

24th CIRP Design Conference

An example of visually supported design of modular product families

Nicolas Gebhardt*, Tammo Bahns, Dieter Krause

*Hamburg University of Technology, Denickestraße 17, 21073 Hamburg, Germany** Corresponding author. Tel.: +49 40 42878 4257; fax: +49 40 42878 2296. E-mail address: nicolas.gebhardt@tuhh.de**Abstract**

To offer individualized products at globally marketable prices, the Integrated PKT-Approach for Developing Modular Product Families aims to generate high external product variety based on a low internal process and component variety. Specific visualizations are an important factor in the success of this approach. In this paper the Module Interface Graph (MIG) developed at the Institute for Product Development and Mechanical Engineering Design (PKT) is used to show how specific visualization concepts of a product family can help present important information, as well as define module interfaces and boundaries during the modularization of a product family. Two brief industrial case studies are presented to give insight into using the MIG and emphasize potential improvements to visual product representations for developing modular product families in a team.

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Selection and peer-review under responsibility of the International Scientific Committee of “24th CIRP Design Conference” in the person of the Conference Chairs Giovanni Moroni and Tullio Tolio

Keywords: *Customized and personalized product development; complexity reduction for innovation teams; creative and innovative design*

1. Introduction

Markets are becoming more and more global. For manufacturing companies this leads to a global customer base with high individual demands. Meanwhile companies face global competition, resulting in high cost pressure. Companies have to handle the conflict of offering highly variant products at low prices. An increase in external product variety due to individual customizations results in an increase in product and process complexity, a loss of transparency within the company and high complexity costs. Companies have to find a solution to offer a wide and flexible range of product variety while retaining low internal variety of components and processes.

A proven product-based solution for this is the strategy of modular product structures. However, while it can lead to reduced complexity in other divisions, e.g. production and logistics, the development of modular product structures is still seen as a major challenge. Using methodical modularization of the product structure, areas of the product are defined as being closely coupled and clearly separated

from each other by well-defined interfaces. Collecting the requirements and allocating them to components for suitable modules are challenging tasks involving stakeholders from all product life phases, such as purchasing and production.

This paper presents an overview of the integrated PKT-Approach for developing modular product families developed in recent years, starting with an introduction of the four underlying attributes which make the approach unique [1]. One of the core visualizations used in the approach - the Module Interface Graph (MIG) - is explained in detail. The tool is used to simplify collaboration between several design disciplines and company departments within a modularization project. Case studies from industry demonstrate its application and identified potentials of improvement.

2. The integrated PKT-Approach for developing modular Product Families

The Institute of Product Development and Mechanical Engineering Design (PKT) developed an approach to support

the development of modular product families [1] in the preliminary design stage.

A product family's degree of modularity is dependent on combinability of modules, function binding, interface standardization and loose coupling between components [2], [3]. Appropriate utilization of these properties, and therefore modularity, within the product structure has to be archived during the development of a modular product family. Advantageous module concepts depend on functional technical as well as strategic requirements [4] from all product life phases. From a variety-oriented point of view, a product structure with the following product structure properties are desired [5, 6]:

- Clear differentiation between standard components and variant components
- Reduction of variant components to the minimal variant part
- One-to-one mapping between differentiating properties and variant components
- Minimal degree of coupling of variant components to other components

The integrated PKT-Approach supports product developers and designers during this task. It was created by combining new concepts with adapted ideas from existing literature and approaches [7], and has been validated in multiple industry projects [8]. The approach consists of a set of method units that consider product and process views (Fig. 1).

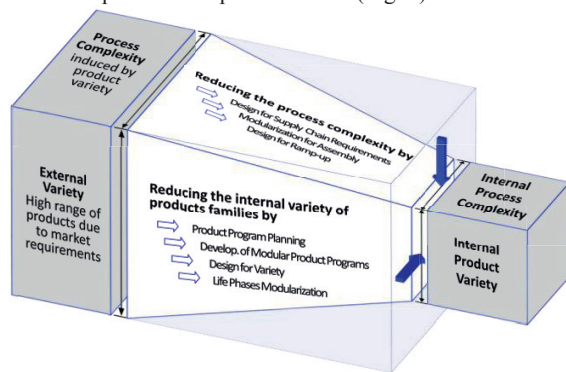


Fig. 1. Overview of the Integrated-PKT Approach for developing modular product families [1]

Four underlying attributes make the approach unique.

- The approach is structured as a set of combinable method units each designed for a specific task. Combining them allows flexible and case-specific support.
- It emphasizes redesign, modification and new design of components to reduce product variety.
- The approach is workshop-based to integrate product knowledge from different disciplines.
- Multiple specially developed visualization concepts are integrated to foster discussion in project teams.

Section 3.2 shows the combined application of two units, "Design for Variety" [5] and "Life Phase Modularization" [2]. A broader overview and in-depth explanation of the approach's method units can be found in [9].

3. The Module Interface Graph (MIG)

The use of task-specific visualization tools is a major factor in the success of all methodical units of the approach. Specific visualization enables multiple experts from different company departments (e.g. R&D, and marketing) to integrate by providing an overview as well as view-specific details.

Working with visualization during the development of modular product families is illustrated by work with the Module Interface Graph (MIG, Figure 2). The visualization was first developed in 2008 by Brees [2]; since then it has been used in more than twenty industrial projects and thirty student projects. During this time the visualization was further developed. The MIG is a schematic 2D graph of a product family and its components. It arranges only the information that is essential for deciding modular structures. It complements the product documentation typically used in product development (e.g. CAD models, bill of materials or function structures) by supporting communication and decision-making in a trade-off situation between the stakeholders of modularization.

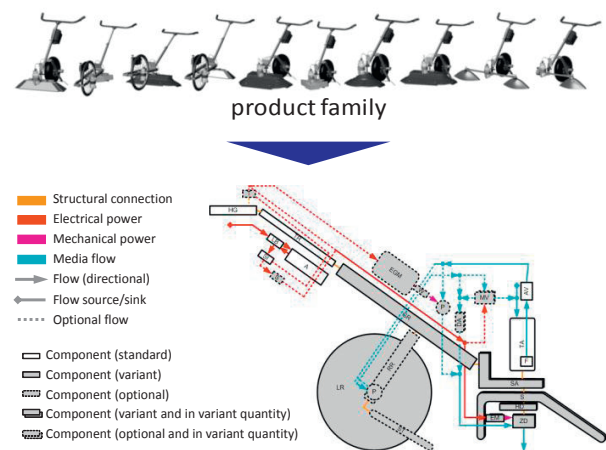


Fig. 2: Example of a Module Interface Graph (MIG) [9]

The MIG contains all essential and optional components of the product family along with their approximate location, shape and size. All components are labeled with their name or an abbreviation to clearly identify components. As described in detail in Section 3.2, it indicates whether the same component can be used in all members of the product family or if variants of the component are required (Fig. 2).

Flows connecting the components via interfaces represent important information about the internal couplings within a product family and are therefore included in the MIG. Flow types, directions, etc. are differentiated by shape and color (Fig. 3).

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