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Systematic Cost Management and Innovation Process for Product Development

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Abstract

Today's success within a head-on competition calls for continuous development of the product in terms of functionality, quality, and costs. Development projects that aim at quick response are usually based on reuse of existing concepts. A variety of product development tools are available today, however their usability at the development of existing product concepts varies.

Cost estimation and product development use data from previous product generations as input. Decomposing the product into subsystems and creating new conceptual aspects for them may obtain considerable benefits. The functionality of modern products is delivered through multi-disciplinary technical systems and efficient development should be carried out within all technological domains involved. Improvements, either on cost or functional aspects, call for innovations; new concepts are searched because a reductionist, one-disciplinary approach results in partial optimization.

New approaches for systematic processes are needed for generating innovative solutions from existing product concepts and architectures. The approach of the study is based on product and concept definitions, design and development processes in literature, which are reflected against today's industry practice. As a result a new systematic approach to systematic cost management and innovation process is presented.

Keywords: product concepts, cost management, systematic innovation process.

Introduction

Industrial companies are faced with a pressure from two sides: First, evolving life cycle requirements set by the market calls for new product functionalities. This pressure drives the companies to adopt systematic ways of boosting innovation and launching new products. Second, the owners and other stakeholders expect sound entrepreneurship of the company and a reasonable profitability. Innovation and cost management are gaining increasing importance in a dynamic product market, where most players adopt lean manufacturing strategies. Within product development there are three main dimensions that an industrial company must manage: cost, functionality, and quality. In this paper we focus on cost and functionality.

Views to product concept

Hansen & Andreasen [1] introduce two aspects for a product concept: *idea in* and *idea with*. Profitability requirements, as presented in Fig. 1, produce a cost pressure, which is a driving force for reducing costs of products. An industrial product can be decomposed into subsystems or chunks. Cost reduction activities are then focused on selected subsystems and new ideas are generated for improved manufacturability, optimized specification, or introduction of new technologies. These goals obviously contribute to *ideas in*. On the other hand, the market has increasing expectations on product's life cycle properties. Performance development produces functionalities, which carry new *ideas with*.

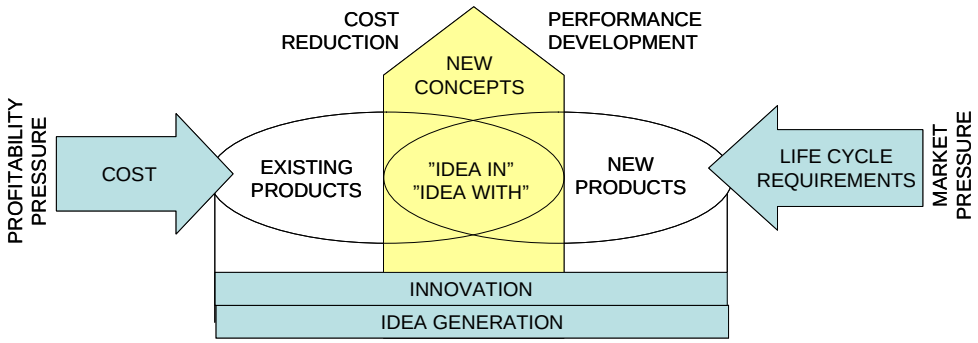

Figure 1: Innovation and new ideas are needed to develop new concepts by which the company can both reduce costs of existing products and develop new ones.

There are more views to product in Fig. 2. A conceptual view encompasses those of management, customer, and designer. The *idea with* integrates product's earning potential with life cycle requirements, which the *idea in* integrates further with design properties.

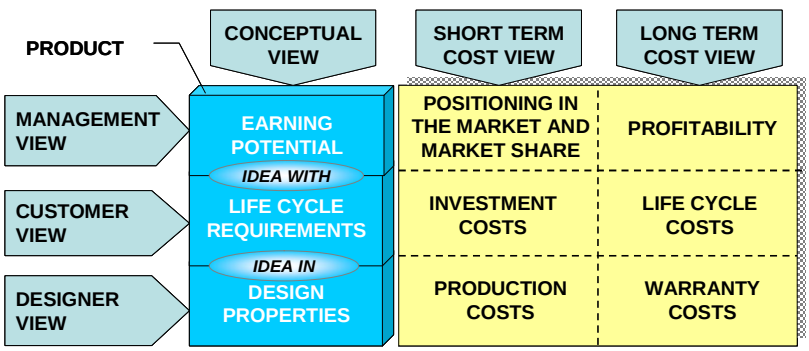

Figure 2: Conceptual view to the product integrates design properties with life cycle requirements ("idea in") and life cycle requirements with earning potential ("idea with").

Cost management and cost reduction

By cost management we usually understand actions taken by managers to satisfy customers while continuously reducing and controlling costs. These actions manifest themselves as cost pressure on the organisation and further on the supplier chain. Cost management constitutes a continuous process, which utilizes standard operational tools of cost accounting, cost estimating and cost control. While this process applies to all business operations we focus here on its impact on product design and development.

Design office engages in cost management process through efforts to reduce product's costs: Cheaper materials shall be used; part number shall be reduced; suppliers are requested to bid. While these actions usually yield reasonable savings they are not sufficient when aiming at radical product cost reduction, which a lean production strategy presumes. Therefore a company must adopt specific tools and methods that are grouped here under the term "cost reduction".

Radical cost reduction has two implications. First, a mindset for new way of working and thinking is planted in organization. Second, a special project is executed to reduce costs of a certain product or product family. Cost reduction project is initiated by management's decision, which must be based on strategic issues. Cost reduction involves establishing a formal project organization and schedule. Project is performed utilizing specific tools and methods, whereof two are prominent: Design-to-cost and target costing.

Design-to-cost and target costing

Design-to-cost (DTC) is the practice of considering product's cost with the same level of importance as its technical performance during the product development process [2]. Simply, in DTC, the objective is to make the design converge to a target cost, rather than to let the cost converge to the design, [3]. Design-to-cost is not the same as Design for cost (DFC). Dean [4] separates them as follows: "In DTC the cost goals are added to the existing requirement set to form an augmented requirement set, while DFC uses cost as the objective function of the optimization problem".

Target costing is defined as follows [5]: "A structured approach to determine the life-cycle cost at which a proposed product with specified functionality and quality must be produced to generate the desired level of profitability over its life cycle when sold at its anticipated selling price." Target costing is a managerial approach to a product development project. In fact, target costing makes an essential part of DTC tool kit.

Boosting idea generation by constraints

The internal profitability pressure and external market pressure push the companies to look for ways to balance between costs and life cycle properties of products. This gives impetus to generate new concepts that are utilized both to improve existing products and to develop new ones. This design context involves three major constraints that need to be managed: Cost constraint, time constraint and performance constraint.

Scarcity of time and money is based on requirements of sound business, which today calls for short time-to-market of products and flexibility in their price setting. However, when faced with constraints a designer is forced to step out of his/her comfort zone and look at the problem from new points of view. This prods the designer into a broadminded thinking, which is a good basis for innovations.

Systematic cost reduction project

The word 'project' refers to an effort, which produces a service or a product that is one-of-a-kind, [6]. In order to be systematic a project needs to be performed through step-by-step procedures and for every procedure methodical approach and strict discipline are applied.

Market survey
Before launching a cost reduction project the senior management needs to define a strategic goal. It may be related to market share of a particular product or to product's profitability in the long term. Market survey reveals the nature of the competition; positions the current product in customer segments, and charts potential success factors for the future.

Target setting and project preparation
Based on the results of market survey and company's strategic goals the senior management sets an explicit target for cost reduction. Typically it is very ambitious, ranging from 10-40% of current manufacturing costs of the reference product. However high the cost reduction target is set, it must be reachable with extended effort. The target cost is fixed and no overrun is allowed. Project scope, schedule and needed resources are planned accordingly. They must be realistic in relation to the target. Structuring the project into several phases or sub-projects helps to manage the limited resources. At this stage it is also decided upon which cost categories and which particular life cycle phases are considered.

Project preparation includes also defining a *reference case*. A valid configuration of the reference product is decomposed into functional subsystems or chunks with their breakdown of realized costs. Chunk-level cost reduction targets are then determined by distributing the total target over the chunks using their actual cost contribution as a weight factor. This step requires careful consideration in view of resource management. The basic idea is to assign a dedicated project team for every chunk. The efforts and work load for each team should be about the same, regardless of cost contribution of its chunk. It means that, if considered easily achievable, the cost reduction target for one chunk may be as high as 60%, whereas for another one only 5%.

Dedicated project teams are cross-functional and they appoint a representative from major functional areas, i.e. from engineering, purchase, manufacturing, sales, and after-sales. General team building rules should be applied; however, one cannot overemphasize the role and skills requirements of the *team leader*. He/she should have influencing power, capability to motivate, skills to act as a facilitator, and be committed to a rigorous reporting process. In addition to the knowledge areas of the team itself know-how about cost accounting and methods planning should normally be available from the line organization.

Cost reduction strategy
Every team establishes a chunk-specific *cost reduction strategy*. In its simple form it is a work plan with major milestones defining the tasks that need to be performed. We can separate three major strategies:

- Redesigning for manufacturability
- Searching for new suppliers, especially from emerging markets
- Redesigning for optimised functionality
- Applying new technology

Tasks are related to selected components and, if considered useful, application of specific cost reduction tools are planned. Depending on the chosen strategy the team can also rely on partnership with suppliers and strive for a win-win situation, which saves both time and costs.

Performing the project phases
Teams start their operative work upon a kick-off meeting that the senior management organises to launch a project phase. Every team follows its own, chunk-specific strategy. The

chunk under consideration is decomposed down to component level and each component is scrutinised. Usually bulk material, such as bolts, nuts, and the like, may be omitted due to their small share in cost contribution. The team works independently but involves line organization for operative actions, such as designing and sourcing.

If a component is mature to such a degree that development efforts are considered gainless, the team may suggest to subject the component to suppliers for bidding.

Value engineering is a useful tool for ranking value indexes of components. Function analysis can be used for estimating if a particular function is needed or not; the results are used for optimizing the specification. The team runs brainstorming sessions to generate ideas and innovations for new concepts. They include both means to realize the necessary product functionality and embodiments of better manufacturability, in which case DFM and DFA are powerful tools.

A successful cost reduction work calls for systematic cost follow-up that is rigorously reported to the senior management. Such a follow-up covers all components under consideration. For every component all development ideas are listed together with their expected savings. Progress of design and sourcing activities shall equally be reported.

Project closing
Upon termination of each project phase the results of cost reduction project are handed over to line organization for implementation. However, senior management must maintain the positive cost pressure. It is advisable to extend the project team leaders' assignment to cover the follow-up of his/her chunk to the ultimate point where its cost reduction target is realized in terms of savings in the cash flow.

Finally, when all phases are terminated and the project is to be closed the teams should be appropriately rewarded. This raises the pride of success and ensures a positive mind-set for new cost reduction projects to come.

An industrial case of cost reduction project
A cost reduction project was conducted in a company that designs, manufactures, and sells diesel powered solutions for marine and power producing applications. The reference product was a marine power package of 1100 kW. We conclude the results with the following experience:

- Radical cost reduction in a limited time span is realizable but requires a new way of working, new tools, and management's visible support.
- A positive cost reduction pressure that is extended to the supply chain as well is imperative; the suppliers ought to be engaged in the cost reduction project.
- The cross-functional product development teams need to understand the power of formal tools. However, applying a specific cost reduction tool in an orthodox way is not an end in itself; it is more important to combine the best aspects of the traditional tools.
- It is important to understand that global market is dynamic where prices fluctuate, especially those of raw materials, energy, and labour.

Views on product development process

Product development can be presented with a model of consecutive sequences. Processes include stages and gates for decision making to continue or reject the development efforts [7, 8]. Generally these models apply to new product development starting from market need

(demand pull) for a product or to new technological innovation (technology push). The product innovations are said to originate in the beginning of the process.

However, the majority of product development activities in industry are aimed at existing products to which the existing development process models are less applicable.

The beginning of a design process description is based on generating product specification and creating functional structure. This principle focuses on product's mechanical realisation and treats other technological disciplines less relevant for delivering functionality. This has lead to a situation, where product specifications are separated into technological disciplines and divided into blocks (or chunks) within the disciplines. Even if this separation is a means to reduce and manage complexity it generates distance between the original use and functionality of the product and the partial specifications. Once the separation is done, the interaction and integration with and between the systems have disappeared.

One consequence of this separation into disciplines, blocks or sub-functions is that reductionistic approach leads to partial optimisation of lower level organs and components. This also impedes the discovery of innovative multi-disciplinary solutions.

However, a closer look at the description of a technical system reveals that all systems (technological disciplines) contribute to the transformation process. The separation of disciplines is a consequence of educational and organisational structure, which the companies have tried to cope with by setting up cross-disciplinary development teams. Management of design process becomes very challenging, specially within large projects. Varying needs of stakeholders tend to drive the design and it may be difficult to find the person who assumes responsibility for product's performance and functionality.

In search for innovative solutions the product's functionality, performance and operational behaviour should be considered as one technical transformation system where the output is the integrated result of different technologies. For a design and development process, this approach sets a new way of modelling the product.

Product concept development

A technical system cannot be absolute, as a solution can be constructed with various different functional structures. Each structure can be composed of different organs and, furthermore, organs can consist of various components. The goodness of product concept is always relative to time and place, depending on which aspects of different stakeholders are preferred.

In business environment there are two determinants for goodness: product's costs and performance (e.g. means to satisfy customer needs with product properties). The first one relates to profitability of the business, representing the "investment for income" and the latter relates to product's position, attractiveness and sales price on the market. These determinants are typically expressed as follows:

- Cost and performance are in contradiction during design phase, generally increase of the performance increases also the costs.
- Cost as such can never reach absolute, zero value
- The limit of performance is unknown, realistic estimates can be done only for short future

Evaluating the situation with an existing concept (A) in Fig. 3, few remarks can be done:

- The dot presents the status of current concept in cost-performance chart. The oval section around the dot describes the achievable opportunities with continuous improvement actions, like material or components changes, DFMA based modifications, relocation of manufacturing, etc.
- If no improvements are activated, the cost will increase along the time due to natural economic change.
- The concept has its borders with cost reduction and performance increase. To maintain competitiveness and profitability and to extend the lifetime of the product, a new solution (concepts) should be implemented.

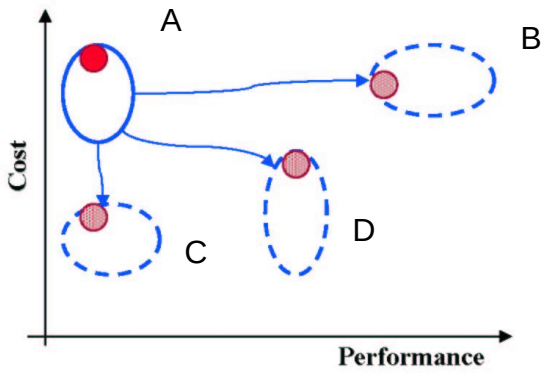

Figure 3. New concept options

New concepts may be introduced in various types, depending on the market situation and product's position compared to competitors:

- Type B presents the case where significant increase on performance is gained with equal or marginally higher costs.
- Type C presents the case where equal performance is gained with significantly lower costs.
- Type D presents the ideal case where significant performance increase is gained with lower costs.

All types share the same requirement: innovative solution is needed to reach targets beyond the borders of traditional improvements.

Systematic innovation process for existing concepts

The conception of innovation implies that a new additional value is provided to one or more stakeholder(s). When existing concepts are developed the product-related improvements may take shape through incremental innovations. A product has multiple meetings with the processes along the life cycle. Each process reflects the actions taken by respective function in the company and the drivers and views accordingly. A challenge within the company is to harmonize the interest of stakeholders and match them with the business targets, thus preventing partial optimisation.

Existence of a product concept and its content has multiple aspects. An overview of the environment for innovative solutions is shown in Fig. 4

A systematic process for generating innovative solutions may include different views along life cycle, not only topics related to technical systems. As the different concepts with time and

place exist, different approaches can be applied to generate seeds for innovations. Considering the views of different concepts, a multitude of interactions and impacts may be found to enhance a creative process.

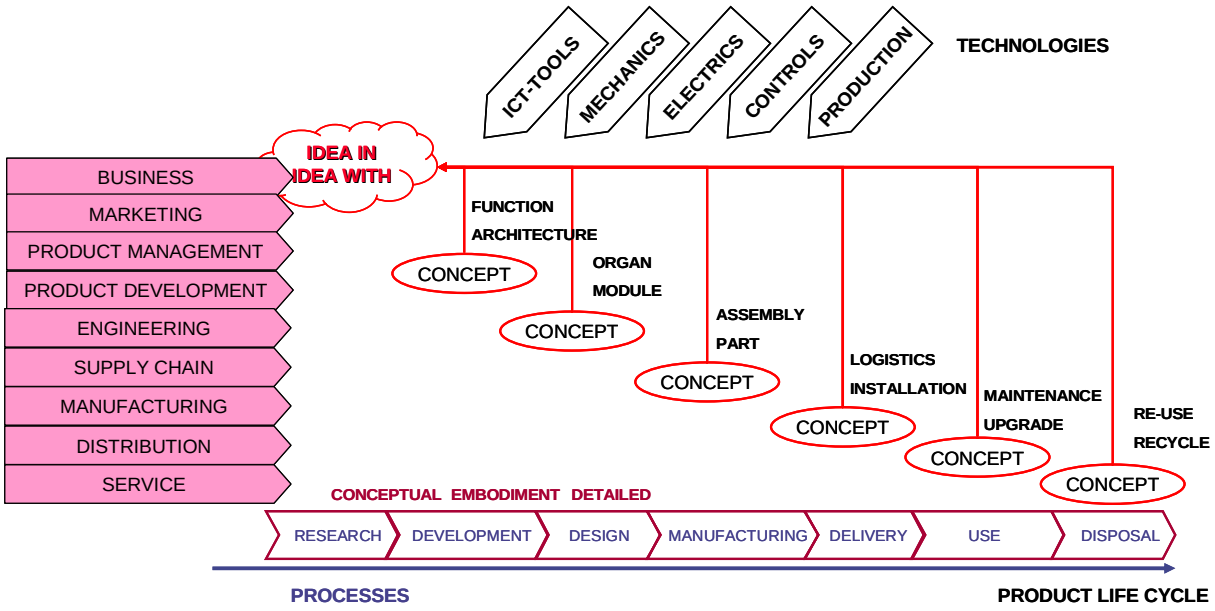

Figure 4. Environment for searching innovative solutions

Delivery model of product functionality and performance

The initiation of innovative solutions should be directed from subsystems and components towards the functionality of product. The delivery mechanism of modern machines consists of connected systems and the functionality is transformed as shown on Fig. 5.

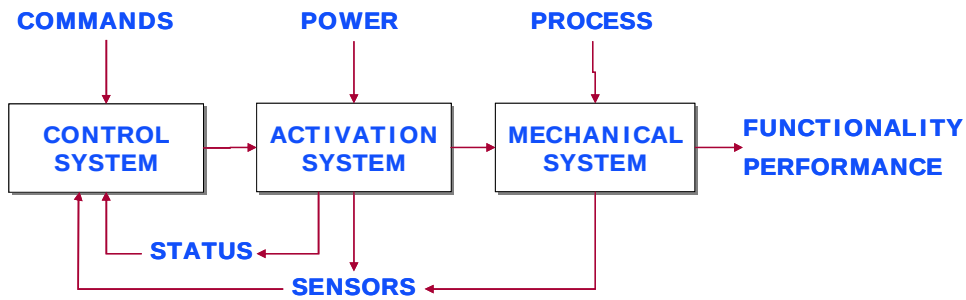

Figure 5. Functionality model

Generally, the functionality of a product is considered only to be actions of the mechanical system, for which the functional structures are composed. However, in reality the delivery mechanism of product functionality and performance is dependent on the integration and interaction of different systems.

An approach to see opportunities for new innovative solutions is based on multi-disciplinary analysis of the delivery mechanism of functionality. The analysis is divided into two stages;

1) The opportunity of functional behavior for a mechanical system (e.g. feature or performance) and phenomena behind it are recognized. The chain of effects and participating elements for behavior through other systems are mapped.

2) The connecting elements of different systems are linked to each other to visualize interactions between systems.

Multi-disciplinary mapping provides a mean to combine and show product functionality for different development team members and improve understanding of product's operating conditions. Functionality model and mapping of interactions provide seeds for new innovative solutions that enable significant cost reduction or functionality improvement.

Conclusions

In this paper we have studied cost management and systematic innovation process for an industrial product. These approaches are needed in a lean manufacturing market, where internal profitablity pressure calls for reduction of existing products' costs and on the other hand, new products are expected to satisfy the evolving life cycle requirements. We have shown that a product concept provides an essential basis for both cost reduction and functionality development.

Cost management means senior management's actions that generate a positive cost pressure on the organization while simultaneously satisfying customer's needs. We have demonstrated a specific project for radical cost reduction. This project utilizes the systematic tools provided by design-to-cost (DTC) and target costing approaches. These tools call for idea generation to improve the existing product concept, especially the aspect of *idea in*. Main strategies of cost reduction are based on redesigning for manufacturability, searching for new suppliers, redesigning for optimised functionality, and applying new technologies. Our experience proves that a radical cost reduction in a limited time frame is realizable, provided that the management gives its full support and cross-functional product development teams commit to the project.

Engineering design generally treats the product as different disciplines, which form a superimposed system structure. While this is a means to reduce and manage complexity it generates distance between the original use and functionality of the product. In search for innovative solutions the product's functionality, performance and operational behaviour should be considered as one transformation system where the output is the integrated result of different technologies. This approach sets a new way of modelling the product in design process.

Product's goodness can be estimated using two determinants: cost and performance. We have demonstrated that the existing product concept provides only limited potential for improving product's goodness and, to exceed these limits, innovative solutions for developing new product concept are needed. For this, a systematic innovation process provides a means to generate solutions. This approach involves different concepts in time and place and includes respective views along product's life cycle. As different concepts with time and place exist, different approaches can be applied to generate seeds for innovations. Considering the views of different concepts, a multitude of interactions and impacts may be found to enhance a creative process.

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