The interchange of environmentally related information – a prerequisite for the next generation of LCA-tools

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1. Introduction

There is no doubt about the crucial influence of the design process on the economical success, as well as the ecological impact of a future product, especially in the early phases of the design process. This is understood by research and industry, and so far, a large number of methods and tools have been developed for the support and implementation of Design for Environment (DfE). Analytical design tasks are assisted by checklists, methods for rough impact assessments, or full life cycle assessments (LCA). Furthermore, we can find structured collections of rules, guidelines, strategies and case studies to support the more constructive design tasks (Birkhofer, Grüner 2001). These are very often isolated solutions which are not integrated into the work environment of engineering designers.

The main goal of the research project SFB 392[3] is to develop an integrated computer-based design environment that meets the special requirements for DfE. The workable prototype of the integrated work environment is presented in paragraph 3.

The core innovation consists of the possibility to carry out an LCA of virtual product variants during the product development process. This way it will be possible in the future to eliminate the currently unfavourable long feedback loop that normally occurs by performing LCA's. This feedback loop is caused by the fact that

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[3] The Sonderforschungsbereich (SFB) 392 "Design of Environmentally-Friendly Products - Methods, Working Aids, Tools" is a collaborative research centre at the Darmstadt University of Technology funded by the DFG since 1996, Internet: http://www.muk.maschinenbau.tu-darmstadt.de/sfb

an LCA is not feasible until a product has already been produced. That is why weak points of a product – identified within an LCA – cannot be optimised or eliminated before the next product generation.

But the large number of supply parts that is used in the product development process poses a serious problem. To obtain a valid LCA as a basis for decision-making, and therefore, the implementation of the integrated design environment, it is necessary to have access to the inventory data of the used supply parts.

The research work done by the project COMA[4] may provide some insight to solve this problem. Actually, the primary objective of the project COMA is to recognise and describe a generic structure for the description of variant products as a prerequisite for the configuration. This structure makes it possible to describe the different aspects of the configurable product, and among other things, to define the necessary data used within the supply chain.

This paper presents the relevant work of both projects and shows the synergies of the future cooperation.

2. Background – Integrated Product and Process Development

Designing environmentally friendly products means designing the product itself, involving the product-related processes, as well as the relationship between them. For this reason, the work of the SFB 392 is based on the concept of the so-called Integrated Product and Process Development (IPPD) (Birkhofer, Grüner 2001). To map the requirements of DfE the existing concept was explicitly extended for the two product life phases "Use" and "End of Life" (Fig. 1).

During the product development process the evaluation of the environmental impact of a solution is impossible without knowing the emissions of, e.g., the selected manufacturing processes. This shows that a holistic, foresighted and preventive approach to DfE postulates additional requirements for the product development process. Nowadays the product development process is supposed to deal with the whole life-cycle of a product, and of course, with the environmental aspects in addition to the costs and quality aspects.

3. The Integrated computer-based design environment

In order to help designers by the selection, definition and evaluation of the processes in the product life cycle, they have to be supported by computer-based systems.

[4] COMA "Configuration Management for the Machine Industry" is an Eureka project with 15 partners in Switzerland and Germany at the Federal Institute of Technology in Zurich, Internet: http://www.coma.imes.ethz.ch

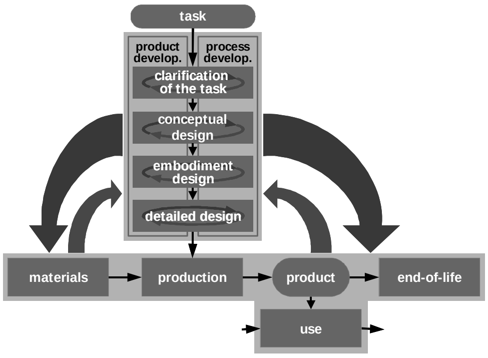

Fig. 1: Model of the IPPD (Birkhofer, Grüner 2001)

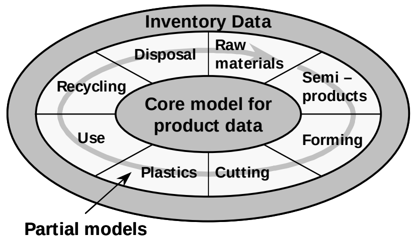

Fig. 2: Information model architecture of the SFB 392 (Anderl et al. 1997)

The architecture of the integrated design environment developed by the SFB 392 is based on a coherent information model (Fig. 2) (Anderl et al. 1997). The core of this information model contains a product data model. The so-called *partial-models* are located in a second layer. They represent environmental knowledge (in the form of calculating procedures) of all life cycle phases in an object-oriented manner. These partial models are used to generate the inventory data of a – by that time – virtual product. These procedures run unnoticed by the designers (the actual users).

From the users point of view, a 3D-CAD-System forms the basis of the integrated design environment (Fig. 3). It enables the designer to define assembly structures, the volume of components or the characteristic dimensions of form features. This standard work environment of a product designer is supplemented by two additional systems. An evaluation system (Atik et al. 1999) enables the designer to evaluate the ecological, as well as the technical and economical performance of virtual product variants. Furthermore, the evaluation system enables the designer to identify the components or life phases with the highest potential for optimisation.

Regarding the concept of the IPPD, a 3D-CAD-system is obviously not applicable for the selection and definition of all processes in a products life cycle. Especially end-of-life scenarios or processes, which are taking place within the use phase, cannot be handled with a 3D-CAD-system. Therefore, an additional editing-tool was developed – the so-called *life-cycle-modeller* (Birkhofer, Grüner 2001). It enables the input of product and process information according to the life phases.

Within the last years the percentage of used components bought from subcontractors has steadily increased, and because of that, the need for external information has increased as well. This becomes even more critical in the early phases of a prospective development of environmentally sound products, where the information is most needed. To obtain a valid LCA as a basis for decision-making, it is necessary to have access to the inventory data of all supply parts and related processes. It should be a goal that every company participating in the ladder of adding value (from producing raw material to waste disposal) provides all relevant information about its products and their related processes (Dick et al. 2001).

But as surveys show, companies have reservations about providing product information about manufacturing processes, used materials, etc. Such information could become very sensitive once a competitor gets hold of it. Moreover, the providing of the relevant data incurs supplementary costs, which the customers are not always willing to pay.

4. The representation of relevant information in COMA

In the COMA-project a data model has been developed in order to handle all configuration relevant information of a product. The COMA-approach obtains the product description data from the *digital product* (Leonhardt 2001). All product-relevant data – generated during the whole product life-cycle (e.g. geometric data, describing data) – is stored within the *digital product*.

To ensure that all relevant information for the configuration is available, a methodology called *K & V-Matrix*[5] has been developed by the COMA-project (Bongulielmi et al. 2001). Particularly the *K-Matrix* (Fig. 3) allows the representation of different kind of data stored in the *digital product*. The following sections focus on this aspect and present the *K-Matrix*.

The basic unit to describe a product for a customer in the *K & V-Matrix* is a product class (DIN 4000). In order to facilitate the product selection process for the customer (e.g. in online catalogues), it is necessary to describe the product range with product characteristics which are known to the potential customers (Dick et al., 2001). The correlation between the characteristics and the product classes is a core aspect in the configuration process and is represented in the *K-Matrix* (Bongulielmi et al. 2001).

Usually, companies provide more characteristics to the customers than are actually required for the product selection. In this manner, a company can insert in the *K-Matrix* other kinds of data like e.g.:

1. internal prices, that are not shown to the customer during the selection process, but can be used by the sales department,
2. additional information, that is required by the customer for the product development (e.g. LCA relevant information).

In order to keep an overview of the increasing number of characteristics during the whole product development process, a clustering of similar properties (e.g., geo-

[5] Konfigurations- & Verträglichkeitsmatrix (K & V-Matrix), English: Configuration and Compatibility Matrix

metrical features, economical data, logistical data, production data, etc.) can be carried out in the *K & V-Matrix*. Clustering the properties in “groups of properties” can be done independently of the product classes. In this way, it is possible to group all product and process relevant information, that is a prerequisite to performing LCA.

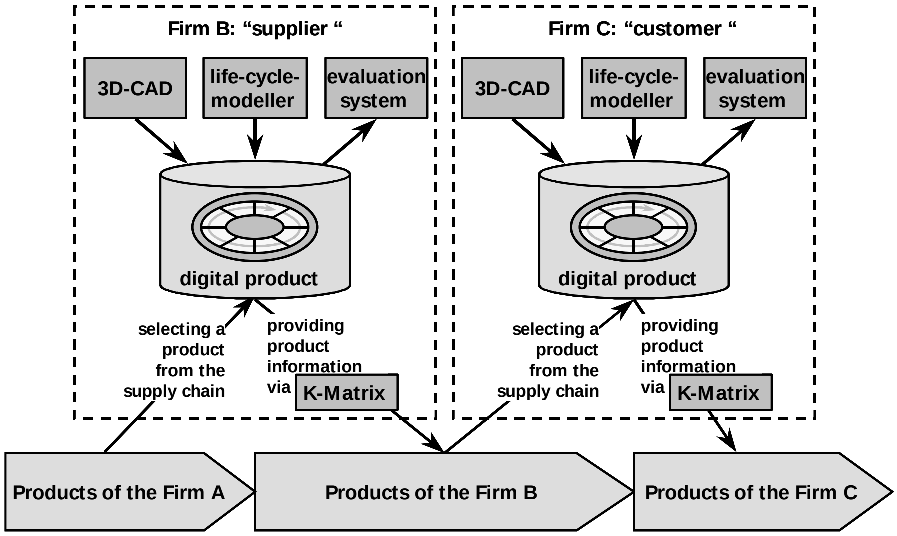

Fig. 3: The interchange of relevant product information along the supply chain (Bongulielmi et al. 2001), (Dick et al. 2001)

Because of the deep integration in the *digital product*, it is possible to integrate data in COMA, that has already been provided by suppliers or has been generated during the product development process. So the holistic interchange of environmentally related information along the supply chain will be enabled and the redundance-free handling of the product description data is provided.

5. Conclusion

The ongoing cooperation between the project COMA and the SFB 392 led to a holistic approach to the interchange of product information along the supply chain. DfE activities, whether they are intended to support or to implement the IPPD, should never be isolated from other perhaps not eco-oriented activities. As it is shown in the present case, the conceptual problems of the integrated computer-based work environment are basically not caused by any eco-oriented aspect related to LCA.

There are rather general problems on how to interchange information from the whole product life cycle: without redundancies, with no supplementary costs and no loss of know how by providing the information.

7. Literature

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