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ECO-INNOVATION, COMBINING ECODESIGN AND TRIZ FOR ENVIRONMENTALLY SOUND PRODUCT DEVELOPMENT

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Abstract

This paper presents the Innovation Module a combination of the multimedia tool ECODESIGN PILOT and TRIZ. Meant for design engineers providing a clear step-by-step procedure for innovative ideas when developing environmentally conscious products. An example is given to demonstrate its capabilities.

Keywords: Design for environment, ECODESIGN, design tool, product improvement, sustainable product development

1 Introduction

International activities like the European Unions Integrated Product Policy (IPP) focuses on products environmental performance over the whole product life-cycle. The recently published technical report ISO/TR 14062 gives advise for integrating environmental aspects into product design and development. Environmental awareness of customers and stakeholders is rising. For companies these issues are often very new. Especially design engineers determine the overall life-cycle performance of a product and they should get adequate support for making the right decision within a product development process (PDP) towards more environmentally sound products.

But “environment” should not be an additional task. It should be integrated and considered along the PDP like quality and cost issues. The first question is always about *what* should designers and engineers do to reduce the environmental impact of a product? This includes searching for activities with highest priority in the environmental context. The research activities at the Institute for Engineering Design at the Vienna University of Technology were concentrated on this over the last years. The result is the ECODESIGN **P**roduct **I**nvestigation, **L**earning and **O**ptimization **T**ool (PILOT) [1], which is available on CD-ROM and Internet (www.ecodesign.at/pilot).

Consequently the second question is *how* to transform the achieved results - resulting from the application of the ECODESIGN PILOT - to specific products? In some cases this can be done easily assuming a specific knowledge and creativity. Often further support is needed.

2 ECODESIGN and innovation

Product innovation is essential for lasting success of companies and can be achieved in different ways. Introducing ECODESIGN in product development is one possibility to do that. ECODESIGN stands not only for reducing environmental impact but also for looking at

products from different perspectives, which can lead to new ideas. This can be further fostered by attempts like learning from different branches (analogies) and mind opening activities (associativity).

A model of the PDP, which links ECODESIGN and innovation, was already developed [2]. From the range of creativity-, design- methods and methodologies the most promising should be used for the *Innovation Module* to be presented here.

The methodology selected to be included first in the new Innovation Module is the Theory of Inventive Problem Solving (TRIZ) [3]. TRIZ is based on the systematic analysis of patents and of engineering origin. Especially when dedicated to design engineers TRIZ promises higher benefit compared to common useable methods like Brainstorming or Synectics.

3 Objectives

The ECODESIGN PILOT can be used for qualitative design assessment with checklists to identify effective measures, which provide detailed ECODESIGN guidelines for design improvements. The objective with the new Innovation Module is to combine appropriate elements from TRIZ with the ECODESIGN PILOT in order to ease the way for finding solutions in the PDP. This add-on module for the PILOT should meet demands for more environmentally sound products as a chance for product innovation. It should be useable in a systematic way and aim at supporting daily work of product developers, rather than learning method procedures or new nomenclature.

4 Methods

4.1 Investigation of the TRIZ key elements

Classical TRIZ consists of the commonly known key elements like:

- Innovation Situation Questionnaire
- Problem Formulation
- Contradiction and Inventive Principles
- The Ideal Design
- Patterns of Evolution
- Substance-Field Analysis

Most important and useful for the generation of new ideas are Problem Formulation, Contradictions and the Inventive Principles. These elements are focusing the search for solutions in the direction of highest probability of success to replace conventional trial and error procedures.

The Problem Formulation can be done with a cause and effect graph to identify contradictions. A main aspect of TRIZ is to overcome contradictions without making compromises. A table of possible conflicts - the Contradiction Table -, which is a 39 x 39 matrix of technical parameters is used to find at least one out of 40 Inventive Principles to solve an identified contradiction. Formulating contradictions via technical parameters is sometimes complicated and needs experienced TRIZ users. Also there are some blank areas in the Contradiction Table which means for certain conflicts there are no related Principles.

The Contradiction Table is the selection aid for appropriate Inventive Principles. But it is also possible to work through the whole 40 Principles and find an appropriate one. The Inventive Principles are generic principles for solving technical problems and therefore best suitable for the combination with the ECODESIGN PILOT.

Analysing existing approaches showed that the idea of using TRIZ for eco-innovation was already proposed by Jones and Harrison [4]. In their approach they link the six main environmental strategies or issues from the Eco-compass tool with matching TRIZ technical parameters. They use the standard TRIZ Contradiction Table to identify appropriate Inventive Principles.

Another approach was published by Liu and Chen [5]. These authors link seven environmental strategies with appropriate TRIZ technical parameters. To identify matching Inventive Principle they use their own created table of single technical parameter.

The suggested approach with the Innovation Module covers more environmental strategies (all strategies available in the PILOT)- these are more detailed and precise - and links with matching Principles *directly*. This provides quicker access to suitable Principles without describing the problem with technical parameters and without using the Contradiction Table.

4.2 Innovation Module

The Innovation Module provides for each ECODESIGN strategy a limited variety of suitable Principles for idea generation. This gives an efficient overview how such environmental demands can be generally supported. To achieve this for every ECODESIGN strategy the 40 Principle were clustered, arranged and assigned as shown in Figure 1.

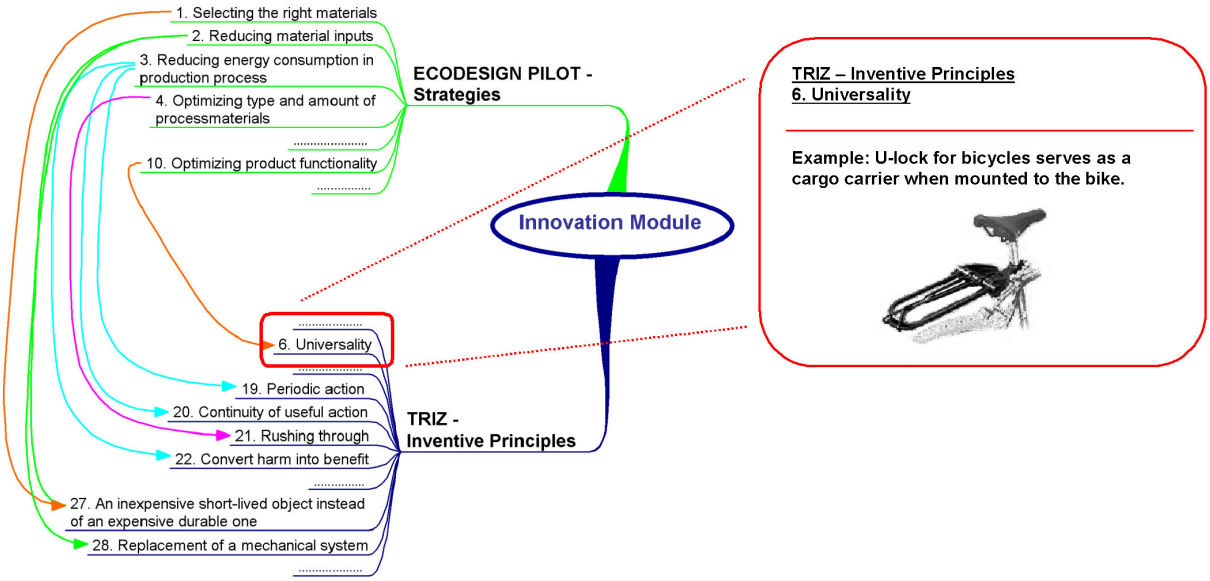

Figure 1. The combination of ECODESIGN strategies and TRIZ Inventive Principles.

For several strategies more than one Principle can be found. For instance the PILOT strategy *Reducing consumption at use stage* matches with TRIZ Principles like *Periodic action*, *Feedback* and *Self-service* among others (compare example in Figure 2). To ease working with the Innovation Module short examples to explain the Principles from an environmental view are provided. These examples contain descriptions, pictures and sketches to stimulate new ideas.

Figure 2 summarises the whole approach. The first step assigns the product to one of the so called five basic types of the PILOT, which are *raw material intensive*, *manufacture intensive*, *transportation intensive*, *use intensive* and *disposal intensive* (how this categorization can be done has been published previously [2]). The second step identifies appropriate strategies within a product type. The third step provides checklists to work through to find ECODESIGN measures for implementation. The Innovation Module delivers Inventive Principles for the identified strategies. These Principles give advise how to implement generic ECODESIGN measures for a specific product.

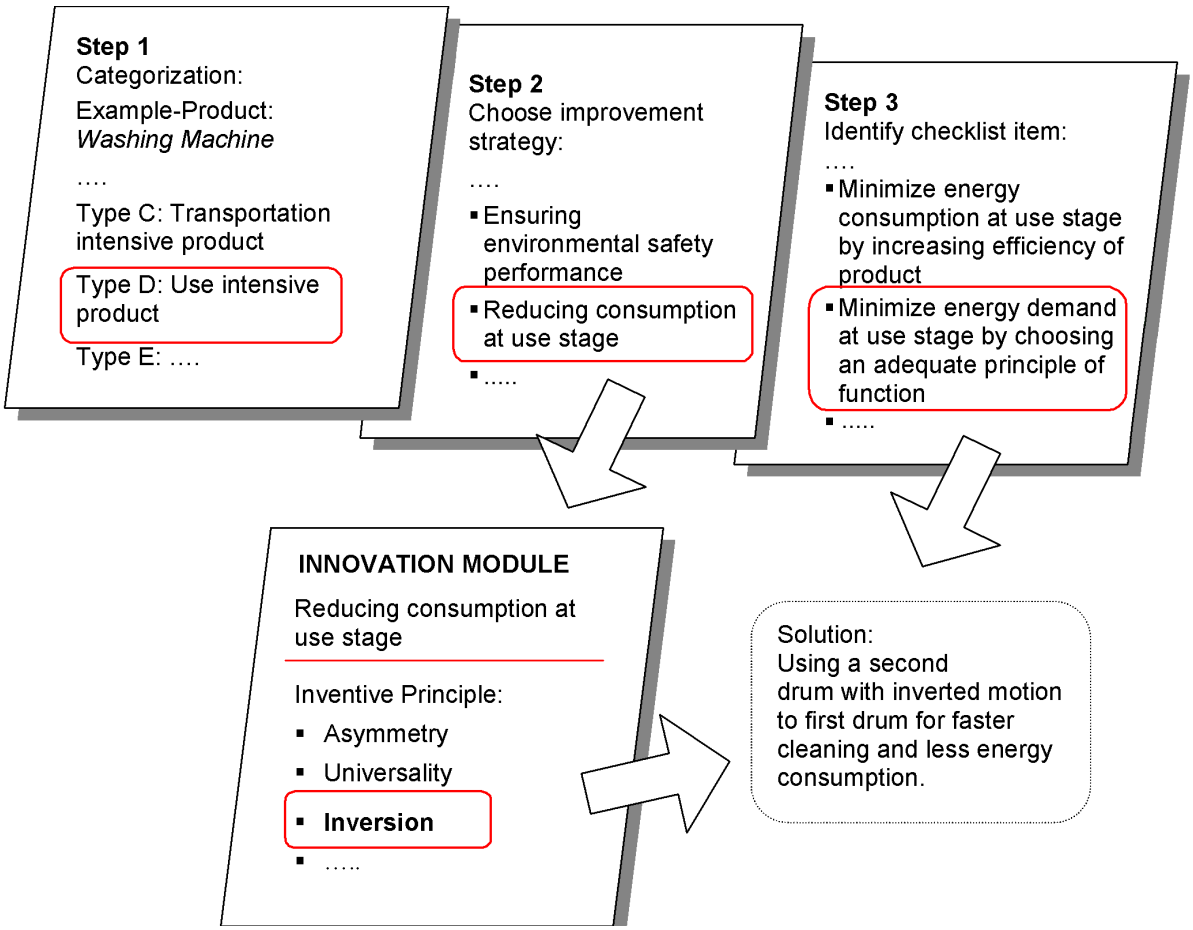

Figure 2. The Innovation Module and the three step procedure of the ECODESIGN PILOT.

5 Design of an environmental conscious noise barrier wall

The Innovation Module combining ECODESIGN and TRIZ was tested within the PDP of an environmental conscious noise barrier wall for highways. These walls are used to protect against traffic noise along the roadside. The structure of a standard noise barrier wall consists on the front side of a panel, which is perforated to let noise in. A layer of absorption material, which is used for reducing the noise reflection. A backside panel, which is closed to reflect the remaining noise towards the absorption material for further reduction (see Figure 3).

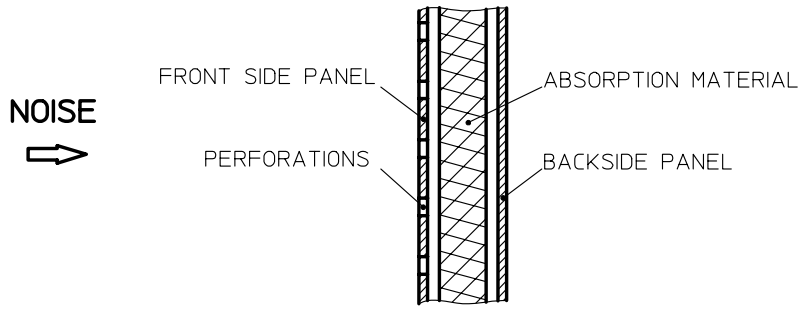

Figure 3. Cross-section of a noise barrier wall.

According to new requirements [6] the objective was to environmentally improve an existing noise barrier wall.

The performance of the Innovation Module should be demonstrated here and compared with the classic TRIZ approach.

5.1 Example carried out with Innovation Module

First the product type has to be determined with the PILOT. One square meter of the noise barrier wall consists of 20 kg wood, 4 kg fibrous material - glass fiber - for the absorption layer and 0,4 kg impregnation agent for wood preservation. The average height is 4 meters on motorways. The lifetime is assumed to be about 15 years. The noise barrier wall can be characterized as a *raw material intensive* product.

Discussing the objectives delivered from the PILOT for the given product type shows possible ways to go. Working through the checklists for each strategy leads to detailed ECODESIGN measures. Additionally the Innovation Module delivers Inventive Principles. The result is shown in Table 1.

Table 1. ECODESIGN measures and Inventive Principles for improving the noise barrier wall.

INNOVATION MODULE		
ECODESIGN - PILOT		**TRIZ**
Strategies	**Measures**	**Inventive Principles**
Selecting the right materials	- Avoid or reduce the use of toxic material and components - Prefer materials from renewable raw materials …….	- Rejecting and regenerating parts - Transformation of physical and chemical states of an object - Composite materials …..
Reducing material inputs	- Reduce material input by design aiming at optimum strength. - Reduce material input by integration of functions …….	- Local quality - Replacement of a mechanical system - Use a pneumatic or hydraulic construction ….
Recycling of materials	- Ensure that materials are suitable for recycling - Ensure that surface coating and base material are suitable for recycling …..	- Homogeneity - Transformation of physical and chemical states of an object …..

Applying the Inventive Principles on basis of the ECODESIGN measures leads now to new solutions. The Principle *Composite materials* brings the idea to use alternative absorption material to realize a high absorptive wall. Such a noise barrier wall can be realized with less

height. This reduces total material input and also the undesired tunnel effect and hindrance of sight.

The Principle *Replacement of a mechanical system* stimulated the search for solutions to minimize material input and reduce the negative effects on the upper edge of the wall like sound diffraction. The phenomenon of sound interference was therefore investigated and the idea of noise canceling by sound interference came up. Two similar sounds which are out of phase cancel each other out. Literature search showed that a passive device can utilize this effect [7]. Four sound channels could be arranged at the upper edge of the wall. Due to the uneven lengths of these channels, interference occurs at the outlets. Such a device can help to minimize the required wall height.

Finally the Principle *Transformation of physical and chemical states of an object* leads to several proposals for the wooden wall panels. This should ensure product durability and replaces the impregnation agents used in the current wall. This is a main requirement for recycling since the impregnation turns the renewable material wood into hazardous waste.

These results by means of Inventive Principles were gathered by a clear stepwise process. Every step delivers suggestions of what can be done. Discussion selects possible options and at the end new ideas can be provided. The integrated TRIZ knowledge is provided in a way that also TRIZ beginners can easily use that tool. Therefore the collection of short examples from different branches is useful for explaining the Principles.

Compared to the classical TRIZ approach the Innovation Module is the “shot cut” to possible solutions.

5.2 Example carried out with classical TRIZ

When following the main aspects of a classic TRIZ approach, in a first step the Innovation Situation Questionnaire delivers the problem description (see Table 2).

Table 2. Problem description for the noise barrier wall.

Innovation Situation Questionnaire	Description
Technical system	Noise barrier wall
Primary useful function	Noise protection, long-lasting
Product structure	see Figure 3
Functioning of the product	Sound reflection Sound absorption
Problem situation	Hazardous impregnation substances High walls cause tunnel effect and hindrance of sight Sound diffraction on the walls upper edge

In a next step the problem formulation process shows the relation of useful and harmful functions (see Figure 4).

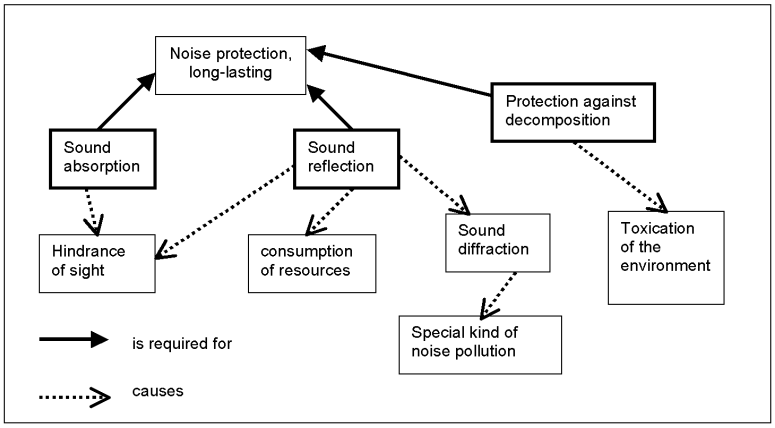

Figure 4. Cause and effect graph for the noise barrier wall.

The last step is formulating contradictions with the technical parameters and applying the Contradiction Table. E.g. functions, which are required for a useful function and causing also drawbacks, are indicating a contradiction (see Figure 4).

Table 3 shows the formulated contradictions and their related Principles.

Table 3. Identification of Inventive Principles with classical TRIZ approach for the noise barrier wall.

Product related contradiction	**Transformation to standard contradiction**	**Contradiction Table delivers Principle**
Sound absorption is required for noise protection and causes hindrance of sight	Area of non-moving object versus Reliability	- Transformation of physical state of an object - Composite materials …….
Sound reflection is required for noise protection and causes high consumption of resources (High walls are needed to eliminate the effects caused by sound diffraction)	Length of non-moving object versus Reliability	- Replacement of a mechanical system - Use a pneumatic or hydraulic construction ……..
Protection against decomposition is required for long-lasting noise protection and causes toxication of the environment	Stability of object versus Harmful side effects	- An inexpensive short lived object - Transformation of physical state of an object - Inert environment ……

6 Conclusion

As Table 3 points out, the TRIZ approach delivered the same results as the Innovation Module, but for this product specific knowledge, environmental knowledge and of course TRIZ knowledge is necessary. Without sufficient environmental knowledge some aspects may be forgotten already at the beginning when answering the Innovation Situation Questionnaire (doing the problem description). In comparison the PILOT contains systematically all these aspects.

On the other hand the classical TRIZ approach needs some effort and practice to do the cause and effect graph and to use the Contradiction Table. Especially the transformation of product related contradictions to standard contradiction for using the Contradiction Table needs some skills (compare Table 3). Otherwise users will leave back frustrated when the obtained

Principles will match in no way. For example reformulating the contradiction in the last row of Table 3 to *Durability of non-moving object* versus *Harmful side effects* delivers only the Principle *Convert harm into benefit*, which doesn't match here.

The Innovation Module extends the well established ECODESIGN PILOT to a powerful tool for product development. The whole structured and coherent approach needs methodical and environmental related only minimum learning effort. These were finally the criteria of the evaluation, which were high-grade fulfilled. Accordingly it can be considered as a ready to go approach. This is essential for acceptance in industrial practice because time to success respective time to market is an important factor.

The Innovation Module delivers systematically stimulation of innovation utilizing the core element from TRIZ. We often hear from our different project partners that they want to integrate TRIZ in their daily work but do not know how. The new Innovation Module is a good possibility to do that.

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