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TOWARDS AN INTEGRATED DESIGN OF PRODUCT AND PACKAGING

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1 Introduction

The globalization of the world economy has forced many enterprises to merge and/or to acquire enterprises worldwide. In the next phase of this development, rationalization calls for specialization of functions such as product development and production in one or a few sites, if not being outsourced to external suppliers. These new divisions of the "virtual" enterprise have to collaborate within internal and external networks, where efficient and effective transportation, handling and storing of intermediary and final products is a must. In order to obtain this objective, an integration concept of the design of product and packaging has been proposed by Bjärnemo et al. [1]. The acceptance of the need for such a concept in industry has been established by Bramklev [2]. In this paper an industrially implementable, integrated procedure model for the concurrent design of product and packaging, confined to the product area of mechanical engineering, is presented.

2 Approach and Objectives

In order to explore the acceptance or rejection of the need for the proposed integration concept, Bramklev [2] performed three surveys in a total of 60 Swedish enterprises, within mechanical, pharmaceutical and food areas. In addition to this task, Bramklev also presented a preliminary, generic, integration concept, based on the findings from these surveys.

As this concept was developed solely based on the findings obtained from the product developers and did not include the role of the packaging designers, the first task to be performed within the project reported here was to study the packaging design process. This has been carried out directly in industry by studying the packaging design process as well as the packaging production process at SCA Packaging in Värnamo, Sweden. In addition to this study, a literature survey of packaging design processes has also been carried out, thus providing the generic dimension of the packaging design process.

Thus, the main objective of this paper is to *provide an integrated product and packaging design procedure model that facilitates implementation of the procedure in industry on an operational level.*

A critical factor in obtaining this objective is to facilitate integration through the coordination between upstream and downstream design activities and across the product development functions. The secondary objective is therefore to *identify suitable methods and techniques to be used and/or to be developed in the integrated product and packaging design procedure.*

In order to obtain the information needed for the development of the procedure model, a *survey method* consisting of a combination of questionnaires and interviews has been used. In this paper, also previously published materials as well as unpublished findings from the three exploratory surveys, previously mentioned, will be referred to and utilized – see Bramklev [2].

In addition to the surveys, two *cases* will be briefly presented here to substantiate the actual need and will of the industry to implement a design procedure of the proposed nature.

Referring to the overall objective, a *generic* development procedure model for all the product areas surveyed is the ultimate goal. It is not presently possible to fully foresee whether or not this can be achieved before exploring the potential for integration concepts within each and every one of the product areas. Even if these implementations turn out favourably, this does not guarantee that it is possible to develop the "ultimate", generic, procedure model.

In order to indicate the complexity of this task, the findings from the surveys regarding typical or generic product development procedure models within each and every one of the three product areas will also be presented here.

Finally, note that the procedure model to be developed here is confined to the product area of mechanical engineering. This is because the mechanical engineering design process is the most researched and thereby the one that is the best known and documented of the product areas covered in the surveys. Furthermore, the area of mechanical engineering also represents the major part of Swedish industry and is thus the ideal area of a first implementation trial of the procedure model.

3 Elements of the procedure model

Before addressing the development of the integrated procedure model, it is necessary to elaborate upon important, constitutive, elements or "building blocks" of the model. As the findings from the surveys form an important source of information for the procedure model, each and every one of the product areas will be covered in some detail — even though the findings from some of the product areas do not directly constitute the foundation on which the procedure model is developed.

3.1 The product

According to Ulrich & Eppinger [3] a *product*, in the given context, is defined as *"something sold by an enterprise to its customers"*. Furthermore, it is *"engineered, discrete and physical"*.

An additional constraint to the concept of product, necessary for the development of the procedure model, is that the main product working principle is based on the principles of mechanics. A *working principle* is here defined as *"The technical realization of the fundamental laws of biology, chemistry or physics, which separately or in combination generates the function(s) performed by the product."*

3.2 The packaging

Based on Paine [4], the following definition of *packaging* has been adopted here. *"Packaging is a co-ordinated system of preparing goods for transport, distribution, storage, retailing and end-use and a means of ensuring safe delivery to the ultimate consumer in sound condition at minimum cost."* Thus, the definition of *packaging* should be interpreted as ranging from simple wrappings to advanced special-purpose containers. It also indicates a hierarchical nature of packaging.

Paine [4] also describes packaging as a *product* with the initial purpose of protecting, collecting and providing information about its content – the actual product.

With reference to the functions outlined above, *packaging* is here regarded as an "extension" of the product in the sense that it provides additional features to the actual product to fulfil the demands on "product performance" during parts of the product life cycle — from the finalisation of the manufacturing or assembly of the product until the product is ready for use or consumed. Note that a *package* is the physical object realising the packaging system objectives.

3.3 Product innovation and the product development process

In order to give an overall perspective of the concept of product development, it is necessary to present it in its industrial context — the *product innovation process*. This process encompasses all activities that precede the successful launch of a new product in a market, such as basic and applied research, market research, marketing planning, design and development, production, distribution, sales and after sales service — see Figure 1.

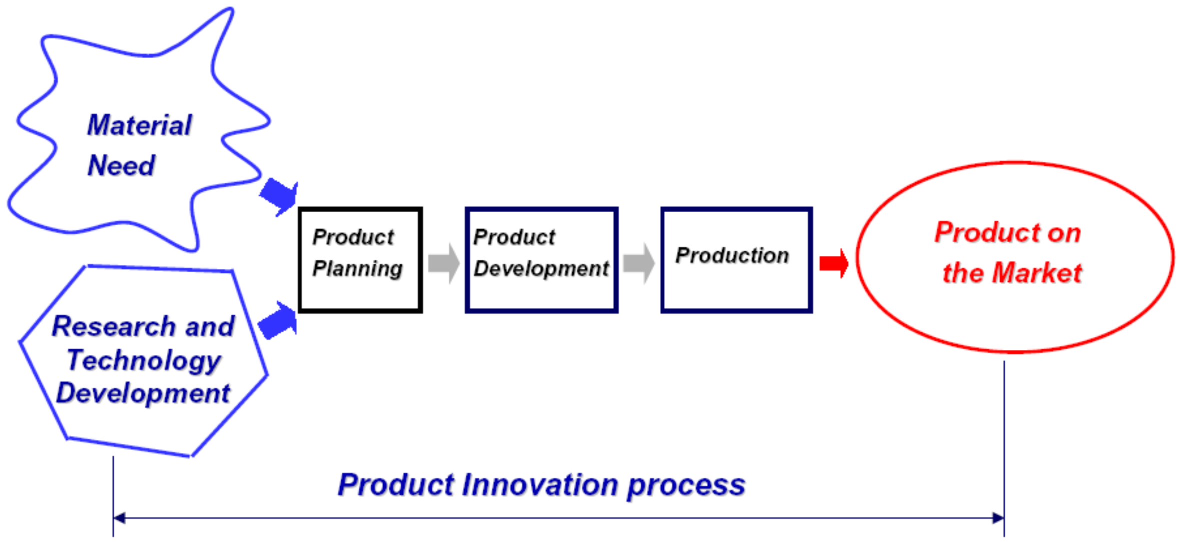

Figure 1. The simplified product innovation process according to Bjärnemo [5].

The *product planning process* takes place before the actual product development project is approved. During this process the search for opportunities, especially emanating from market and research/technology development, is conducted; the opportunities are identified and prioritised into a set of product proposals or a product portfolio. For each and every one of these product proposals a *(project) mission statement* is established, which constitutes the input information to the actual product development project.

According to Ulrich & Eppinger [3] product development is described as *"a set of activities beginning with the perception of a market opportunity and ending in the production, sales and delivery of a product."* The *product development process* is commonly described as consisting of three "parallel" processes — the design, manufacturing and marketing processes. These three processes have to successfully interact during the overall product development process. This interaction is usually referred to as *integration* (vertical – between the subprocesses, as well as horizontal – within each and every one of the subprocesses). Integration is also often interpreted as *concurrent.* The process is normally described in terms of activities in what is here denoted a procedure model. Note that this procedure model might also include all of the methods and techniques utilized to perform the activities on an operational level. Furthermore note that the product development procedure models usually represent an *extension* of the previous models provided within (engineering) design methodology.

Findings from the survey on product development processes within mechanical engineering – see Bramklev [2]

The literature on product development and design within mechanical engineering is fairly extensive and dates back to early German publications on engineering design from the mid 1850s. Some examples of contributors to the current literature in the field are: Andreasen & Hein; Hubka; French; Pahl & Beitz; Roozenburg & Eekels; Ullman; Ulrich & Eppinger; Wheelwright & Clark.

A frequently cited publication within the field is "Product Design and Development" by Ulrich & Eppinger [3]. In their book they give an extensive account of all of the activities constituting a market-pull product development process. This process, also denoted the *generic* product development process, consists of six phases – see Figure 2.

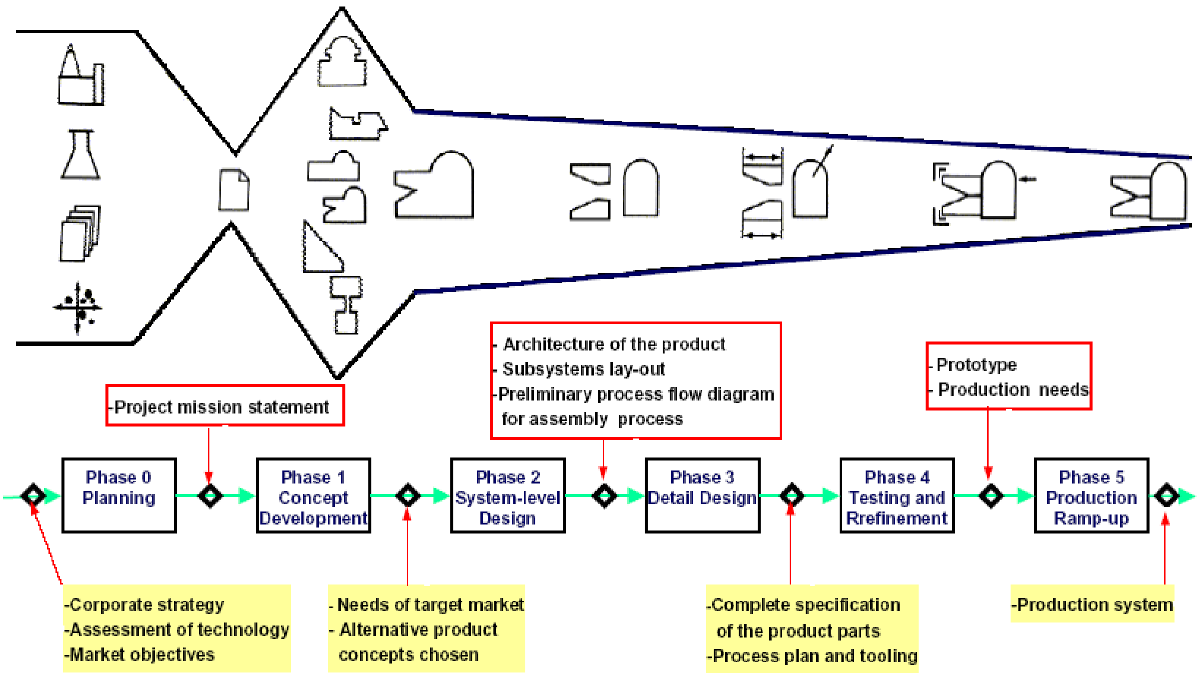

Figure 2. The generic product development process according to Ulrich & Eppinger [3].

These six phases of the generic product development process are:

- *Planning* precedes the project approval and actual product development process launch. It includes corporate strategy, assessment of technology and market objectives. Outputs are a project mission statement, specifying the target market for the product, business goals, key assumptions and constraints.

- *Concept development* identifies the needs of the target market, and alternative product concepts are generated and evaluated. Note that a concept is a description of the form, function, and features of a product, and is usually accompanied by a set of specifications, an analysis of competitive products, and an economic justification of the project.

- *System-level design* includes the definition of the product architecture and the decomposition of the product into subsystems and components. The product architecture can be described as the assignment of functional elements of a product to physical building blocks, also called *chunks*. Assembly is also often defined at this point. Typical outputs from this phase are geometric product layout, functional specification of product subsystems, and a process flow diagram for final assembly.

- *Detail design* includes complete specification of the geometry, materials and tolerances of all of the discrete parts in the product, and the identification of all the standard parts to be purchased from suppliers. In addition, a process plan is established and tooling is designed.

- *Testing and refinement* involves testing and refinement of multiple pre-production versions of the product. Usually an early prototype, the *alpha prototype*, is manufactured in order to determine if the product will work as designed, and if it satisfies customer needs. Later, a *beta prototype* is manufactured to test performance and reliability, which identifies necessary engineering changes in the final product.

- *Production ramp-up* is the phase where the product is made using the intended production system, the purpose being to train the workforce and eliminate any remaining problems in the production process.

Findings from the survey on product development processes for food products – see Bramklev [2]

The definition of a *food product* is, in accordance with “Federal food and drug and cosmetic act” as amended by the FDA Modernization Act of 1997, based on the fact that the product is used for food or drinks for humans, or used for components of any such article.

Authors providing descriptions of the food product development processes, or sequences of such processes, are Blanchfield; Buzzell & Nourse; Earle; Fuller; Meyer; and Rudolph.

Blanchfield [6] provides a description of the product innovation process starting with a phase denoted as *Idea/Perceived need/Perceived opportunity.* This phase includes the results for a food product idea retrieved from ideas suggested by technology, market research, ideas suggested by functional ingredients, gap analysis, ideas triggered by products in other countries, lateral thinking, bright ideas, brainstorming and hunches.

Food product development includes activities for functional characteristics and ingredient formulation, sensory analysis of form, flavour and colours, formulations of processing variables, shelf-life requirements and ingredient constraints, sketches for packaging and product interaction and standardised recipe formulation.

It should also be noted that it is difficult to find empirical work on the development of a food product development process. Blanchfield [6] describes the development of a food product as consisting of six activities: *(1) an ingredient formulation (or recipe), (2) choice of raw materials, (3) choice of processing method, equipment and conditions, (4) choice of packaging system and materials, (5) decisions for labelling declarations*, and *(6) decision on quality control declarations*. Note that this sequence of activities does not form a development process, but merely defines the constitutive elements of such a process.

Findings from the survey on product development processes for pharmaceutical products – see Bramklev [2]

In general, a pharmaceutical product is a product for *prevention, cure, treatment, suppression, diagnosis* and/or *enhancements of health.* The classification of a *pharmaceutical*, or equivalently of a *drug* or *medical device,* is here defined in accordance with "Federal food and drug and cosmetic act" as amended by the FDA Modernization Act of 1997.

Authors providing descriptions of the pharmaceutical product development processes are Drews; Lombardino & Lowe III; and Spilker. The description of the generic pharmaceutical product development process provided by Lombardino & Lowe III [7] consists of two phases, each divided into a number of sequential substeps – see Figure 3.

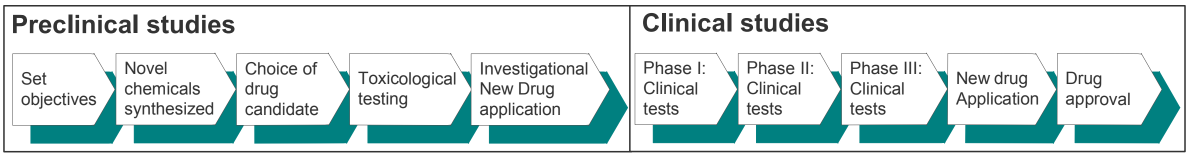

Figure 3. The generic pharmaceutical development process as described by Lombardino & Lowe III [7].

Note that the product planning process is referred to as either *preclinical studies* or *the discovery process* in pharmaceutical development literature. It is a process for the creation of a new substance, which is a matter of creating a molecule that will bind to a particular receptor with a required degree of binding affinity, and that will not bind to other receptors that may be structurally similar but have different functions. The process is also described as the creation of a *lead compound* and ends with the decision to develop a specific lead compound, now denoted as a *candidate compound*, as a future pharmaceutical.

The actual development process for pharmaceutical products is denoted *clinical studies* or *the medicine development process.* It includes operative individual steps of clinical and non-clinical methods. The process for developing a pharmaceutical (or substance) aims at developing a formula for molecular reaction. The development starts with a quality target, and prediction of toxicity and metabolism response, and works through a pipeline of clinical trials to minimise side effects and maximise efficacy, to arrive at a new drug approval review process, market launch and diagnostics for the practice of better medicine.

For the future, the pharmaceutical product development process has to be faster and more efficient to deliver more fully developed pharmaceutical products. Research indicates that pharmaceutical development will need to adopt more experience and understanding of biotechnology in order to create systematic approaches in development work. In addition, emphasis is also placed on a greater involvement of manufacturing in the product development process. Furthermore, pharmaceutical development needs to be more engaged in alternative formulations and delivery systems, as there is a tendency towards higher potency compounds to reduce the cost of goods. Higher potency compounds result in smaller dosages and the use of alternative delivery systems, or packaging, such as inhalation, nasal, buccal and sublingual absorption. Thus, packaging and distribution are and will be of importance to pharmaceutical development.

Findings from the study and survey on packaging design processes – see Bramklev [2]

A very limited number of publications for the description of the overall packaging design process are available. For the existing process descriptions, it should be noted that packaging design procedure models are often provided in close relationship to specific product areas.

For the packaging development process, authors with publications on the subject are for example DeMaria; Paine; Griffin; and ten Klooster. However, a complete generic design procedure model for packaging design has not been found.

For the generic development procedure, Paine [8] provides a brief description of a *package development process*, dividing it into 6 steps: *concept, preliminary sorting, prototyping, packaging engineering, package evaluation* and *package quality criteria*. Only DeMaria [9] provides a more detailed step-by-step approach to the packaging development process, dividing it into three phases. This packaging development procedure model consists of *(1) planning, (2) proving functionality* and *(3) package launch*, where each phase is divided into a number of sequential substeps:

- *Phase I – Planning*: This phase includes business planning and goals, assembling a project team, identification of package concept and feasibility assessment. Phase I continues with consumer concept testing, development of package prototypes, testing of package consumer usage and final concept evaluation.

- *Phase II - Provisional functionality:* This phase includes package testing and final approval.

- *Phase III - Package launch:* This phase includes production start-up and monitoring of package performance.

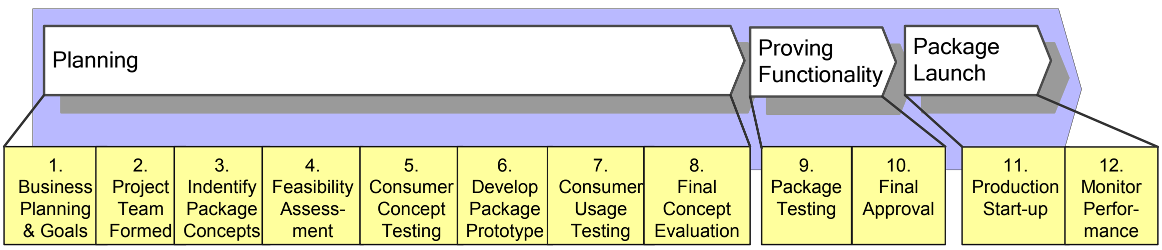

Figure 4. The Packaging Development Process according to DeMaria [9].

4 On the development of an integrated product and packaging development procedure model within mechanical engineering

From the survey within the product area of mechanical engineering, as well as for the other product areas, additional findings were obtained during the surveys that constitute important information for the development of the procedure model(s). When commenting on and utilizing these findings below, only those with direct relevance for mechanical engineering will be considered.

Regarding mechanical engineering, the development of the packaging was launched after the actual product was fully designed – the only exception found will be elaborated upon below when discussing the case studies. This means that the specifications of the packaging were not to be established until the product was ready for production, and the actual development of the packaging took place in parallel with the production of the product, thus increasing the development time for product and packaging and the risk of extending the lead time for the entire project.

Another result was that the packaging was always regarded as the means for adding those features necessary for the product to withstand the loads and other environmental impacts during storing, handling and transportation. On a direct question, the majority of the companies agreed that if product and package were developed concurrently, there was an apparent potential to cut product costs when loads during transportation were more severe than during normal operation of the product. The same advantages were also expected if it was possible to develop "tailor made" or "optimal" packages, which could cut the transportation of "air". Figure 5 illustrates the above discussion.

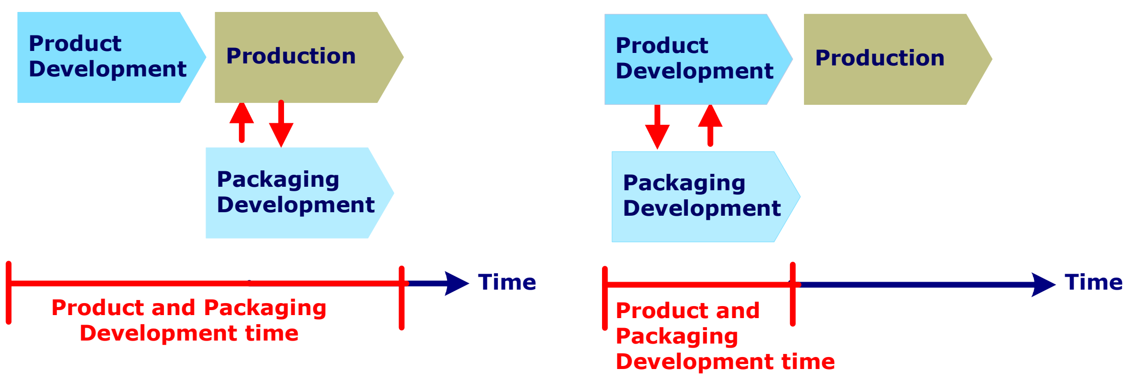

Figure 5. Traditional and concurrent development and design of product and packaging.

One of the most important cornerstones in the development of the procedure model is the concept of *integration*. In the given context, integration should be interpreted as *connecting people, processes* and *technologies*. However, when integration is mentioned, it is usually the *"vertical"* integration between the key functions, design, production and marketing, which is referred to. It is important not to forget the *"horizontal"* integration, or maybe more adequately, the *compatibility* between the subactivities forming each of the phases of a given function. In other words, the latter integration/compatibility refers to the integration *along* the time-axis of the project and *within* each and every one of the subprocesses, thereby focusing not only on connecting people and process but also, more specifically, on connecting technologies.

Referring to what has been presented above and the necessity of providing a procedure model that is generic, the choice of a basis for the (mechanical) product development process part of the procedure model fell to the development process by Ulrich & Eppinger [3]. This process is of a true generic nature and fulfils the demands on the integration concept as well as being well established and widely accepted in industry.

For the packaging development process part, the process by DeMaria [9] has been chosen. In comparison to the other packaging development processes, this is identified as being the one that best fulfils the demand of being of a true generic nature. This is substantiated by the findings and experiences obtained from the study at SCA Packaging.

For simplicity of illustrating the proposed procedure model, the chosen procedure models have been combined into one by connecting activities – indicated by letters A – F in Figure 6. These activities are the result of identifying those coordination problems that emanate from the findings of the survey. Each and every one of these coordination problems will be briefly elaborated upon below, where suitable methods and techniques for dealing with these will also be addressed. Note that references are made to the subactivities defining each of the constituent phases of the procedure models – see Figures 2 and 4.

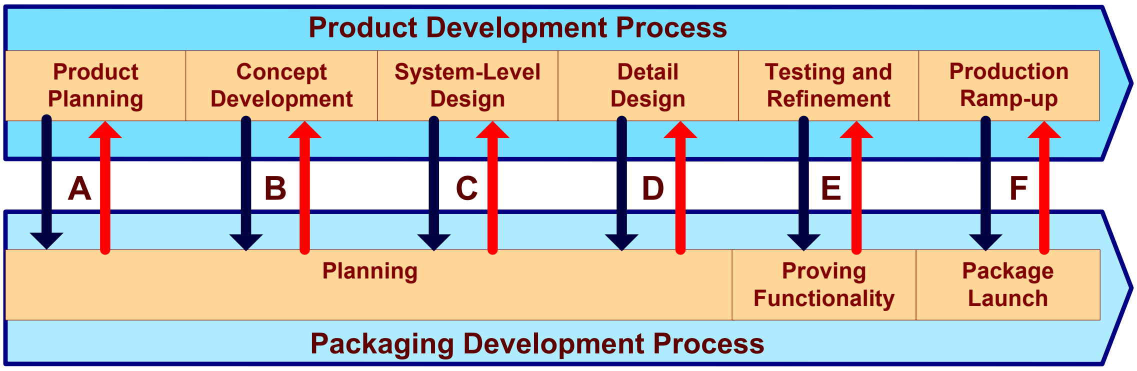

Figure 6. The proposal for an Integrated Product and Packaging Development Process.

4.1 A - co-ordination of product planning and packaging planning

The survey results establish that the introduction of packaging and logistics aspects into the project/product calls for a joint *project mission statement.* When *evaluating and prioritising* projects in product planning it is important to coordinate this activity with planning of the packaging development process and the activity of *business planning and goal.* This calls for an extended product planning process that more clearly incorporates the significance of product policy as derived from the overall business goal.

The survey results also indicate that the majority of projects are prioritised on the basis of expected yield and market potential; it is recommended to provide a technique for the integrated evaluation of packaging influences on expected product yield and product market potential.

Furthermore, when addressing *allocate resources for the project* and *complete pre-project planning* in product planning, it is important to synchronize the information regarding the product plan, project timing and resource allocation with the packaging planning.

4.2 B - co-ordination of concept development and packaging planning

For the coordination of *concept development* and *packaging planning*, the results from *the identification of customer needs* and *the establishment of target specification* should be carried out with reference to the packaging as well, and before package concepts are identified. When packaging development sequentially assesses *feasibility of packaging*, this constitutes valuable information for *the generation of product concepts* and *selection of product concept*. When the product concept(s) is chosen, it is important that this information is passed on to the packaging development, so that the steps for *consumer concept testing, development of package prototype* and *consumer usage testing* may be coordinated with *the test of product concepts*. Finally, when *the final specification is set* it is important that this activity is coordinated with the packaging development and the step for *final usage testing*, where information about financial commitments may be shared between product development and packaging development.

It should be noted that when the concept is finalised, and the product is given a more definite description, it will be possible to decide upon the packaging principles and the function decomposition between product and packaging over the product life cycle. Thus, it is especially important that the coordination of *concept development* and *packaging planning* integrate packaging into the final product specifications.

In addition, to guide the creation of the product when establishing the function structure of the product, the *function decomposition* of product and packaging should be established. Note that the packaging represents a potential to support the product, as previously mentioned, by taking over product functions for parts of the product life cycle, especially during distribution of the product.

4.3 C - co-ordination of system-level design and packaging planning

During the *system-level* design phase, the design and/or selection of packaging must be decided upon concurrently with the establishment of the product architecture. For the functional specification of each product subsystem, one must decide the corresponding geometric layouts of the packaging as well as the packaging material.

Secondary and tertiary packaging are especially emphasised in order to provide efficient and effective product complement. Distribution and production requirements in particular should be adapted to this layout, preferably through design for packaging methods and techniques.

4.4 D - co-ordination of detail design and packaging planning

It is important that the marketing function complies with regulations and restrictions on product and packaging, to secure the protection and safety of the product. It is also important that marketing calculates those costs that are associated with the packaging and the launch of the product. Concurrently, production should optimise the product and packaging features to minimise failures. For the product design function, suitable materials for product and packaging should be chosen based upon both product-packaging interactions and packaging-product life cycle requirements. Here the primary packaging is especially emphasised. Final-part geometry should also be defined with packaging as part of the subsystem.

4.5 E - co-ordination of testing and refinement and proving functionality

For the coordination of the phase *testing and refinement* in the product development process and the phase of *proving functionality* in the packaging development process, information valuable for the establishment of a test plan should be shared between product development and packaging development, which may ensure that every detail has been tested.

During this phase it is important to facilitate field testing of product *and* packaging *and* packaged products for major parts of the realisation phases of the product life cycle. To support testing and refinement, methods and techniques for the evaluation of reliability and durability should be developed. It is important that regulatory approvals are guaranteed not only for the product design or packaging design, but also for the interaction of product and packaging.

4.6 F - co-ordination of production ramp-up and package launch

Finally, for the coordination of the phase *production ramp-up* in the product development process and the phase of *package launch* in the packaging development process, product development should provide results from test production to packaging development in order to make decisions regarding purchase of packaging materials and/or installation of additional equipment explicit. In turn, packaging development should provide results of test manufacturing to product development so that decisions regarding how well the package performs technically are established.

It is here important that the marketing function place early production examples with key customers, and evaluate feedback of product and packaging in order to rapidly respond to demands for alterations of product and/or packaging. Simultaneously, the design function should evaluate production outputs, including packaging, and production should begin operations to train the workforce. Here it is important to identify and correct any remaining problems associated with packaging production facilities.

5 The potential of the proposed concept

An important factor influencing industry's interest in implementing the proposed procedure model lies primarily in its potential to generate reductions in costs and in lead times. In order to get a preview of the actual potential of the concept, some cases in industry have been investigated in which the objectives and to some extent also the actual activities of the proposed procedure model have been put to practice.

5.1 The gasoline pump

The first case was carried out in a company developing and manufacturing gasoline pumps. As new markets opened up, gasoline pumps were sold and delivered to countries in Eastern Europe.

Since the company did not have any previous experience of delivering pumps to these countries, they were unaware of the magnitude of loads and other environmental conditions facing the pumps during handling and transportation to the sites where they were to be installed. The result in terms of gasoline pumps that were severely damaged during the distribution phase demanded immediate actions from the company.

The first reaction was to improve the “strength” of the pumps by redesigning those parts that were damaged. One such part was a consol shelf design on which a number of the hydraulic valves are mounted. This redesign solved the problem, but increased the costs for the pumps.

The lesson learned was that an improved, more effective load carrying package might be a cheaper and easier way of solving the problem, thus also avoiding the problem of providing different pump solutions or, alternatively, over-dimensioned pumps to the majority of the customers. The action taken by the company was to enrol one of its engineering designers in a packaging design course, thereby creating the possibility to more efficiently and effectively handle this kind of problem in the future. The actual reductions in costs and lead time are not available, but the company claims that they were “significant”.

5.2 The IKEA case

Even though IKEA of Sweden is not a “pure” representative of the mechanical industry, their main products in terms of furniture might, in the given context, be considered as taking their main working principles from the field of mechanics.

The case studied at IKEA was the “Karlsund” armchair – see Figure 7.

Figure 7. The IKEA Karlsund armchair.

Since IKEA is well known for its efficient and effective handling of its products, the interest in additionally strengthening this profile is constant at IKEA. In the given context they are one of the very few companies who systematically follow up the savings in terms of time and money when introducing packaging oriented redesigns of their products and packages. For this reason the savings accounted for in Figure 8, below, give some indications of the potential of concurrent design and development of product and packaging.

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TECHNICIAN:	NGXH	ART.NUMBER:	
DATE:	03-10-06	ART.NUMBER:	
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FORECAST:	130000	ART.NUMBER:	

	OLD	NEW		
PALLET QUANTITY	4	18	=	350,0%
PALLETS/CONTAINER	42	21	=	-50,0%
PIECES/CONTAINER	168	378	=	125,0%
PALLETS/YEAR	32 500	7 222	=	-25 278
CONTAINERS/YEAR	773,8	343,9	=	-429,9
SAVINGS CONTAINERS $			=	859 788
SAVINGS PALLETS $			=	25 278
SAVINGS/YEAR $			=	885 066
SAVINGS HANDLING $			=	328 611
SAVINGS/YEAR TOTAL $			=	1 213 677

Figure 8. Savings established in the IKEA case for the concept of developing product and packaging concurrently.

6 Conclusions

Based on the findings from the surveys in industry as well as in the current literature, an integrated procedure model for the concurrent design and development of product and packaging for the mechanical industry has been proposed, thus fulfilling the main objective set out for the project reported here. The second objective was to provide an account of the methods and techniques to be used on the operational level in industry. This part has also been carried out, but in a more implicit fashion than originally intended. The reason for this is the limited possibilities available here to elaborate on the actual methods and techniques. However, by referring to the activities forming the development processes, it is fairly simple to obtain a deeper understanding by consulting the literature used. As the proposed procedure model is intended to be implemented and evaluated in industrial practice, the reference to the two cases in industry provides a rough indication as to the potentially obtainable benefits inherent in the concept.

7 Acknowledgements

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References

[1] Bjärnemo, R., Jönson, G., and Johnsson, M., "Packaging Logistics in Product Development", Proceedings of the 5th International Conference: Computer Integrated Manufacturing., Singh, J., Lew, S.C., and Gay, R. (eds.), Gintic Institute of Manufacturing Technology, Singapore, 2000, (135-146).

[2] Bramklev, C., "Concurrent Development of Product and Packaging - towards an integrated development procedure", Division of Packaging Logistics, Department of Design Sciences, Lund Institute of Technology at Lund University, 2004.

[3] Ulrich K.T. and Eppinger S.D., "Product Design and Development", McGraw-Hill, Singapore, 2003.

[4] Paine F.A., "Fundamentals of Packaging", Brookside Press Ltd, Leicester, 1981.

[5] Bjärnemo, R., "Lecture note from the course MMK040: Product Development and Design", Division of Machine Design, Department of Design Sciences, Lund Institute of Technology at Lund University, Lund, 2004.

[6] Blanchfield, R., "How the New Food Product is Designed", Food Science & Technology Today, 2 (1), 1988, (54-56).

[7] Lombardino, J.G. and Lowe III, J.A., "The role of the medicinal chemist in drug discovery - then and now", Nature reviews, 3 (October), 2004, (853-862).

[8] Paine F.A., "Packaging Design and Performance", Pira, Surrey, 1990.

[9] DeMaria K., "The packaging development process: a guide for engineers and project managers", Technomic Publication Co., Lancaster, 2000.

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