Design for Open Innovation

Individualization-Oriented Product Architecture Planning

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***Abstract*— The continuously increased aspiration level of customers and the growing saturation of the markets are the main drivers for the development of customer individual products. In this context, the determination which of the product components shall be individualized by the customer represents a major challenge for the product development. In order to meet these challenges, the „Design for Open Innovation (DfOI) Methodology" will be presented in this extended abstract and shall support the product developer during the definition of an area of individualization within already existing products. Therefore, a five phase methodology is proposed. Each phase contains several work steps which follow sequentially. The level of detail for describing the single work steps of the DfOI Methodology has been deliberately kept low in order to focus the conceptual framework of the methodology.**

Keywords*— Open Innovation; Web-based Toolkit; Customized Product Development; Product Architecture Planning

I. Introduction and Motivation

"Customers – consumers and corporations alike – demand products and services designed for their unique and particular needs. There is no longer such notion as the customer; there is only this customer, the one with whom a seller is dealing at the moment and who now has the capacity to indulge his or her personal tastes. The mass market is broken into pieces, some as small as a single customer." [1]

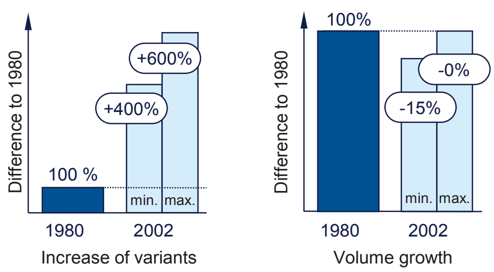

Fig. 1. Development of diversity of variants and of quantities in stagnating markets (according to [2])

The continuously increased aspiration level of customers [3] and the growing saturation of the markets which has led to a surplus of goods [4], [5] are the main drivers for the development of customer individual products. Thus, in stagnating markets a strong increase in the number of variants appeared during the last years while the sales remained at the same level as it can be seen in Fig. 1. Only companies who can achieve a successful differentiation from their competitors by expanding their product portfolio are able to succeed in the international markets [6], [7], [8]. For that reason many companies see themselves as a service provider for customers and try to achieve an entire fulfillment of the customers' demands [4].

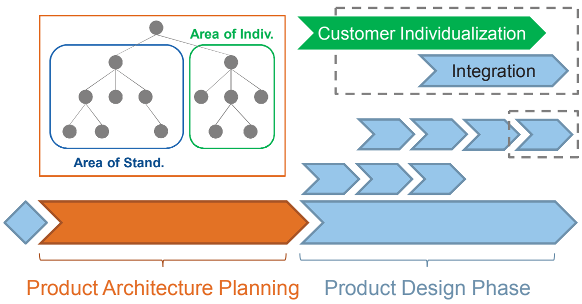

Fig. 2. Classification of the product architecture planning and the customer individual product definition (according to [3])

With the possibility of a direct communication between customer and company via web-based open innovation-toolkits, the customer is in a position to participate actively in the product development process with extensive degrees of freedom. Degree of freedom is generally understood as all those product components which the customer can adapt and design by specifications related to its needs [9]. An open innovation toolkit describes a design environment which enables user to formulate, concrete their needs iteratively and transfer it into a producible solution by a trial and error process [10]. Against this background, the customer is able to individualize, for example, the product design in certain dimensions and therefor to implement implicit product wishes and imaginations independently (in the following such a customer integration is described as customized product design). Such active customer integration leads to a multitude of different product variants coupled with a small quantity through to lot size one. As a result, a "manual integration" (intervention of developer necessary) of every single customized solution into the overall product is from an economic point of view not realizable for the respective company. Developer are therefore forced to plan the product architecture in advance in a way that a "fully automated

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integration" (intervention of developer not necessary) of every single customized solution into the overall product will be enabled (see also Fig. 2).

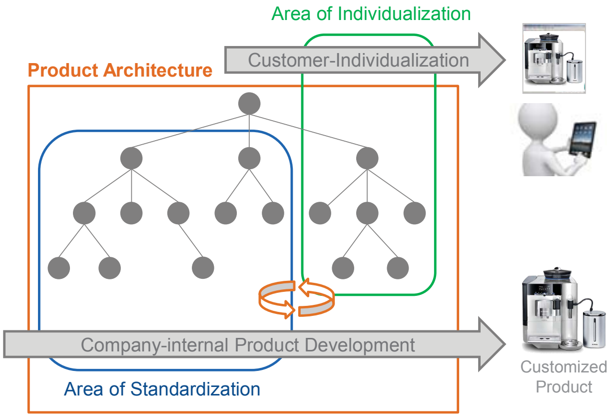

Fig. 3. Product architecture of customer individualized products contain of both, an area of standardization and of individualization

The product architecture planning (PAP) described above represents a major challenge for the product development. Thus, during this phase, developers have to create areas within the product architecture where customers can creatively intervene via web-based toolkits during later development phases (see also "Area of Individualization" in Fig. 3). To be more precise, developers are facing the challenge of breaking-down the product structure into an area of standardization and an area of individualization and by this defining which components of the product can be individualized by customers and which are standardized. Such a break-down of product architecture is necessary due to the individualization of all product components is not realizable from a company perspective based on uncontrollable interdependencies. Furthermore, the product architecture has to be planned in a way that detrimental interdependencies between the area of individualization and standardization are avoided.

In order to meet these challenges, the „Design for Open Innovation (DfOI) Methodology" will be presented in this paper [11]. The main objective of this methodology is providing support to the product developer in defining the area of individualization during the phase of product architecture planning. In this case it is assumed that the product in question is already developed and commercialized. Furthermore, the product to be individualized has to be preselected by the company, since the identification of appropriate products is no part of DfOI Methodology.

II. State of the Art

A. Open Innovation

Open innovation represents a strategic concept which describes the opening of an innovation process and the interactive, strategic use of company's environment for improving its own innovation potential [12]. The leverage effect of open innovation is based above all on a range extension of idea and solution finding. By integrating external partners it is the objective of both, improving the access to need and solution information [13]. [14] defines this as change from closed towards open innovation. Closed innovation processes are limited to the creative input and the existing knowledge of a small group of company internal employees. If this group is now enlarged with company external partners, ideas, creativity, knowledge and solution information of a significantly larger group of individuals can be involved into the innovation process. For this reason, input factors will be exploited which were not available for the innovation process before [13]. With regard to [14], opening not only means the creation of an idea but also their realization. Thus, the role of customers is changing from passive beneficiaries to active value-adding partners.

B. Open Innovation Toolkit

The integration of customers into the innovation process is neither in praxis nor in literature a new phenomenon [15]. A broader discussion and active implementation of respective organization structures in form of open innovation could be increasingly observed in recent years [13]. The main reason for this is the rapid development of modern information and communication technology which enable companies to contact individually a broad range of customers by using web-based platforms. Based on this interactive process, it is possible to integrate customers into different phases of the innovation process. At the same time this interactive process represents an optimal lever for increasing the degree of individualization of products comprehensively. This perspective describes cooperation between company and customer which is initiated by the company and carried out by a cooperative process between these two essential players. Thereby, customers themselves become active and concrete their implicit knowledge about new product ideas and concepts by using open innovation toolkits which are provided by the company [13].

C. Individualization via Open Innovation Toolkits versus Mass Customization

[16] defines the phenomenon of individual mass products as "Mass Customization of markets means that the same large number of customers can be reached as in mass markets of the industrial economy, and simultaneously they can be treated individually as in the customized markets of pre-industrial economies". The integration of customers into added value in connection with a co-design process is the central element of this definition. Thereby, the existing solution space is concreted individually by the customer and in interaction with the company. The main objective underlying this interaction is that the customer can choose from pre-considered options.

The central commonalities of Mass Customization and individualization via open innovation toolkits are represented by the interaction between manufacturer and customer and the active integration of customers into the added value processes by web-based platforms. Both approaches aim to provide individualized products to the customers which are tailored to their needs. Unlike product individualization via open innovation toolkits in the field of mass customization, the customer arranges his own individual product by combining already developed alternatives of certain product components respectively functions. In this case customers only fulfill configuration tasks. In contrast, open innovation toolkits are related to a mostly open solution space which can be extended or modified by customers under consideration of some restrictions. Thereby, customers take on design tasks related to the innovation process which aims to developing novel, not pre-considered products.

D. Product Architecture Planning

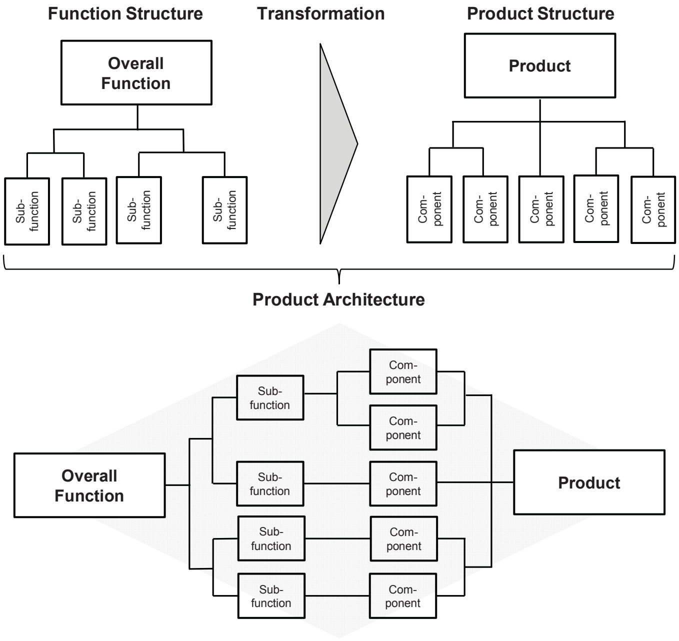

Fig. 4. Product architecture as transformation of function and product structure (according to [17])

According to [18], the product architecture consists of three main aspects – the product structure, function structure and their transformation, thus, the relation between functional and physical description of the product (see also Fig. 4). The function structure represents the product function to be fulfilled in different levels of decomposition. Unlike the product structure defines by which technical-physical correlation these functions shall be fulfilled. [18] suggests that the product architecture creation as main part of the product development and defines it as combination between function structure and product structure including all related transformations. Thus, the product architecture describes exactly which product function is fulfilled by which product components. The transformation of an abstract function structure into a concrete product structure represents the main task of product architecture planning and the following development phases. According to [18], the transformation process is not described as linear, deterministic process but as iterative procedure towards an acceptable solution with lots of wrong tracks, attempts and subjective decisions. At the same time function and product structure cannot be developed sequentially but parallel. The closely mutual coupling of function and product structure is explained by the fact that every particular function to be fulfilled determines the physical product design. Furthermore, the identified sub-functions already depend on an implicitly assumed, physical solution principle as well as product structure. The product architecture developed during this transformation process will be modified in cycles of generating, evaluating and reflecting as long as an acceptable is identified [18].

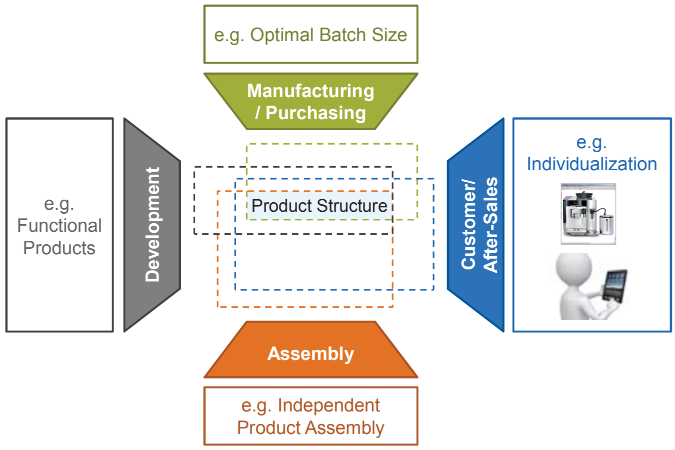

Fig. 5. Possible perspectives on product structure (according to [19])

During its planning, the product architecture can be optimized regarding different perspectives and related requirements. Thus, [19] describes four main groups of requirements (see also Fig. 5):

- manufacturing/ purchasing,
- customer/ after-sales,
- assembly,
- development.

For each of that group it is possible to develop an individual product structure with an individual modularization where the focus is on the requirements of the particular perspective. From the development perspective, it is for instances the development of functional products. From the manufacturing/ purchasing perspective, it could be the optimal batch size which can be reached by applying a suitable carry-over parts strategy. From the assembly perspective, it is perhaps useful to summarize product components into modules which enable an order-independent product assembly. Out of the perspective of customer/ after-sales, requirements are derived from customer needs and after-sales services like for instances changeability of product components or recycling. These different perspectives and related requirements constitute an area of conflict within the product architecture planning and present the product developer with the challenge to define a suitable compromise.

III. Design for Open Innovation Methodology

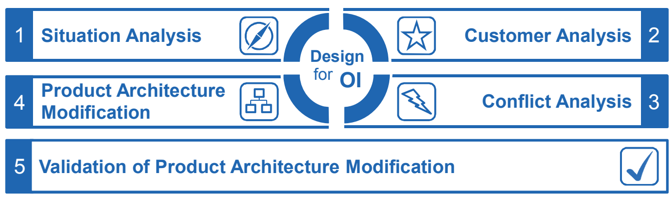

Fig. 6. Overview of the phases of the DfOI Methodology

The DfOI Methodology consists of 5 phases, each phase contains several work steps which follow sequentially (see also Fig. 6). In the following, the individual phases and work steps contained therein will be described in detail.

A. Phase 1: Situation Analysis

Fig. 7. Main work steps of the DfOI Methodology phase "Situation Analysis" (Phase 1)

Within the first phase the company has to determine their ambition regarding the product individualization (see also Fig. 7). From public relations measurements through to the real enhancement of customer benefits by product individualizations, this ambition may take several forms. This allows the company to reflect the relevance of product individualizations compared to further strategic considerations (e.g. platform and standardization strategies) during the phase of product architecture planning and is essential for decisions within later phases of the DfOI Methodology. In the next work step the product architecture of the product to be individualized and preselected is analyzed in detail. The objective is the consolidation and preparation of information required for development of the product which are often insufficiently or incompletely documented in the industrial context. Thus, a transparent and consistent basis of information created for all following work steps within the DfOI Methodology. As already described, the product architecture consists of function structure and product structure [20]. Both structures can be combined by means of a transformation [20] and can be transparently depicted as shown in Fig. 8.

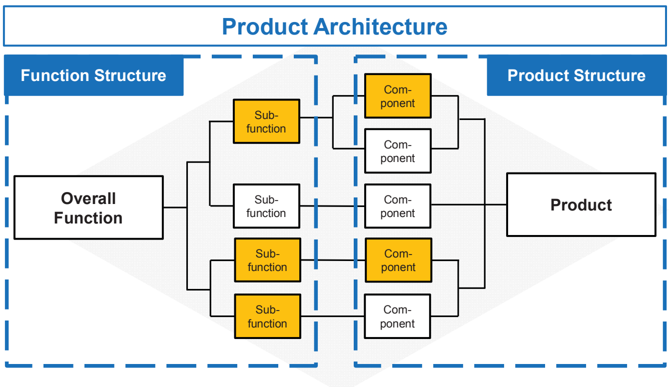

Fig. 8. Exemplary product architecture depicted by the approach of [20] (standardized components are highlighted in orange)

The consolidation of dependencies between the product components (e.g. geometrical, functional) as well as respective reasons for the definition of product modules which were considered for the original architecture planning of the concerned product, represents the second part of the product analysis. Therefore, the methods of Structural Complexity Management [21], [22] are applied which support both, the analysis steps and subsequent preparation of the results through suitable graph visualizations. As last work step of phase two, the standardized and therefore not changeable product components and functions are highlighted within the product architecture. These must neither be direct nor indirect affected by later individualization activities because it would mean uncontrollable adaptions of functions and components over the whole product portfolio. The orange highlighted components in Figure 8 exemplary represent these standardized product functions and components.

B. Phase 2: Customer Analysis

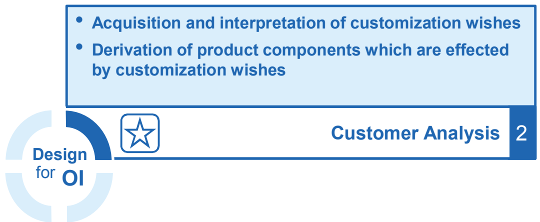

Fig. 9. Main work steps of the DfOI Methodology phase "Customer Analysis" (Phase 2)

In phase two of the DfOI Methodology the product related individualization wishes of the customers (PIW) are structural gathered by customer surveys, web-based platforms or similar methods (see also Fig. 9). This includes the following information:

- product components to individualized,
- type and extent of product individualization,
- motivation of product individualization,
- accepted extra costs for product individualization (here the marketing can be considered as support).

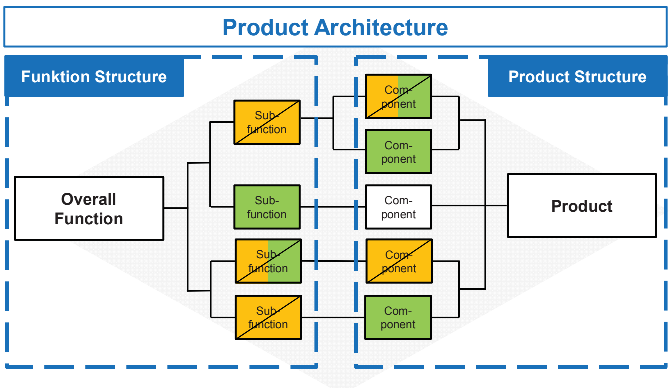

Fig. 10. Exemplary product architecture by the approach of [20], divided into function structure and product structure (standardized components are highlighted in orange; components which are affected directly by individualization wishes of the customers (PIW) are highlighted in green; standardized components which are affected directly by PIW are highlighted orange-green)

After successful gathering, the PIW will be analyzed and prioritized according to their relevance. Based on that, the product components which are directly affected by the PIW will be derived and highlighted within the already analyzed product architecture (see also Fig. 10). At this point it becomes clear which of the standardized and not changeable components are affected by the PIW. PIW which cause changes of standardized product components will not be considered in the further course of DfOI Methodology because of uncontrollable consequences. Both, the remaining PIW and the product components concerned thereby, represent the basis for the next phase.

C. *Phase 3: Conflict Analysis*

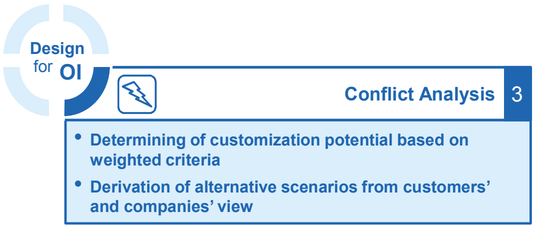

Fig. 11. Main work steps of the DfOI Methodology phase “Conflict Analysis” (Phase 3)

At the beginning of the third phase of DfOI Methodology, the individualization potential of the product components which were identified in phase two will be determined (see also Fig. 11). Thus, it is described to which potential the respective products components have – the higher the potential, the more suitable the component is from the perspective of the company regarding individualizations by customers. To determine this potential, the developer, first of all, has to define suitable criteria. Beside functional and geometrical dependencies, aspects like manufacturing efforts or the crosslinking density of the component could be such criteria. Based on this definition, the individualization potential for every single product component will be determined.

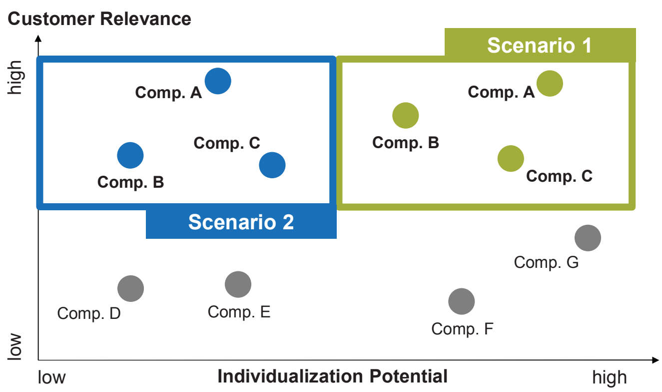

Fig. 12. Classification of exemplary product components into the portfolio for the derivation of alternative scenarios; individualization potential is plotted

In the next work step the particular components will be assessed regarding the customer relevance. Therefore, it will be recapitulated which of the PIW – gathered in phase two – is responsible for the change of the respective product component and which customer relevance this PIW has (based on prioritization of PIW in phase two). To obtain a better overview the concerned product components will be depicted in a portfolio (see also Fig. 12), whereby the individualization potential is plotted against the customer relevance. On this basis, different alternative scenarios can be derived within the next work step. As shown in Fig. 12, every scenario contains certain product components which later represent the area of individualization within the product architecture. Related to the example in Fig. 12 a scenario of components results which have both, a high individualization potential and high customer relevance (see also “Scenario 1” in Fig. 12). In a second, alternative scenario there are product components defined as area of individualization which also have high customer relevance but in any event a significantly lower individualization potential (see also “Scenario 2” in Fig. 12).

It would be possible to create further scenarios – but for reasons of clarity there will be only two scenarios considered in this paper. The suitable number of alternatives has finally to be determined by the product developer. In the last work step of phase three, the scenarios are checked for consistency. This means that it is checked to what extent it may be appropriate from company’s perspective to combine the selected product components within the same area of individualization. In the event that there will be identified any kind of inconsistency, the concerned scenario has to be revised. Only when each scenario is consistent, the fourth phase of the DfOI Methodology can be started.

D. *Phase 4: Product Architecture Modification*

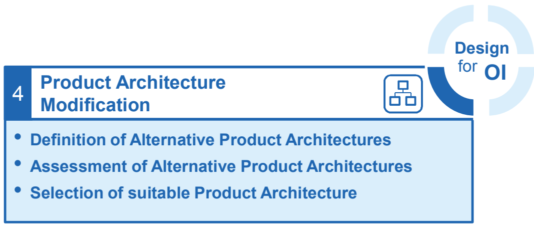

Fig. 13. Main work steps of the DfOI Methodology phase “Product Architecture Modification” (Phase 4)

In phase four, the product architecture will be adapted in accordance with the previously defined scenarios (see also Fig. 13). Such an adaption takes place by a suitable re-modularization of the already existing product architecture as well as by redefinition of respective interfaces between the already existing product modules. Thus, adapted product architecture will be created for each scenario. Within the following work step, the alternative product architectures have to be assessed regarding the extent of necessary changes. In addition to the product components within the area of individualization, it is at this point also necessary to consider components which have to be adapted due to the creation of this area. Accordingly, those product components are indirectly affected by the PIW. The assessment of necessary product architecture changes shall enable the product developer to estimate the modification effort for creating such alternative areas of individualization. Based on this estimation, the developer is then in the position to decide which scenario is economically feasible for the company. For this it is necessary to confront the estimated modification efforts with the increase in turnover by selling customer individual products and predicted by the marketing. Finally, the necessary changes of the product architecture and in consequence for the related components have to be triggered for the selected scenario and its area of individualization which has to be realized within later phases of the product development.

E. Phase 5: Validation of Product Architecture Modification

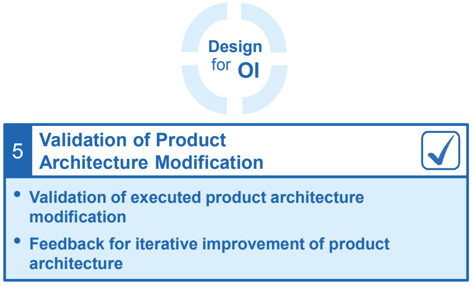

Fig. 14. Main work steps of the DfOI Methodology phase “Validation of Product Architecture Modification” (Phase 5)

In the last phase of the DfOI Methodology, the triggered changes of the respective product components are validated about the further product development process (see also Fig. 14). The objective is to check to which extent planned changes of the product components and related efforts are conform to the estimations within phase four of the DfOI Methodology. On this basis, it is possible to iteratively improve the architecture of the product to be individualized by a suitable reflection of the results.

IV. REFLECTION AND OUTLOOK

The DfOI Methodology presented in this paper addresses the objective to support the product developer during definition of an area of individualization within already existing products. The level of detail for describing the work steps of the DfOI Methodology has been deliberately kept low in order to focus the conceptual framework of the methodology. In addition to detailing particular work steps, a continuous example from the industrial context (based on an automatic coffee machine) will be prepared during the further course. This example shall serve as a first evaluation and is intended to the further development of the DfOI Methodology.

REFERENCES

[1] M. Hammer, J. Champy, “Reengineering the corporation”, New York: Harper Business, 1994.

[2] H. Wildemann, “Variantenmanagement: Leitfaden zur Komplexitätsreduzierung, -beherrschung und -vermeidung in Produkt und Prozess”, München 2009.

[3] U. Lindemann, R. Reichwald, M. F. Zäh, “Individualisierte Produkte - Komplexität beherrschen in Entwicklung und Produktion”, Berlin 2006.

[4] E. Westkämper, “Einführung in die Organisation der Produktion”, Berlin 2006.

[5] G. Baumberger, “Methoden zur kundenspezifischen Produktdefinition bei individualisierten Produkten“, München 2007.

[6] M. Röhrig, “Variantenbeherrschung mit hochflexiblen Produktionsendstufen”, Düsseldorf 2002.

[7] F. T. Piller, C. M. Stotko, “Mass Customization und Kundenintegration: Neue Wege zum innovativen Produkt”, Düsseldorf 2003.

[8] M. E. Porter, “Wettbewerbsstrategien”, Frankfurt 1999.

[9] U. Lindemann, “Methodische Entwicklung technischer Produkte”, 3. korrigierte Aufl. Berlin: Springer 2009.

[10] R. Reichwald, F. T. Piller, “Interaktive Wertschöpfung - Open Innovation, Individualisierung und neue Formen der Arbeitsteilung”, 2 Auflage, Wiesbaden: Gabler, ISBN: 978-3-8349-0972-5, 2009.

[11] M. Holle, U. Lindemann, “Design for Open Innovation (DfOI) – Product Structure Planning for Open Innovation Toolkits”, Proceedings of IEEM International Conference on Engineering and Engineering Management, 2014.

[12] O. Gassmann, E. Enkel, “Towards a Theory of Open Innovation: Three Core Process Archetypes”, R&D Management Conference (RADMA), Lisabon (Portugal) 2004.

[13] F. T. Piller, “User Innovation: Der Kunde als Initiator und Beteiligter im Innovationsprozess”, 2006.

[14] H. W. Chesbrough, “Open innovation: The new imperative for creating and profiting from technology”, Harvard Business Press, ISBN: 1578518377, 2003.

[15] C. Herstatt, E. v. Hippel, “Developing new product concepts via the lead user method: a case study in a low tech field”, Journal of Product Innovation Management, 9, 3: 213-221, 1992.

[16] S. Davis, “Future perfect Reading”, MA: Addison-Wesley, 1987.

[17] J. Feldhusen, K. H. Grote, “Methoden und Anwendung erfolgreicher Produktentwicklung“, In: Pahl/Beitz Konstruktionslehre, 8. Aufl., Heidelberg: Springer, ISBN: 9783540220480, 2013.

[18] J. Göpfert, “Modulare Produktentwicklung: Zur gemeinsamen Gestaltung von Technik und Organisation“, Wiesbaden: Gabler, ISBN: 3-8244-6827-1, 1998.

[19] G. Schuh, “Produktkomplexität managen: Strategien-Methoden-Tools”, Wien: Carl Hanser, ISBN: 3-446-40043-5, 2005.

[20] K. Ulrich, “The role of product architecture in the manufacturing firm”, Res Policy 24, 419-440, 1995.

[21] T. U. Pimmler, S. D. Eppinger, “Integration Analysis of Product Decompositions”, Proceedings of the 6th Design Theory and Methodology Conference, New York 1994.

[22] U. Lindemann, M. S. Maurer, T. Braun, “Structural Complexity Management - An Approach for the Field of Product Design”, Berlin 2009.