properties are reached, which are far beyond environmental aspects. Additional utilizable potentials for the user or manufacturer thereby develop a market for more environmentally friendly products, especially agains the background of the fact, that customers are not willing to pay more money for same products which are in difference only more environmental aware.

References

[1] ADEME, 1999, "Conception de produits et environment: 90 ecamples d'eco-conception".

[2] Meerkamm, H., Rosemann, B., Steinmetzer, H.-C., 2000, "Integrated Product Policy in Bavaria and the Bavarian Network for the Development of Innovative Technologies (BEnefiT)", Proceedings Conference Electronics Goes Green 2000+, volume 1, pp. 567-572.

[3] Pahl, G., Beitz, W.,, 1996, "Engineering Design", 2nd Edition.

[4] Reichl, H., Griese, H. (Editors), 2000, Joint International Congress and Exhibition Electronics Goes Green 2000+: A Challenge for the next Millennium, Proceedings Volume 1: Technical Lectures.

[5] Rosemann, B.; Künkel, R.; Wolf. M., 2002, „Umweltmanagement: Markterfolg durch Innovation – Produktgestaltung", Umwelt Focus: Das Fachmagazin für erfolgreiches Umweltmanagement, pp. 33-35.

[6] Rosemann, B.; Meerkamm, H., 2002, "Methodological Framework and Examples of an Environmental Innovative Development" Proceedings 9th CIRP International Seminar on Lifecycle-Engineering, pp. 135–142.

[7] VDI, 1986, Methodik zum Entwickeln und Konstruieren Technischer Systeme und Produkte (Methodology to Develop and Design Technical Systems and Products), VDI-Guideline 2221.

[8] v. Weizäcker, E.U, Lovins, A.B., Lovins, L.H., 1998, "Factor four".

[9] Wirtgen, J., 2003, „Langer Atem: Centrino Notebooks mit Intel Pentium M" ("Huge Breath: Centrino Notebooks with Intel Pentium M"), pp. 158-160.